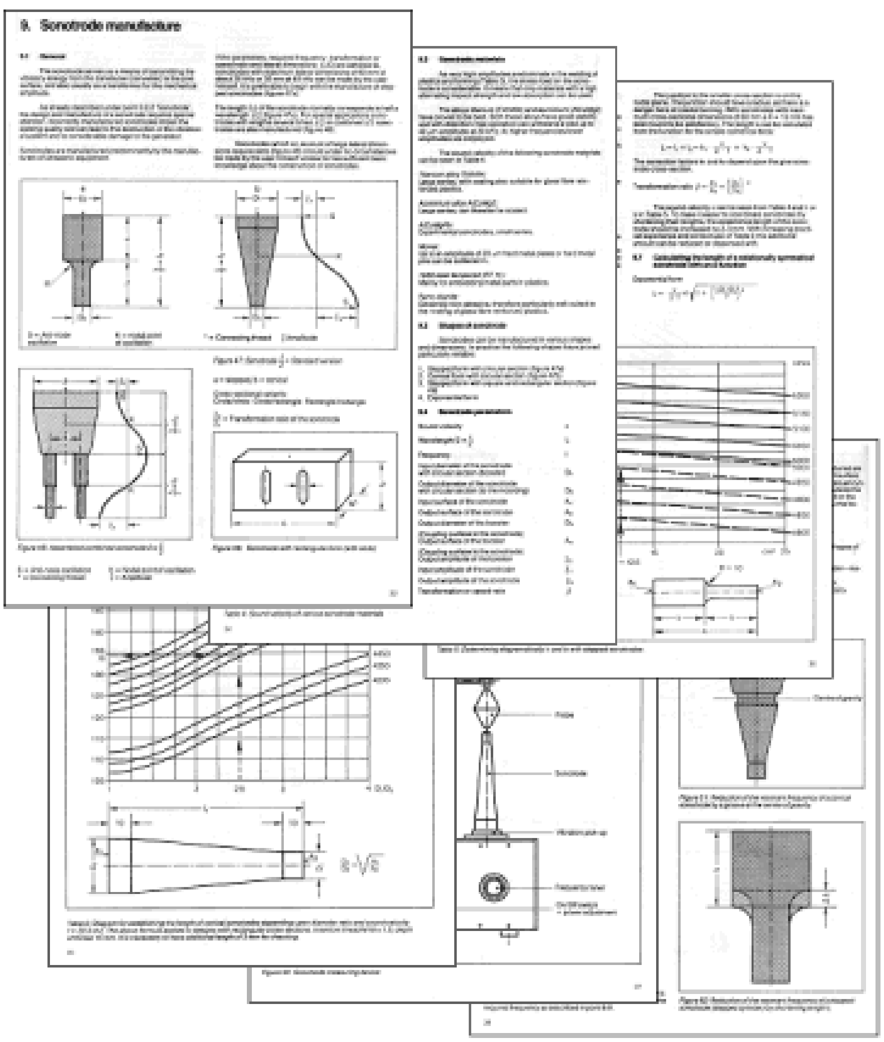
NEW (August 2006):

Dr. Claudia Oviedo S. from the University of Bio-Bio in Chile has asked me to help advertise a workshop on non-destructive testing of wood products (including ultrasonic techniques) to be held there December 11-13, 2006. Although the powerultrasonics web site is specifically NOT about non-destructive testing, I know from the logs (the search phrases used) that many visitors here are interested in the subject, so I'm happy to oblige. There is a call for papers on the web site at www.tnd.ciencias.ubiobio.cl.



ZVEI (the German Electrical Manufacturers Association) produced a handbook some 20+ years ago covering all aspects of ultrasonic plastic welding equipment design and manufacture. This book "Ultrasonic assembly of thermoplastic mouldings and semi-finished products - Recommendations on methods, construction and applications", remains highly relevant today and the section on sonotrode (horn) design, manufacture and tuning is the best publicly available information I know on this topic.

ZVEI has kindly given me permission to reproduced the relevant section here. The complete handbook is still available direct from them: **Sonotrode design and**

manufacture (from ZVEI Handbook)

Power Ultrasonics - What?!

Newcomers to the technology should start with the introduction to power ultrasound for an explanation of the physics and a description of the equipment used.

Then the anatomy page describes the components of a high power ultrasonic system.

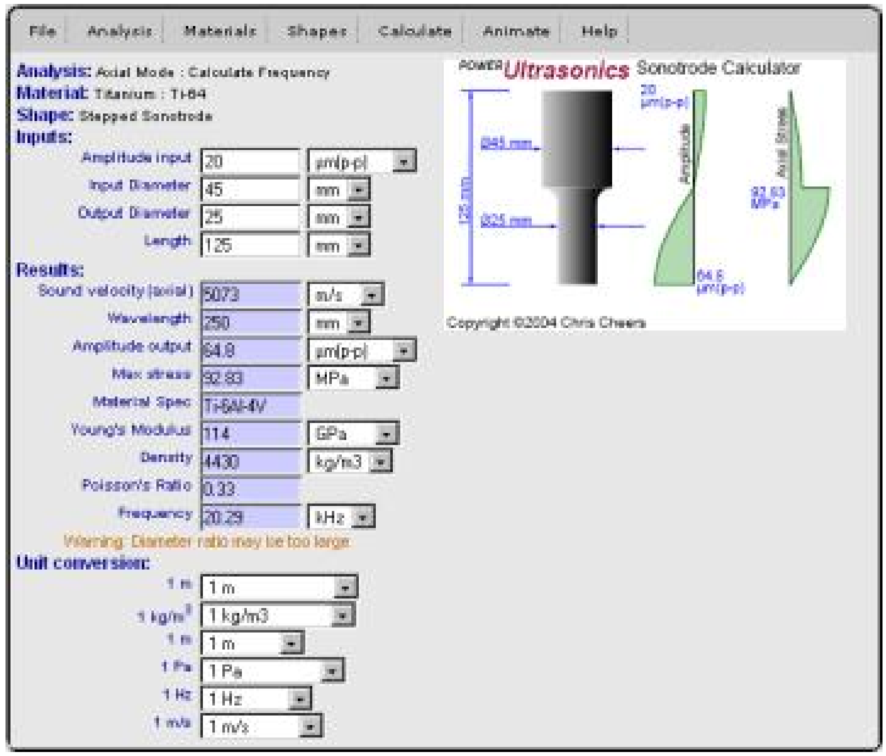
Finally the applications page describes a variety of high-power industrial applications such as cleaning, cutting, forming, machining, sieving, sintering, welding and sonochemistry.

Site Search

Web PowerUltrasonics

Search

October 2004:



First draft of the specialised ultrasonic component calculator is now up for testing and comments. This offers sound velocity, wavelength and frequency calculations for some simple shapes in commonly used materials such as steel, titanium and aluminium.

If you're a supplier please check and update your entry in the ultrasonics suppliers database, since new fields are available for you to include more detailed information about your business. More details and instructions on the Latest news page.

To those of you who have already seen the planned improvements to the site and given me your opinions - thank you. I am listening but have limited time to work on this so please be patient! If you haven't yet, please see the developments page, or have your say on the discussion forum (bulletin board).

Chris Cheers - April 2005.

More information...

Technical articles and research papers from researchers around the world. Specialist books on: ultrasound physics sonochemistry transducers and materials industrial applications provided by Barnes and Noble .

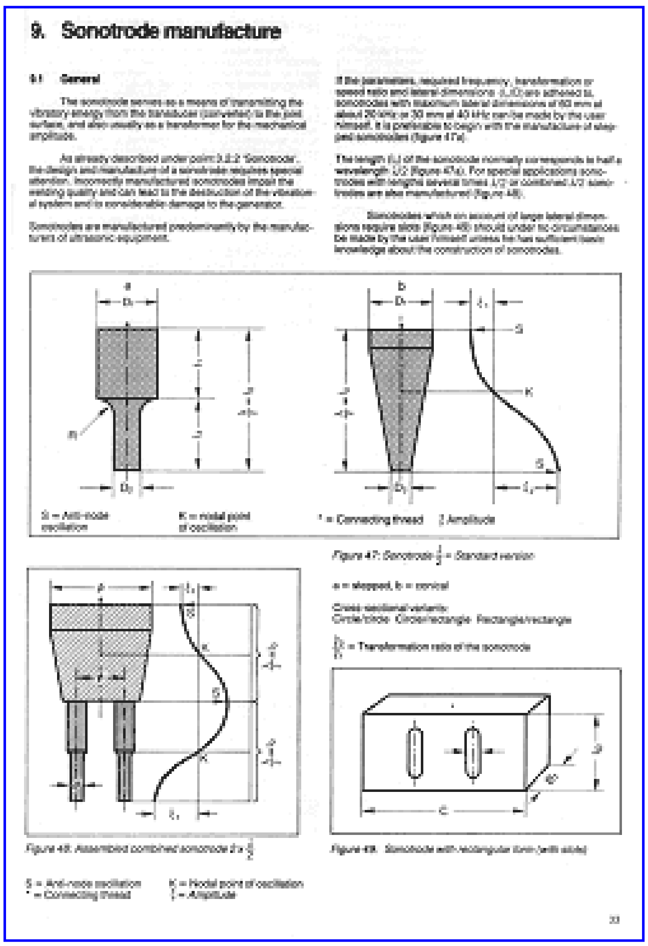
Database of ultrasonic equipment suppliers around the world. (If your company is a supplier of ultrasonic equipment or expertise, and I haven't yet found you then please add your details.)

Other links:

1. M.P. Interconsulting Miodrag Prokic is an independent consultant, developer of new ultrasonics applications (such as ultrasonic cleaning in liquid CO_2) and supplier of special ultrasonic systems for cleaning, sonochemistry and other applications. This is the new site I've just built for him, which includes a variety of technical articles and photos of modern ultrasonic cleaning systems.

The best published information on sonotrode design I know of is a 20+ year old handbook produced by ZVEI (the German Electrical Manufacturers Association) "Ultrasonic assembly of thermoplastic mouldings and semi-finished products - Recommendations on methods, construction and applications", available direct from them.

In this section, by kind permission of ZVEI, I've reproduced pages 33 to 38 (Sonotrode manufacture) - to view, click on the page images or links below.



9. Sonotrode manufacture

9.1 General

Figure 47: Sonotrode $\frac{\lambda}{2}$ = Standard version

a = stepped, b = conical

Cross-sectional variants:
Circle/circle Circle/rectangle Rectangle/rectangle

Figure 48: Assembled combined sonotrode $2 \times \frac{\lambda}{2}$

Figure 49: Sonotrode with rectangular form (with slots)

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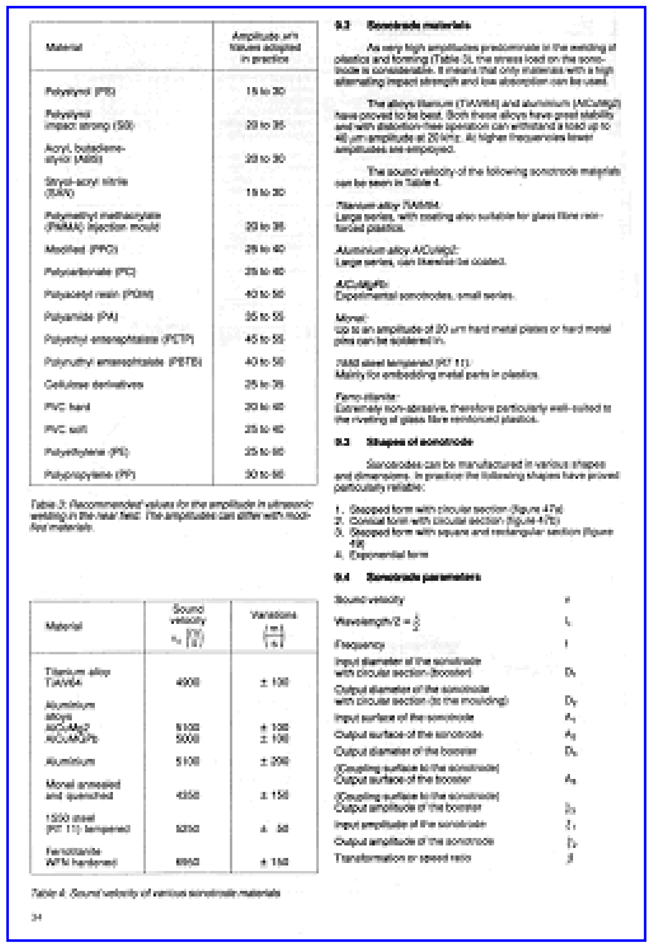

Material	Amplitude µm Values adopted in practice
Polystyrol (PS)	15 to 30
Polystyrol impact strong (SB)	20 to 35
Acryl, butadiene-styrol (ABS)	20 to 30
Styrol-acryl nitrile (SAN)	15 to 30
Polymethyl methacrylate (PMMA) injection mould	20 to 35
Modified (PPO)	25 to 40
Polycarbonate (PC)	25 to 40
Polyacetyl resin (POM)	40 to 50
Polyamide (PA)	35 to 55
Polyethyl enterephtalate (PETP)	45 to 55
Polybuthyl enterephtalate (PETB)	40 to 50
Cellulose derivatives	25 to 35
PVC hard	30 to 40
PVC soft	25 to 40
Polyethylene (PE)	25 to 50
Polypropylene (PP)	30 to 50

Table 3: Recommended values for the amplitude in ultrasonic welding in the near field. The amplitudes can differ with modified materials.

Material	Sound velocity	Variations
Titanium alloy TiAl6V4	4900	± 100
Aluminium alloys AlCuMg2 AlCuMgPb	5100 5000	± 100 ± 100
Aluminium	5100	± 200
Monel annealed and quenched	4350	± 150
1200 steel (RT 11) tempered	5250	± 50
Ferrotitanite WFN hardened	6950	± 150

Table 4: Sound velocity of various sonotrode materials

9.2 Sonotrode materials

9.3 Shapes of sonotrode

1. Stepped form with circular section (figure 47a)
2. Conical form with circular section (figure 47b)
3. Stepped form with square and rectangular section (figure 49)
4. Exponential form

9.4 Sonotrode parameters

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The following values should be indicated by the manufacturer of the instrument and strictly observed:

Sound frequency $f \pm$ tolerance
Amplitude of the booster ξ_B
Output surface or output diameter of the booster A_2 or D_2

9.5 Determining the sound velocity

If the sound velocity of the sonotrode material is not known, it can be established with the measuring device (figure 50), the frequency of a 130 mm long sample without rolling scale or draw scale being measured. The sound velocity is obtained from the function

$$\boxed{v = 2 \cdot l \cdot f}$$

in which the function $l \geq 3 \cdot D$ must be fulfilled, as sound velocity depends upon shape.

By coordinating a cylinder with a diameter of about 40 mm made of the sonotrode material with the unknown sound velocity as given under section 9.9 the sound velocity and the resonance length can be established.

9.6 Determining the length of stepped sonotrodes

Stepped sonotrodes are made up of

$$\boxed{l_s = l_1 + l_2}$$

(figure 47a).

The junction to the smaller cross-section is on the nodal plane. The junction should have a radius, as there is a danger here of cracks forming. With sonotrodes with maximum cross-sectional dimensions of 60 mm a R = 10 mm has been found to be satisfactory. The length can be calculated from the function for the simple cylindrical body:

$$l_s = l_1 + l_2 = k_1 \cdot \frac{v}{4 \cdot f} + k_2 \cdot \frac{v}{4 \cdot f}$$

The correction factors k_1 and k_2 depend upon the give sonotrode cross-section.

Transformation ratio $\beta = \frac{A_1}{A_2} = \left(\frac{D_1}{D_2}\right)^2$

The sound velocity v can be seen from Table 4 and l_1 or l_2 in Table 5. To make it easier to coordinate sonotrodes by shortening their lengths, the established length of the sonotrode should be increased by 2-3 mm. With increasing practical experience and correct use of Table 5 this additional amount can be reduced or dispensed with.

9.7 Calculating the length of a rotationally symmetrical sonotrode with an e-function

Exponential form

$$l_s = \frac{v}{2 \cdot f} \sqrt{1 + \left(\frac{\ln \beta}{\pi}\right)^2}$$

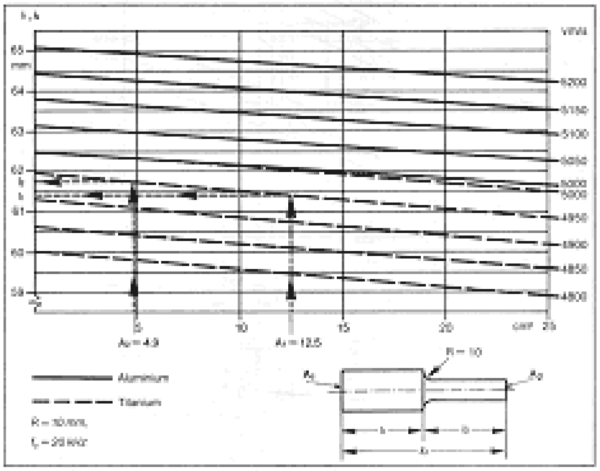

Table 5: Determining diagrammatically l_1 and l_2 with stepped sonotrodes.

The e-function sonotrode is very good in terms of sound, but expensive to manufacture and is therefore only used to a small extent, especially as most sonotrodes are used in practice with a speed ratio smaller than 1 : 4.

Transformation ratio $\beta = \sqrt{\frac{A_1}{A_2}} = \frac{D_1}{D_2}$

9.8 Establishing the length of a conically shaped sonotrode with rotationally symmetrical and rectangular cross-section

The conical sonotrode is the most difficult to calculate of the three shapes mentioned. In practice, therefore, the function of the exponential sonotrode is generally used and multiplied by a safety factor of 1.1. Table 6 makes it possible to determine the length of the cone for different sound velocities with diametrical ratios up to 1 : 4 in the case of sonotrodes

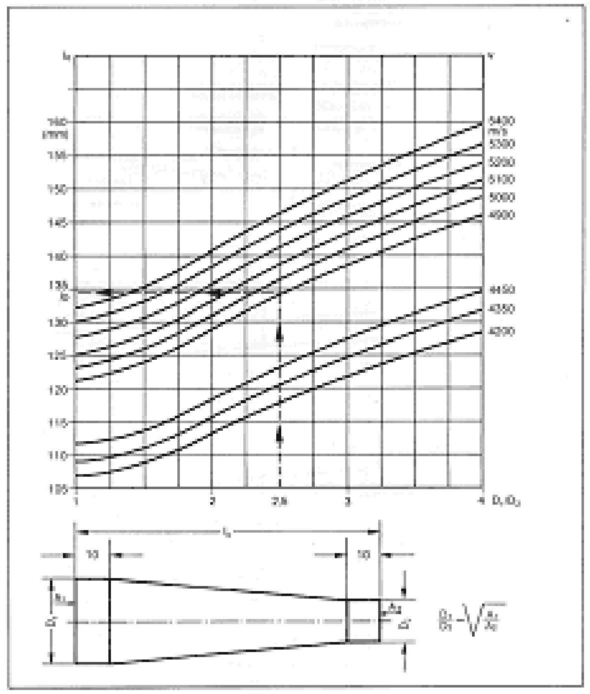

Table 6: Diagram for establishing the length of conical sonotrodes depending upon diameter ratio and sound velocity f = 20.3 kHz. The above formula applies to designs with rectangular cross-sections. Insertion thread M16 x 1.5, depth of thread 15 mm. It is necessary to have additional length of 3 mm for checking.

with threads M 16 x 1.5 and thread depths of 15 mm. With larger thread diameters there should be additional length on the thread side.

Transformation ratio

$$\beta = \sqrt{\frac{A_1}{A_2}} \cdot \cos\frac{m \cdot l}{1} + \frac{v}{\omega \cdot 1}\left(1 - \sqrt{\frac{A_1}{A_2}}\right) \sin\frac{m \cdot l}{1}$$

9.9 Tuning the blank sonotrode

The frequency of the blank sonotrode is as a result of added material of 2-3 mm generally 0.5 to 1 kHz below the desired resonant frequency. The sonotrode reaches the required frequency as a result of being shortened and remeasured several times. The sonotrode measuring device is used to measure the natural frequency (figure 50). It consists of an RC generator, a measuring transducer and frequency indicator. Sonotrode measuring devices are also marketed as compact devices with built-in RC generator.

For measuring, the sonotrode is placed as shown in figure 50 on the measuring transducer or in the case of other types of instrument screwed to the measuring transducer, which is connected to the RC generator. The probe (vibration receiver) coupled with the tuning instrument touches the tip of the sonotrode. The frequency range in which the sonotrode is assumed to lie must be gone through on the RC generator. The resonant frequency has been obtained when the maximum amplitude reading is observed on the tuning instrument or when the indicator reading of the instrument is observed on the compact instrument.

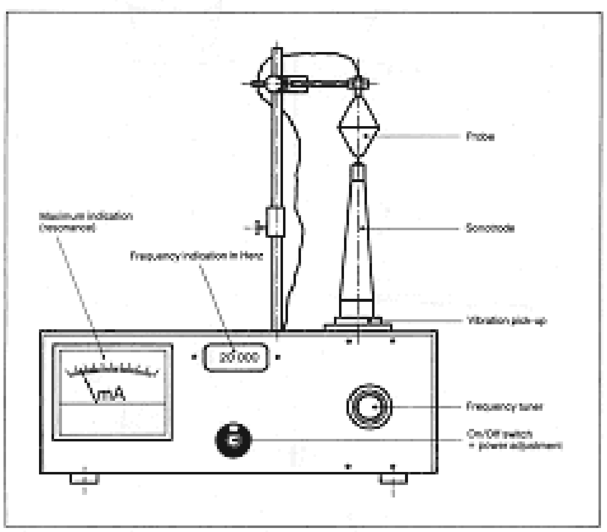

Figure 50: Sonotrode measuring device

9.10 Practical example

Calculation of a sonotrode made of titanium for a moulding made of polystyrol with a diameter of 25 mm.

Data given by the manufacturer of the machine:
Amplitude of the booster ξ_B = 10 μm
Coupling diameter of the booster D_B = 35 mm
Working frequency f = 20 kHz ± 0.2 kHz

Required amplitude for the moulding made of polystyrol, Table 3, page 34, ξ_2 = 25 μm (selected)

for an ideal coupling surface: $\xi_1 = \xi_B$
Amplitude transformation $\beta = \frac{\xi_2}{\xi_1} = \frac{25\,\mu m}{10\,\mu m} = 2.5$

1. Sonotrode with stepped shape (circular section) diagrammatic solution, Table 5, page 35.

$$\beta = \frac{A_1}{A_2} = \left(\frac{D_1}{D_2}\right)^2$$

$$D_1 = \sqrt{\beta \cdot D_2^2} = \sqrt{2.5 \cdot 25^2} = 39.53 \approx 40 \text{ mm}$$

D_1 = 4 cm
A_1 = 12.57 cm²
D_2 = 2.5 cm (adapted to the part)
A_2 = 4.9 cm²
v = 4950 m/s for the titanium selected, Table 4, page 34
l_1 = 61.4 mm Table 5, page 35
l_2 = 61.7 mm Table 5, page 35
l_s = l_1 + l_2
l_s = 61.4 + 61.7 = 123.1 mm
+ allowance of 2 mm at l_2

Arithmetical solution

$$l_s = K \cdot \frac{v}{2 \cdot f} = \frac{4950}{2 \cdot 20} = 123.75 \text{ mm}$$

+ allowance of 2 mm

The correction factor K is adapted with 1.

2. Conical form

Diagram solution, Table 6, page 36

Approximate calculation of the transformation ratio

$\beta = \frac{D_1}{D_2}$ only applies for small diameters.

The divergence for $\frac{D_1}{D_2} = 3$ is approximately 10% and at $\frac{D_1}{D_2} = 5$ is approximately 30%.

$$\beta = \frac{\xi_2}{\xi_1} = \frac{25\,\mu m}{10\,\mu m} = 2.5$$

D_2 = 25 mm (adapted to the part)
D_1 = $\beta \cdot D_2$
D_1 = 2.5 · 25 = 62.5 mm
l_s = 134 mm + 3 mm allowance (Table 6)

In the example presented the stepped shape is chosen, as less material is required and the coupling surface is completely covered. The sonotrodes should be attuned to the required frequency as described in point 9.9.

9.11 Reworking sonotrodes

When sonotrodes which have already been attuned are reworked on the front surface (adjustment of the front surface of the sonotrode to the outline of the moulding) the frequency becomes higher. Afterwards the sonotrode can be outside the permissible tolerance and may no longer be operated on the ultrasonic welding instrument. It is possible to reduce the frequency again slightly.

9.11.1 Frequency correction

The frequency should be increased:
- ☐ Shortening of the complete length (applies to all shapes of sonotrodes). Attention: not linear!

The frequency should be reduced:
- ☐ Conical shape (figure 51), exponential form, cylinder – making a groove at the centre of gravity.
- ☐ Stepped shape (figure 52) – shortening of length l_2.
- ☐ Square or rectangular shape – widening of the slots (figure 48).

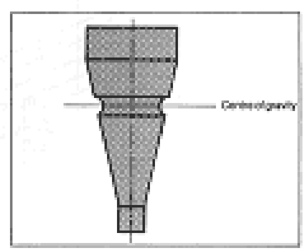

Figure 51: Reduction of the resonant frequency of a conical sonotrode by a groove at the centre of gravity.

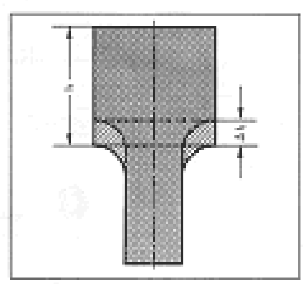

Figure 52: Reduction of the resonant frequency of a stepped sonotrode (stepped cylinder) by shortening length l_2.

General questions, comments etc.

For most general questions about ultrasonics and comments about the site please use the new power ultrasonics discussion forum (or if bulletin boards are something new to you then you could start at the BB intro page).

Additions / changes to supplier information.

If you want to add your company to the ultrasonic suppliers database, or alter details for one already there, please start with the add supplier page, which will take you through the process of registering and editing records. If you have problems feel free to contact me via the discussion board.

Confidential questions, patentable applications.

If your question cannot be made public, eg. if it concerns a new application with potential for patenting, please use the contact page to discuss it with me privately, or e-mail me directly (chris@powerultrasonics.com).

Through the powerUltrasonics web-site, Chris Cheers offers a range of consultancy services:

Ultrasonics consultancy to all manufacturing industry:

- Evaluation of how power ultrasonics can be applied to your process
- Equipment specification and selection
- Ultrasonic tooling design

Internet services, particularly to the ultrasonics industry:

- Advertising on this site
- Web design and hosting, internet consultancy

To discuss any of these, or if you have other requirements, please contact me.

POWER Ultrasonics

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[Search]

This section is for people who already know about the technology of power ultrasonics, or want to know more than just the basics.

New April 2005 Particularly since the publishing of the sonotrode calculator (see below), I've been getting enquiries from people wanting more information on sonotrode design. The best reference I can give them is a 20+ year old handbook produced by ZVEI (the German Electrical Manufacturers Association) "Ultrasonic assembly of thermoplastic mouldings and semi-finished products - Recommendations on methods, construction and applications".

I contacted ZVEI who told me that this excellent publication is still available direct from them, and they have also generously given me permission to reproduce a part of it on this site, so here it is (thanks again Klaus!): **Sonotrode manufacture (from ZVEI Handbook)**

The sonotrode calculator was built mainly as an educational tool to enable newcomers to experiment with sonotrode lengths and frequencies. While it's limited in the present version to calculation of sound velocity, tuned lengths and resonant frequencies of rods and stepped-sonotrodes, a range of enhancements are planned including torsional / radial modes of vibration and animation.

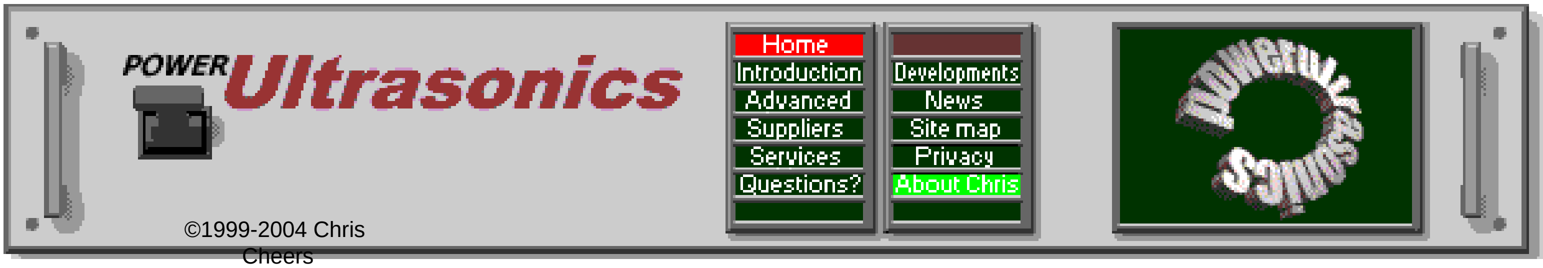
The articles page provides links to a variety of research papers, technical articles and technology reviews in applied high-power ultrasonics (topics currently include ultrasonic food processing, metal and plastic welding, sonochemistry and ultrasonic metal forming).

The books page has references to all the relevant books and other publications (conference proceedings etc.) I can find.

Finally, my doctoral thesis - essential reading for anyone interested in ultrasonic metal forming, radial resonators (ultrasonic dies) or if you just have trouble sleeping!

If you're a newcomer to "ultrasonics" technology, wanting to know what it's all about, this section is for you. I've tried to avoid using too much jargon while explaining what ultrasound is, what it does and how it's used in industrial applications. If you have any further questions, or if anything is unclear please check the ultrasonics forum, and if your question isn't answered there (the forum's new so it probably won't be!) then post it as a new question.

- Ultrasonics basic concepts
- Anatomy of an ultrasonic system
- Industrial applications of power ultrasonics



After growing up in Manchester and the mountains of North Wales, Chris Cheers studied Engineering at St. John's College, Cambridge, graduating in 1984. On joining the Research and Development division of Metal Box plc (now swallowed up by the US packaging giant Crown Cork and Seal) at Wantage, UK, his first position was working for Paul Porucznik - a brilliant (if a bit eccentric!) engineer. Paul had proposed using ultrasonics in a new metal-forming process for manufacturing aerosol cans. Chris began evaluating the benefits of using high-power ultrasonics but quickly found that these were barely measurable and there was practically no chance of the process working! So began a long research project to develop new, high efficiency ultrasonic equipment to make the idea work.

The first change was the transducer: Metal-forming applications had traditionally used magneto-strictive transducers to generate the ultrasonic vibrations. These use coils of wire around a laminated core, like an electrical transformer - they are robust but very inefficient. Using piezo-electric transducers borrowed from the plastic-welding industry, the vibration amplitude under load was increased by about 300%! Using titanium or aluminium alloys for the bulk of the die further improved the efficiency of the system so that while not under load the power drawn was less than 100W.

The improved efficiency highlighted existing problems with the ultrasonic dies - the desired mode of vibration was a uniform radial expansion and contraction of the die, but the reality was often very different. Several unwanted modes of vibration were identified and the die design was improved to eliminate them.

A further problem concerned the mounting of the ultrasonic equipment. If mounted on the booster flange, as is normal for plastic-welding systems, the die would deflect under the force of the metal-forming process, causing misalignment to the rest of the tooling. A new mounting system was designed, fitting directly to the back surface of the die. This provided rigid support against the forming forces but, thanks to its design, still permitted the die to vibrate with hardly any resistance.

Two patents covering these developments were filed in 1988 and 1990, in the names of Chris Cheers and Paul Porucznik.

The final development of the new ultrasonic system was done as a collaborative research project with Loughborough University, sponsored by the Science and Engineering Research Council. Researchers Margaret Lucas and Mike Shellabear developed new methods of evaluating and analysing the vibrations, while Chris Cheers continued to optimise the designs using finite element analysis. All three were awarded PhDs on completion of their research. Thanks are due to supervisors Dr. John Tyrer (electronic speckle pattern interferometry) and Prof. Graham Chapman, now at De Montford University (modal and finite-element analysis).

The ultrasonic forming process finally went into production making small-diameter aerosol cans in a UK factory. One of its products ("Fleurs de Paris" parfum deospray can) won a silver in the 1997 Metal Packaging Manufacturers Association awards.

Other projects undertaken during and after the ultrasonic forming work included new machinery for manufacturing cans and ends, for applying caps to glass jars and improving the heat-processing of canned foods. A further six patents were filed for these developments, with Chris named as inventor along with various colleagues. His last role with Crown Cork was as team-leader of the Can-shaping team, creating the new manufacturing processes and machines needed to produce these special customised cans for customers such as Heineken and Coca Cola.

Chris left Crown Cork at the end of 1998, to pursue a new life in Australia as an independent consultant. Since the industrial use of ultrasonics in Australia is limited he now divides his time between ultrasonics consultancy for international clients and web design / internet programming work for (mainly) local clients. This site - powerultrasonics.com - is the first example of commercial web design, created in 1999 and finally receiving a much-needed update beginning August 2004.

Chris met Fiona McKenzie, an Australian clinical geneticist, in early 2002 and they were married at the end of 2003. They now live in a not-quite-finished house overlooking Lake Macquarie, about 1 hour north of Sydney.

The PowerUltrasonics web site is owned and operated by Chris Cheers. Your privacy is important to me. This page explains what I will do with the information you provide.

Information is collected on this site in several different ways:

Web forms

Web forms give you the option to enter information about yourself, your opinions and / or your business. On each page that includes a form you will see a statement that the information is either **confidential** or **for publication**, and a link to this page.

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I use IP addresses to analyze trends, administer the site, track users' movement, and gather broad demographic information for aggregate use. IP addresses are not linked to personally-identifiable information.

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If I decide to change this privacy policy, I will post those changes on the homepage so you are always aware of what information will be collected, how it will be used, and under what circumstances, if any, I will disclose it. If at any point I decide to use personally identifiable information in a manner different to that stated at the time it was collected, I will notify all users by way of an e-mail. Users will have a choice as to whether or not their information can be used in this different manner.

The structure of the web-site is designed to be really simple to navigate - there are six main subject areas, each with a number of pages (the image above indicates where you are). Sometimes there are sub-pages - in this case there are "Next" and "Previous" links at the bottom of each. If you have any problems, please contact me.

1. **index**

   PowerUltrasonics Home Page

   a. **improvements_vote**

      View and vote on proposals for powerultrasonics website

   b. **news0**

      Latest news of powerultrasonics site development

      i. **Newsletter August 2004**

         Power ultrasonics August 2004 newsletter

      ii. **Newsletter June 2001**

         Power ultrasonics June 2001 newsletter

      iii. **Newsletter July 2000**

         Power ultrasonics July 2000 newsletter

      iv. **Newsletter June 2000**

         Power ultrasonics June 2000 newsletter

v. **Newsletter April 2000**

Power ultrasonics April 2000 newsletter

vi. **Newsletter February 2000**

Power ultrasonics February 2000 newsletter

vii. **Old news (to Jan 2000)**

Power ultrasonics news page to Jan 2000

c. **SITEMAP**

Map of powerultrasonics web site

d. **privacy**

e. **about**

About Chris Cheers

2. **intro**

Power what?! A brief introduction to power ultrasonics

a. **ultrasonics_applications**

Industrial applications of power ultrasonics

i. **Sonochemistry**

Applying ultrasonics to chemical reactions is called sonochemistry. Dramatic changes in the rates and even the products of reactions can be achieved

ii. **Sintering**

Ultrasonic sintering offers improved density and uniformity in powder-metallurgy metals.

iii. **Sieving**

Ultrasonics increase sieving flow rates and help prevent blockages.

iv. **Plastic welding**

Ultrasonics can weld plastic parts rapidly, providing a strong joint without the need for solvents or adhesives.

A. **Sonotrodes**

Notes on designing and manufacturing plastic welding horns (sonotrodes)

B. **Monitoring**

Monitoring, quality-control and automated inspection in the ultrasonic plastic welding process

C. **Control**

Control and setup of ultrasonic plastic welding equipment

D. **Components**

Discussion of component and joint design for ultrasonic plastic welding?

E. **Compared to other processes**

Comparison of ultrasonic welding to other plastics joining methods

F. **Related methods**

Plastics joining methods related to ultrasonic welding

G. **Limitations**

Limitations of ultrasonic plastic welding

H. **Materials**

Discussion of suitability of different polymer materials ultrasonic welding

v. **Metal welding**

Ultrasonic metal-welding can weld different metals together without flux or special preparation.

vi. **Metal forming**

Ultrasonic metal-forming can improve many metal-forming processes, reducing friction and minimising pick-up

vii. **Machining**

Ultrasonic machining can improve surface finish in metal cutting processes, or shape hard materials by erosion.

viii. **Cutting**

Ultrasonic blades cut without any pressure, so soft materials can be cut without distortion.

ix. **Cleaning**

Ultrasonic cleaning uses cavitation to dislodge dirt and allow cleaning fluid to penetrate small crevices.

b. **ultrasonic_system**

Anatomy of an ultrasonic system

c. **basics0**

Ultrasonics basic concepts

c. **articles**

Power ultrasonics articles index

d. **books0**

Power ultrasonics books and publications

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Power ultrasonics applications - books and publications

ii. **Transducers and materials**

Power ultrasonics transducers and materials - books and publications

iii. **Physics and applications**

Power ultrasonics general books and publications

iv. **Sonochemistry**

Sonochemistry books and publications

e. **ultrasonic_forming_thesis**

Design and optimisation of an ultrasonic die system for forming metal cans.

i. **Chapter 6 - Results**

Design and optimisation of an ultrasonic die system for forming metal cans - Results

ii. **Chapter 1 - Introduction**

Design and optimisation of an ultrasonic die system for forming metal cans - Introduction

4. **suppliers**

Search for power ultrasonics suppliers

a. **supplier**

View supplier details (only available after search)

b. **register**

Register as user to add / modify supplier details

c. **add_supplier**

Add supplier details to the PowerUltrasonics database

5. **services**

Power ultrasonics client services

a. **consultancy**

PowerUltrasonics Consultancy Services

b. **advertising**

Banner Advertising on the PowerUltrasonics Web-site

c. **internet**

PowerUltrasonics Internet Services

6. **questions**

Questions about power ultrasonics

a. **feedback**

Contact powerultrasonics

b. **bulletin_board_intro**

Introduction to bulletin boards (discussion forum)

c. **yabb**

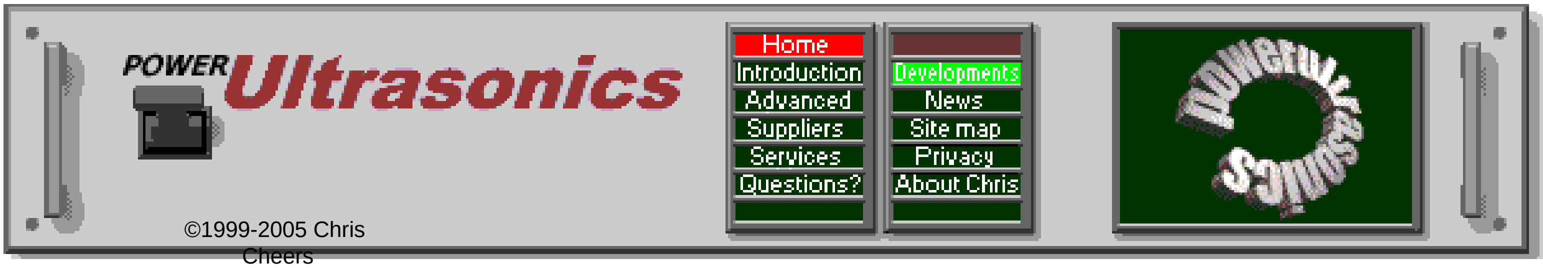
Power ultrasonics discussion board / forum

LATEST NEWS (August 6, 2004)

After 3 years doing other things I've finally got back to work on the PowerUltrasonics site, starting with improvements to the ultrasonics suppliers database. More details on the latest newsletter.

These news pages are based on the e-mail newsletter sent out to subscribers. If you want to receive these newsletters in future (at irregular and probably infrequent intervals!) just send a blank e-mail to subscribe@powerultrasonics.com. You can remove yourself from the mailing list at any time by e-mailing unsubscribe@powerultrasonics.com.

If you previously subscribed but your e-mail address has changed, or you didn't receive the latest newsletter for any other reason, please follow the instructions above to subscribe again. Any duplicate addresses will be automatically removed.



To vote, select the radio buttons that best reflect your opinon of each development...

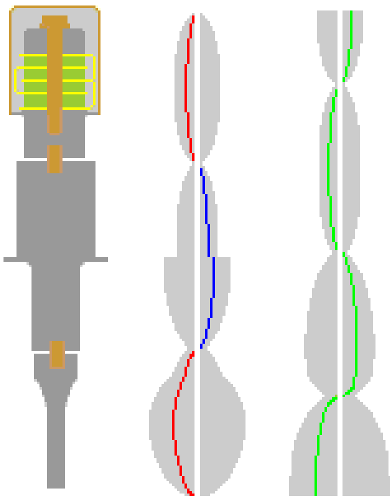
New developments planned for the powerultrasonics site:

	Don't do it!	Not important	Worth doing	Do it now!
Improved database of ultrasonics suppliers (done)				
New sexier style and graphics	○	◉	○	○
Updated books page with more listings and links to amazon.com as well as Barnes and Noble	○	◉	○	○
Advertising links based on suppliers database	○	◉	○	○
Complete version of my thesis available for download (probably in pdf form)	○	◉	○	○
Technical article links in a searchable database	○	◉	○	○
More links to technical articles	○	◉	○	○
More basic information on existing applications and processes	○	◉	○	○
More Flash animations of industrial ultrasonic processes (like the metal welding and plastic welding movies)	○	◉	○	○
Detailed FAQ page based on ultrasonics questions received over the past 4 years	○	◉	○	○
Online calculator for sound velocity, resonant frequency, sonotrode length etc. (initial version done - here - vote for developments if interested)	○	◉	○	○
Public forum for technical questions and responses from industry representatives (now up and running here, thanks to the good folks at YaBB)				
Improved and updated guest book (done, and I suspect made redundant by the forum above!)				

Any other suggestions or comments? (optional):

Thanks for your time - now click 'Vote' to confirm.

Vote



ULTRASOUND CONCEPTS

Sound waves are mechanical vibrations in a solid or fluid. Ultrasound is the same, but at a frequency higher than the range audible to humans - the lowest ultrasonic frequency is normally taken as 20 kHz (20,000 cycles per second). The top end of the frequency range is limited only by the ability to generate the signals - frequencies in the gigahertz range (upwards of 1 billion cycles per second) have been used.

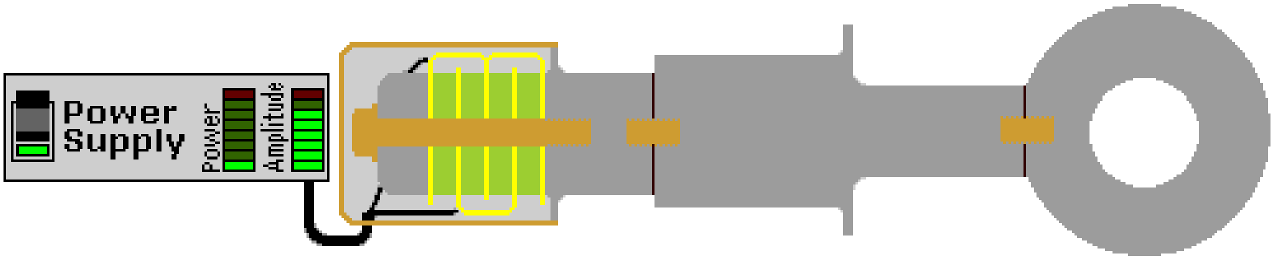
Ultrasound has been used for a huge variety of applications, but for convenience I propose to divide these into two broad categories: low- and high-power ultrasound. Low power applications include medical imaging (e.g. scanning the unborn foetus) and non-destructive testing (e.g. regular crack-testing for aircraft structures). Notice that in both of these cases it's kind of important that **the ultrasound doesn't have any significant effect on the subject of the scan...** By contrast in the high power uses (described on the applications page) we are using ultrasound because it **does have some effect**. This site, as the name implies, is all about the power ultrasonics applications. I'll come to the effects shortly, but first let's look at some figures.

High power applications tend to use frequencies at the low end of the spectrum (i.e. from 20 kHz to about 100 kHz). This is because the power available is limited by mechanical stress in the vibrating parts (more about this later). Conversely higher frequencies (and square waves or step functions that include high frequency harmonics) tend to be used in measuring applications because the shorter wavelength offers greater accuracy, and at low power mechanical stress is not a problem.

To maximise the effects, high power applications often use as much amplitude as possible - in practical terms you turn the amplitude up until something breaks, or you run out of power! Typical amplitudes range from about 5 to 50 microns (that's 0.005 to 0.05 mm, or 0.0002 to 0.002 inches). It doesn't sound like much however you measure it, but think about this: **An ultrasonic system operating at 20 kHz and 50 microns is moving with a cyclic acceleration of 80,000 g** (eighty-thousand times the force of gravity). Can anything else on earth match that?

One minor point about amplitudes: There's a convention within the ultrasonics industry to quote amplitudes in "peak-to-peak" terms. This gives a figure of twice the amplitude as it would be defined by engineers, physicists and indeed the rest of the world (i.e. mid-point to peak). On the assumption that most people reading these pages will not be ultrasonics specialists I'm using the true amplitude here - if you feel the need for a peak-to-peak figure then double it!

To keep up all this frantic movement you have to supply some power (but surprisingly little in well-designed equipment). Typical power supplies have maximum outputs ranging from a few hundred watts to several kilowatts, but almost invariably have an automatic regulation system which supplies just enough power to maintain the vibrations at the specified amplitude. This is often called "power by demand".



Mouse-over the diagram above for descriptions of the parts.

Power ultrasonics are used in many diverse industrial processes. This is a short list of the most popular applications, and some more unusual ones I happen to have come across. I would like to widen it to include as many others as possible, so if you are using ultrasonics for something else, why not tell me (and the world) about it. Anyone kind enough to supply me with suitable words or pictures will receive a brief acknowledgement on the page and a link to their entry on the suppliers page. If you can help, please let me know via the discussion board or contact page, as you prefer.

Alternatively, if you think your process would benefit from the application of ultrasonics why not contact me - I would be delighted to discuss it in confidence.

Calculate sound velocity, resonant frequency and dimensions of tuned parts for a range of power ultrasonics components and sonotrodes. Sonotrode analysis example (or click File -> Examples -> Length Ti Sonotrode)

File Analysis Materials Shapes Calculate Animation Help

Analysis: Not defined
Material: Not defined
Shape: Not defined
Inputs:
Results:
Please select analysis / material / shape
Unit conversion:

This first version analyses axial-mode vibrations of straight rods and stepped sonotrodes. Radial and torsional mode analyses are planned for future releases. Please let me know if you have a particular interest or need for one of the options not yet set up.

Note: The calculator uses SVG (Scalable Vector Graphics). When you first load this page you should see a simple text animation above; this will be replaced during calculations with a scale drawing of the sonotrode and graphs of stress and amplitude. If you don't see the animation your browser doesn't fully support the SVG code used.

Recent versions of Firefox and Mozilla browsers include a built-in SVG engine that doesn't support animation - to view animated images in these browsers you need to disable the built-in SVG and use the Adobe plug-in as before - more info.

Users of Microsoft Internet Explorer should download and install the latest plugin from Adobe. See the help page for more information.

New 14 October: If you find the graphics too small you can also view the same sonotrode calculator alone on the page (at least 800 x 600 resolution recommended).

This message is sent only to people who have requested it (and rarely even to them!). If you don't wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

The message above seems particularly true since the previous newsletter went out in June 2001! Since then I've been so tied up with trivia (earning a living, building a house, meeting my soul mate, getting married, in fact generally getting a life!) that the important job of maintaining this web site has been sadly neglected...

Seriously though, despite my neglect the site has continued to grow in popularity and many new people have signed up for the mailing list so I've decided to make an effort to improve it. Thank you for your patience and support!

~~~~~~~~~~~~~~~~ SUPPLIERS DATABASE UPDATED ~~~~~~~~~~~~~~~~~~

The first visible change is to the ultrasonics suppliers database, which is now implemented using a much more robust MySQL database for improved searching and easier updating. A new "simple search" looks for a keyword anywhere in the supplier information, and initial search results are now shown as a list of business names and descriptions with links to the full details.

So the description text is an important factor influencing visitors in their choice of which suppliers to investigate further. But since this field had no direct counterpart in the old database I've just used business name and country for the initial descriptions. **I'd strongly recommend to all suppliers that you update your entry now to provide a more interesting and informative description**. The new description field is limited to 255 characters, but there's also another free-form field you can use for extra information, keywords or notes. (I'm not sure yet what this will be limited to - probably 1000 to 2000 characters).

To add a new ultrasonics supplier to the database you must first register for a login name and password. Then follow the prompts.
~~~~~~~~~~~~~~~~

Existing ultrasonics suppliers wishing to update their details should start by finding their entry - start by searching the database for your company name, then click on the name to take you to the details page, and from there click the link "Edit this record" and follow the prompts.

You will also need to register again, but if you can use the same e-mail address as before then you will be allowed to change your record as you see fit. If not you'll be prompted to create a new record based on the existing one, and I'll delete the old record once I'm satisfied that you really represent the company concerned.

Entry in the ultrasonics suppliers database remains free of charge to relevant businesses and organisations.

~~~~~ HAVE YOUR SAY ON OTHER CHANGES TO THE SITE ~~~~~~~

Here are some of the other developments I have in mind for the powerultrasonics site:

- New sexier style and graphics
- Updated books page with more listings and links to amazon.com as well as Barnes and Noble
- Advertising links based on suppliers database
- Complete version of my thesis available for download (probably in pdf form)
- Technical article links in a searchable database
- More links to technical articles
- More basic information on existing applications and processes
- More Flash animations of industrial ultrasonic processes (like the metal welding and plastic welding movies)
- Detailed FAQ page based on ultrasonics questions received over the past 4 years
- Online calculator for sound velocity, resonant frequency, sonotrode length etc.
- Public forum for technical questions and responses from industry representatives
- Improved and updated guest book
- Other improvements may well come to mind, perhaps from your suggestions. I'll try to keep the voting form up to date with the latest list.

At current rate of progress it will take months or years before all of these are in place so please tell me what you think is most important: online voting form.

~~~~~~~~~~~~ POWERULTRASONICS CONTACT DETAILS ~~~~~~~~~~~~~~

Just a small change to the address (the Post Office boxes have been renumbered):
Chris Cheers
PO Box 7117, Mannering Park, NSW 2259, Australia.
Phone / fax +61 (0)2 4359 3801
Mobile +61 (0)408 676255

~~~~~~

That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

If you wish to stop receiving these messages just send an e-mail to unsubscribe@powerultrasonics.com, from the e-mail account to which this message was sent. To start receiving these messages at another e-mail address, send an e-mail from the new account to subscribe@powerultrasonics.com, If you have any problems with the automatic system please e-mail me directly at chris@powerultrasonics.com.
~~~~~~

POWER Ultrasonics

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Discussions

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Powerultrasonics Forum

Forum name	Last post	Topics	Posts
General			
News Read about the latest changes on the powerultrasonics site! *Moderator: Chris*	28.02.2006 at 13:19:53 **In:** Forum upgrade **By:** Chris	3	3
Questions Any questions about ultrasonics technology and equipment? *Moderator: Chris*	07.08.2006 at 20:31:40 **In:** Re: Far Field weld **By:** Myles	23	63
New applications Suggestions for new applications of power ultrasonics. How can I apply ultrasonics to.... *Moderator: Chris*	09.06.2006 at 10:21:35 **In:** (spam deleted) **By:** gill - *Ex Member*	7	29

	Sonotrode calculator Questions about the sonotrode calculator, and suggestions for improvements *Moderator: Chris*	11.12.2004 at 18:35:55 **In:** Diameter ratio too large **By:** Chris	4	12
	Board rules Rules for registered users and guests *Moderator: Chris*	12.10.2004 at 22:06:07 **In:** Starting up **By:** Chris	1	1

New Posts

No New Posts

Info Center

Forum Statistics

Our users have made **108 Posts** within **38 Topics**. The most recent post is **Re: Far Field weld** (07.08.2006 at 20:31:40). View the 10 most recent posts of this forum.

We have **223** registered members. The newest member is **suven**.

	Most Users ever online was **7** on 10.07.2006 at 22:52:13 Most Members ever online was **2** on 24.07.2006 at 14:52:11 Most Guests ever online was **7** on 10.07.2006 at 22:52:13

Users online

	Members: **0** Guests: **2** ||||| YaBB Administrator ||||| Global Moderator

Login

Username: Password: Logged in for: Keeps

Login Forgot password?

Powerultrasonics Forum » YaBB 2 powered!

On this page I am collecting a series of links to technical articles that will interest users and suppliers of ultrasonic equipment, as well as researchers. Practical industrial applications are just as welcome as cutting-edge high-tech research.

If you know of a relevant article or technical paper that is available from the web I would be happy to provide a review and a link on this page. Suitable subjects would be equipment and applications of high-power ultrasonics, either new research or technology reviews, that would be of interest to power-ultrasonics users.

As of August 2004 I now have hundreds of good links awaiting reviews... If you'd like to see them on this page please give me some encouragement and direction by selecting your field of interest from this list!

I am interested in articles about:

Select your area of intere Vote

Note - this system is designed to accept up to 3 different votes in one session from any individual (identified by their IP address). Results are updated in real time. Please select the subject(s) that interest you most and click 'Vote'.

Votes cast on "Request for articles on powerultrasonics web site".

Cleaning	14% (53 votes)
Ultrasonics for beginners	13% (50 votes)
Plastic welding	10% (41 votes)
Very high power ultrasonics	10% (39 votes)
New applications	7% (30 votes)
Machining	7% (27 votes)

Date range: 18th August to 16th September

Alternatively, if you have written a relevant article that's not yet published on the web I will consider it for publication on this site, if necessary scanning paper documents and / or converting files from other formats for you free of charge. (Of course, in this case it must be highly relevant!).

To suggest a link to an existing on-line article please use the discussion forum, but if you have an article to send to me please see the contact page.

Ultrasonic cleaning in supercritical liquid CO_2

Miodrag Prokic et al (View)
M. P. Interconsulting

23 June 2001 Using liquid carbon dioxide as a cleaning solvent offers some great environmental advantages. Compared to conventional chlorinated solvents and detergents it is very clean, with no harmful emissions. Separating the liquid from the dissolved contaminants is easy - just reduce the pressure and allow the CO_2 to boil off (after which it can be trapped and recycled).

However the pressure required to maintain CO_2 in liquid form (>60 bar) does present some challenges for ultrasonic tank design... Using a novel multifrequency actuator made it possible to generate ultrasonic vibrations in an autoclave with very thick walls.

This paper, written for the 2001 UIA conference by Miodrag and fellow researchers from ECO_2 SA, a Swiss company specialising in supercritical fluid technology, describes the equipment they developed and results obtained.

Design and optimisation of an ultrasonic die system for forming metal cans. Chapter 6 - Results.

Chris Cheers (View)
Power Ultrasonics (Australia)

23 June 2001 At long last, another chapter from my PhD thesis converted to HTML. All measured results are shown, including modes and frequencies (comparing finite element predictions with actual results), ESPI (electronic speckle pattern interferometry) evaluation and force measurements with and without ultrasonics.

Ultrasonic Motor Development

(View)

12 Aug 2004 (Now updated with a new link to NASA Telerobotics Program Plan, since the old page has been removed.)

An interesting page about research at MIT to develop a high torque-density solid-state actuator for use in the NASA/JPL Mars Micro Lander manipulator arm. It includes a general explanation of the principles of ultrasonic motors, and some cool animations! Note the use of dynamic and time-averaged ESPI (electronic speckle pattern interferometry) to evaluate the vibration modes.

Canon Ultrasonic Motors (USMs)

(View)

12 Aug 2004 (Link updated August 2004)

Canon's brief description of their development of ultrasonic motors for use in camera auto-focus lenses. Their explanation of the arrangement of piezoelectric elements is particularly good. There are two sets of elements, offset by a quarter-wavelength, each generating a standing wave. Superimposing the offset standing waves creates a travelling wave that drives the rotor.

Sonocrystallizer (TM)

AEA Technology (View)

12 Aug 2004 (Link updated August 2004)

The AEA Technology Sonocrystallizer (TM) is a new reactor which produces better crystals for the pharmaceutical and bio-tech industries. For more details see the July 2000 newsletter.

Ultrasonic Washing of Textiles

Fraunhofer Technology Center / Institute of Acoustic, Madrid. (View)

12 Aug 2004 (Link updated August 2004)

Ultrasonic cleaning, normally used in industrial applications, may now be applied to fabric cleaning in both domestic and commercial washing systems, according to FTech. This brief article discusses the process and potential advantages: significant savings of energy and water usage.

Magneto-strictive transducers are back!

Chris Cheers

19 Apr 2000 Not an article as such, but hopefully of interest to readers...

Since the early 1980's, piezo-electric transducers have dominated the power ultrasonics industry. After some early reliability problems (cured largely by improvements to the electronic control systems used to drive them) they have now almost completely replaced the old inefficient laminated nickel alloy transducers wrapped in coils of PTFE insulated wire (the heat generated would melt conventional plastic insulation!).

ETREMA plans to change all that, with their new ultrasonic transducers based on Terfenol D®.

This is a special magneto-strictive iron alloy which tolerates high strains. It has been available for many years but only from laboratory-scale production. Now full production brings larger sizes and much better pricing, plus laminated blocks to reduce eddy-current losses in high frequency systems. Their new 20 kHz, 6kW transducer handles more power than any other ultrasonic transducer I know, and they are promising something much bigger in the near future...

Watch this space!

Update August 2004 (still watching)

Four years later both pages I originally linked to have disappeared. Instead Etrema now offer a system called MaXonics, delivering 3kW in continuous operation. I have to say it's a bit disappointing...

Piezoceramic Tutorial

	PIEZO SYSTEMS, INC.	(View)
19 Apr 2000	And in order to maintain a strict sense of balance... this is an excellent tutorial on the piezo-electric effect, provided by Piezo Systems, Inc..	

Theory of ultrasonic metal welding

	American Technology (AmTech) Inc.	(View)
12 Aug 2004	(Link updated August 2004) The subject of metal welding seems to attract high-quality articles from equipment suppliers. While not as comprehensive as Stapla's book, this article from AmTech gives a good introduction to the theory and practice of welding metals, aimed particularly at wire-joining applications.	

Creating Sonoluminescence

	Hiroshi	(View)
12 Aug 2004	(Link updated August 2004) Ultrasound in liquids creates cavitation bubbles, which as they collapse can generate immense temperatures and pressures, and brief faint flashes of light - called sonoluminescence. It's a strange phenomenon, not yet fully understood but very reproducible. This article gives a clear account of the equipment required to generate and study sonoluminescence - a surprisingly simple set up suitable for a high-school laboratory.	

Power ultrasonics improve food quality - Reducing the degree of processing of heat-preserved foods using power ultrasound.

	Campden & Chorleywood Food Research Association	(View)

10 Jan 2000 The CCFRA is a food-industry funded research organisation in the UK. This is the March 1999 newsletter (I found it rather late but I still think it's worth a look!) in which they describe results of early trials using ultrasonics to speed up food processing. Most of their results are available only to subscribers.

Power ultrasonic equipment for sonochemistry research.

John Perkins (View)
Sonic Systems (UK)

12 August 2004 (Link updated August 2004)

John has vast experience in power ultrasonics. Here he starts with the basics, covering the design and construction of piezo sandwich transducers and sonotrodes, before giving a detailed description of sonochemistry principles - cavitation, energy-density, monitoring power and amplitude. The article concludes with a discussion of safety precautions and scaling-up the equipment to full production. It is aimed primarily at the chemist who wants to evaluate the use of sonochemistry techniques, but is also excellent reference material for anyone with an interest in power ultrasonics.

Ultrasonic Metal Welding - Principles and applications of high-grade bonding technology.

Stapla Ultrasonics (USA) (View / download)
Stapla Ultraschall-Technik (Germany)

22 Sept 1999 Stapla's comprehensive textbook of ultrasonic metal welding technology, available on-line or as a free download. Includes an overview of ultrasonic technology, equipment setup, quality-control techniques, materials and component sizes suitable for welding by this method. Essential reading!

Design and optimisation of an ultrasonic die system for forming metal cans. Part 1 - Introduction.

Chris Cheers (View)
Power Ultrasonics (Australia)

29 Sept 1999	My PhD research was all about making steel aerosol cans the same shape as the existing aluminium ones. This is surprisingly difficult, since the steel cans are much less formable, a consequence of their higher yield strength and thinner walls. Using ultrasonic dies solved the problem, reducing forming forces to make the process possible.

Books on the theory and applications of power ultrasonics are fairly rare - I believe this selection, offered in connection with **barnesandnoble.com** is the best available today. For full details of any book listed, just click on the title. Alternatively click on the author's name for a full list of his / her works.

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If you find other books in print which you think should be on these pages please place a message on the discussion board giving as much information as you can (particularly the ISBN number if at all possible). Please note that I have specifically excluded books on medical (scanning) ultrasound and non-destructive testing to concentrate on the main subject of this site.

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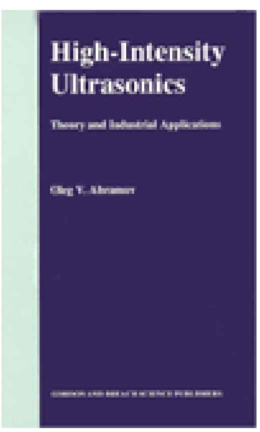
Sonochemistry
PHYSICS AND APPLICATIONS
Transducers and materials
Industrial applications

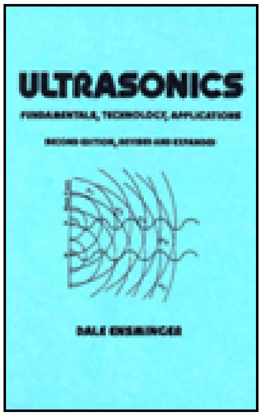
Books on the theory and applications of power ultrasonics are fairly rare - I believe this selection, offered in connection with **barnesandnoble.com** is the best available today. For full details of any book listed, just click on the title. Alternatively click on the author's name for a full list of his / her works.

ISBN: 2881246842
Title: Fundamental Physics of Ultrasound
Author: Vladimir Aleksandrovich Shutilov
Publisher: Gordon & Breach Publishing Group
Date Published: January 1988
Format: Cloth Text



ISBN: 9056990411
Title: High-Intensity Ultrasonics: Theory and Industrial Applications
Author: Oleg V. Abramov
Publisher: Gordon & Breach Publishing Group
Date Published: January 1998
Format: Trade Cloth

"...an invaluable source of information, largely unavailable in the West until now...comprehensive coverage of theory and physics...also discusses a wide range of problems associated with the industrial applications of ultrasound."



ISBN: 0824776593
Title: Ultrasonics: Fundamentals, Technology, Applications
Author: Dale Ensminger
Publisher: Marcel Dekker
Date Published: January 1988
Format: Cloth Text

ISBN: 0750302453
Title: Developments in Acoustics and Ultrasonics
Author: M. J. Povey
Publisher: Iop Pub
Date Published: January 1992
Format: Trade Paper

ISBN: 012756960X
Title: Ultrasound: Biological Effects and Potential Hazards
Author: A. Roy Williams
Publisher: Academic Press, Incorporated
Date Published: January 1983
Format: Cloth Text

Sonochemistry
PHYSICS AND APPLICATIONS
Transducers and materials
Industrial applications

If you find other books in print which you think should be on these pages please place a message on the discussion board giving as much information as you can (particularly the ISBN number if at all possible). Please note that I have specifically excluded books on medical (scanning) ultrasound and non-destructive testing to concentrate on the main subject of this site.

SONOCHEMISTRY
Physics and applications
Transducers and materials
Industrial applications

Books on the theory and applications of power ultrasonics are fairly rare - I believe this selection, offered in connection with **barnesandnoble.com** is the best available today. For full details of any book listed, just click on the title. Alternatively click on the author's name for a full list of his / her works.

ISBN: 0-306-46141-2
Title: Cavitation Reaction Engineering
Authors: Yatish T. Shah, A. B. Pandit, V. S. Moholkar
Publisher: Kluwer Academic/Plenum Publishers
Date Published: September 1999
Format: Hardcover

ISBN: 0751404292
Title: Ultrasound in Food Processing
Author: M. Povey (Editor), T. Mason (Editor)
Publisher: Routledge
Date Published: September 1999
Format: Trade Cloth

ISBN: 0851862934
Title: Sonochemistry: The Uses of Ultrasound in Chemistry
Author: T. J. Mason (Editor)
Publisher: CRC Press, Inc.
Date Published: June 1990
Format: Trade Cloth

ISBN: 0198503717
Title: _ Sonochemistry
Author: Timothy J. Mason
Publisher: Oxford University Press, Incorporated
Date Published: October 1999
Format: Paper Text

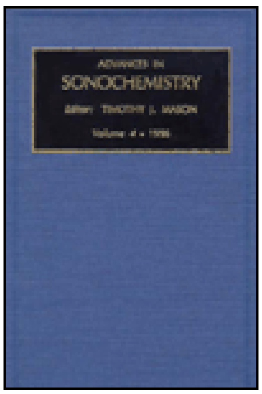
ISBN: 0306459167
Title: _ Synthetic Organic Sonochemistry
Author: Jean-Louis Luche, Claudia Bianchi
Publisher: Plenum Publishing Corporation
Date Published: January 1998
Format: Trade Cloth

ISBN: 0792355490
Title: _ Sonochemistry and Sonoluminescence
Author: Kenneth S. Suslick, Lawrence A. Crum (Editor), Timothy J. Mason (Editor), Jacques L. Reisse (Editor)
Publisher: Kluwer Academic Publishers
Date Published: March 1999
Format: Trade Cloth

ISBN: 076230331X
Title: _ Advances in Sonochemistry
Author: Timothy J. Mason (Editor)
Publisher: Jai Pr., Inc.
Date Published: September 1998
Format: Trade Cloth

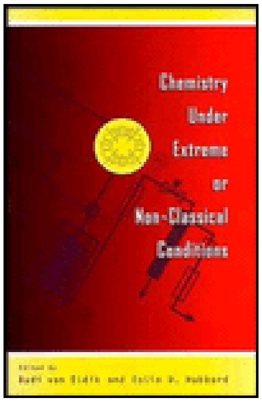
ISBN: 1559381787
Title: Advances in Sonochemistry
Author: Timothy J. Mason (Editor)
Publisher: Jai Pr., Inc.
Date Published: July 1990
Format: Trade Cloth

ISBN: 1559382678
Title: Advances in Sonochemistry
Author: Timothy J. Mason
Publisher: Jai Pr., Inc.
Date Published: November 1991
Format: Trade Cloth



ISBN: 1559387939
Title: Advances in Sonochemistry
Author: Timothy J. Mason (Editor)
Publisher: Jai Pr., Inc.
Date Published: September 1996
Format: Trade Cloth

ISBN: 155938476X
Title: Advances in Sonochemistry
Author: Timothy J. Mason (Editor)
Publisher: Jai Pr., Inc.
Date Published: January 1993
Format: Trade Cloth



ISBN: 0471165611
Title: Chemistry under Extreme and Non-Classical Conditions
Author: Rudi Van Eldik (Editor), Collin D. Hubbard (Editor)
Publisher: Wiley, John & Sons, Incorporated
Date Published: November 1996
Format: Trade Cloth

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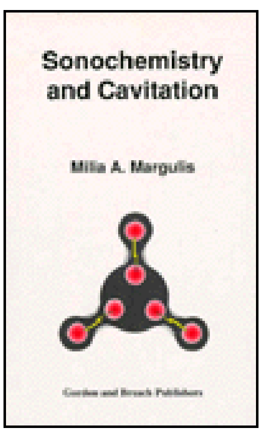

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Author: Timothy J. Mason, Phillip J. Lorimer
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ISBN: 0387510230
Title: Ultrasound in Synthesis
Author: Steven V. Ley, Caroline M. R. Low
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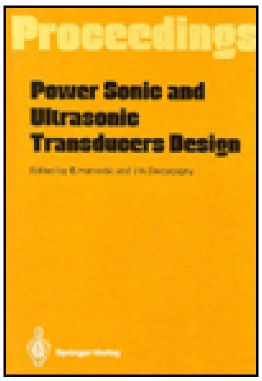

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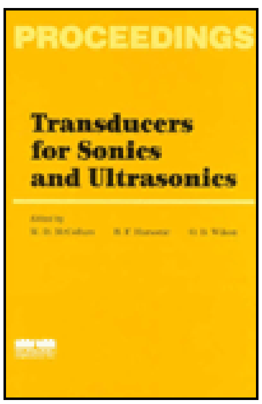
Publisher: Springer-Verlag New York, Incorporated
Date Published: March 1988
Format: Trade Cloth



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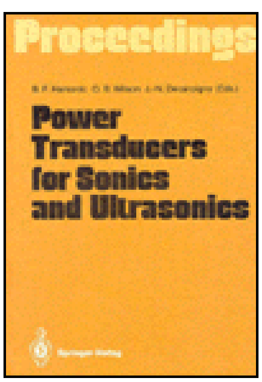
Publisher: Technomic Publishing Company
Date Published: January 1993
Format: Cloth Text



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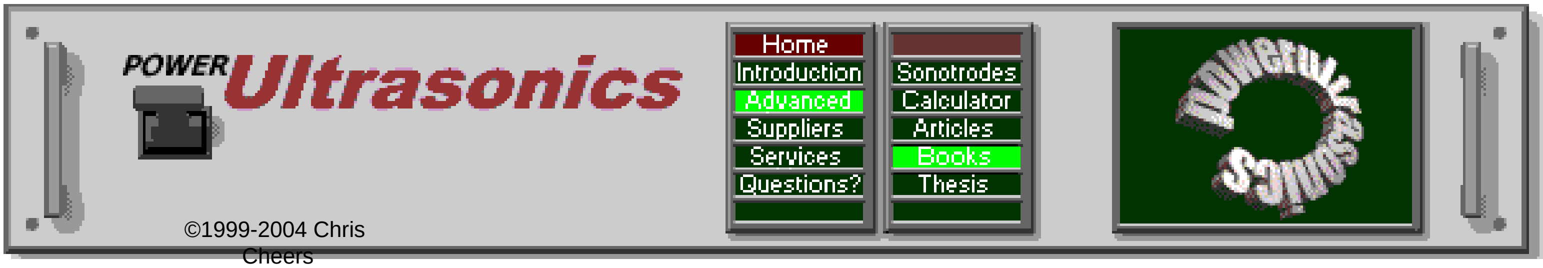

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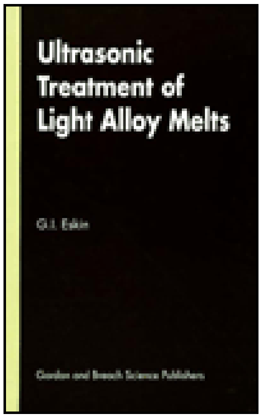
ISBN: n/a
Title: Understanding Ultrasonic Plastics Assembly
Author: Vinoo Kumar
Publisher: Nevik Sales & Services, Mumbai 400 098, India.
Date Published: December 1998
Format: A4 Soft cover, 118 pages with photos and diagrams.

Mr Vinoo Kumar is a Mechanical Engineer with almost 20 years experience in ultrasonic plastic welding. He makes good use of that experience to produce this highly-detailed yet accessible book, which is published privately by his own company. For the newcomer he covers the basic principles, systems specification and safety without assuming any prior knowledge, and there is also a useful glossary. The main subject of the book, plastic welding, is covered in great detail - including materials selection, joint design, equipment selection, tooling design and a comprehensive troubleshooting guide. An excellent introduction to the subject.



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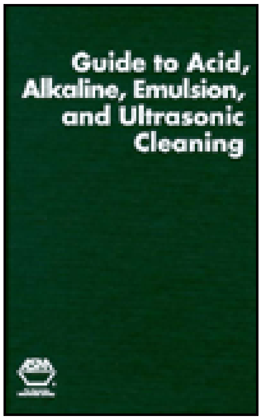

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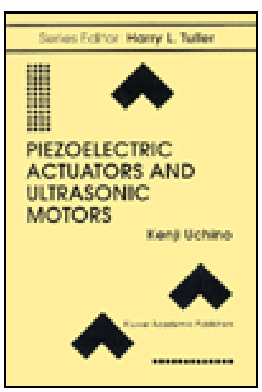

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Author: Kenji Uchino
Publisher: Kluwer Academic Publishers
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9. Sonotrode manufacture

9.1 General

The sonotrode serves as a means of transmitting the vibratory energy from the transducer (converter) to the joint surface, and also usually as a transformer for the mechanical amplitude.

As already described under point 3.2.2 'Sonotrode', the design and manufacture of a sonotrode requires special attention. Incorrectly manufactured sonotrodes impair the welding quality and can lead to the destruction of the vibrational system and to considerable damage to the generator.

Sonotrodes are manufactured predominantly by the manufacturers of ultrasonic equipment.

If the parameters, required frequency, transformation or speed ratio and lateral dimensions (l_o/D) are adhered to, sonotrodes with maximum lateral dimensions of 60 mm at about 20 kHz or 30 mm at 40 kHz can be made by the user himself. It is preferable to begin with the manufacture of stepped sonotrodes (figure 47a).

The length (l_o) of the sonotrode normally corresponds to half a wavelength $\lambda/2$ (figure 47a). For special applications sonotrodes with lengths several times $\lambda/2$ or combined $\lambda/2$ sonotrodes are also manufactured (figure 48).

Sonotrodes which on account of large lateral dimensions require slots (figure 49) should under no circumstances be made by the user himself unless he has sufficient basic knowledge about the construction of sonotrodes.

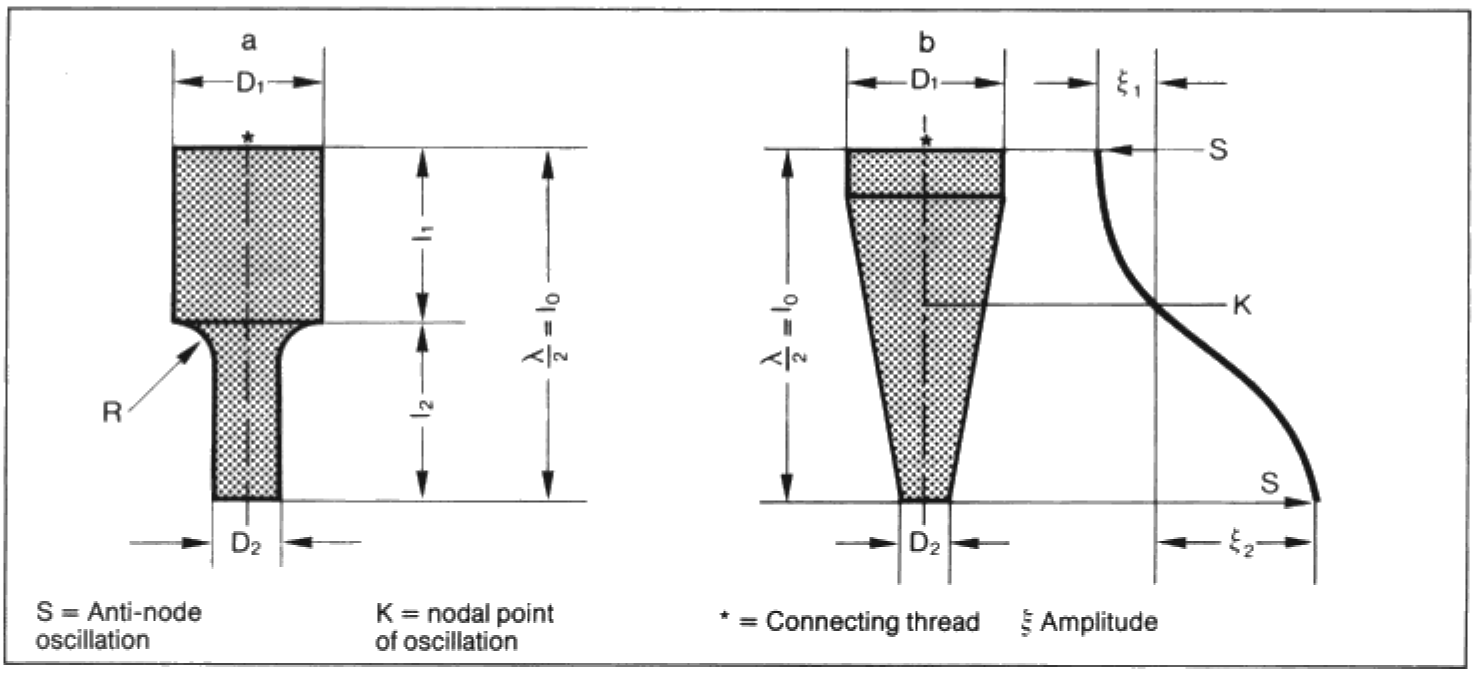
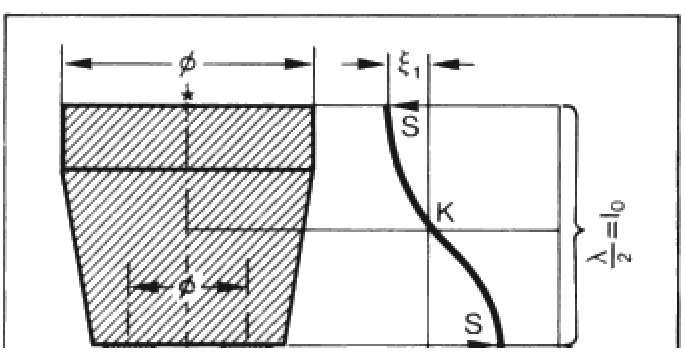


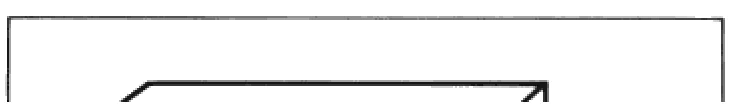
Figure 47: Sonotrode $\frac{\lambda}{2}$ = Standard version

a = stepped, b = conical

Cross-sectional variants:
Circle/circle Circle/rectangle Rectangle/rectangle

$\frac{\xi_2}{\xi_1}$ = Transformation ratio of the sonotrode





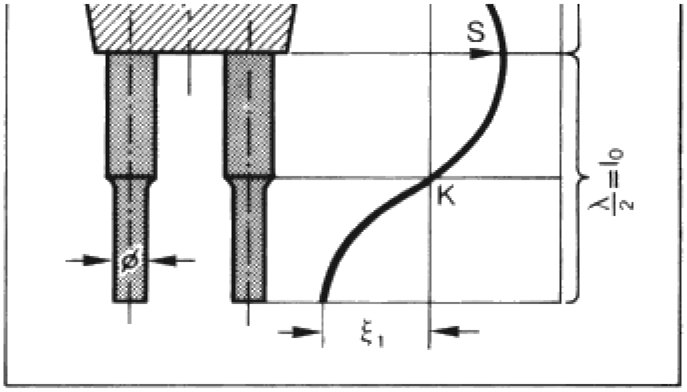


Figure 48: Assembled combined sonotrode $2 \times \frac{\lambda}{2}$

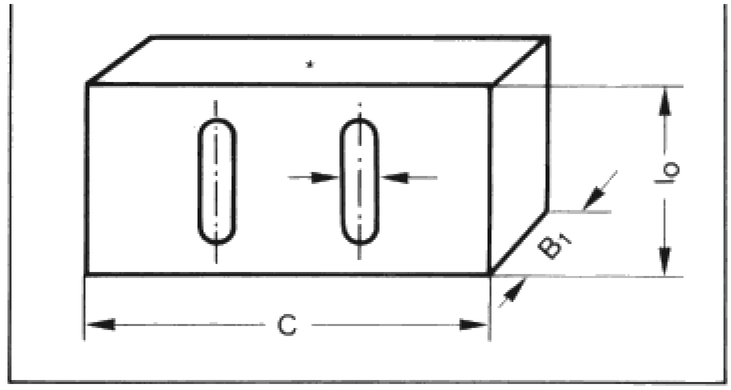


Figure 49: Sonotrode with rectangular form (with slots)

S = Anti-node oscillation
* = Connecting thread
K = Nodal point of oscillation
ξ = *Amplitude*

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Material	Amplitude μm Values adopted in practice
Polystyrol (PS)	15 to 30
Polystyrol impact strong (SB)	20 to 35
Acryl, butadiene-styrol (ABS)	20 to 30
Stryol-acryl nitrile (SAN)	15 to 30
Polymethyl methacrylate (PMMA) injection mould	20 to 35
Modified (PPO)	25 to 40
Polycarbonate (PC)	25 to 40
Polyacetyl resin (POM)	40 to 50
Polyamide (PA)	35 to 55
Polyethyl enterephtalate (PETP)	45 to 55
Polynuthyl enterephtalate (PBTB)	40 to 50
Cellulose derivatives	25 to 35
PVC hard	20 to 40
PVC soft	25 to 40
Polyethylene (PE)	25 to 60
Polypropylene (PP)	30 to 60

Table 3: Recommended values for the amplitude in ultrasonic welding in the near field. The amplitudes can differ with modified materials.

Material	Sound velocity $v_0 \left(\frac{m}{s}\right)$	Variations $\left(\frac{m}{s}\right)$
Titanium alloy TiAlV64	4900	± 100

9.2 Sonotrode materials

As very high amplitudes predominate in the welding of plastics and forming (Table 3), the stress load on the sonotrode is considerable. It means that only materials with a high alternating impact strength and low absorption can be used.

The alloys titanium (TiAlV64) and aluminium (AlCuMg2) have proved to be best. Both these alloys have great stability and with distortion-free operation can withstand a load up to 40 μm amplitude at 20 kHz. At higher frequencies lower amplitudes are employed.

The sound velocity of the following sonotrode materials can be seen in Table 4.

Titanium alloy TiAlV64:
Large series, with coating also suitable for glass fibre reinforced plastics.

Aluminium alloy AlCuMg2:
Large series, can likewise be coated.

AlCuMgPb:
Experimental sonotrodes, small series.

Monel:
Up to an amplitude of 20 μm hard metal plates or hard metal pins can be soldered in.

1550 steel tempered (RT 11):
Mainly for embedding metal parts in plastics.

Ferro-titanite:
Extremely non-abrasive, therefore particularly well-suited to the riveting of glass fibre reinforced plastics.

9.3 Shapes of sonotrode

Sonotrodes can be manufactured in various shapes and dimensions. In practice the following shapes have proved particularly reliable:

1. Stepped form with circular section (figure 47a)
2. Conical form with circular section (figure 47b)
3. Stepped form with square and rectangular section (figure 49)
4. Exponential form

9.4 Sonotrode parameters

Sound velocity	v
Wavelength/2 $= \frac{\lambda}{2}$	l_0
Frequency	f
Input diameter of the sonotrode with circular section (booster)	D_1
Output diameter of the sonotrode with circular section (to the moulding)	D_2

TiAlV64	4900	± 100
Aluminium alloys AlCuMg2	5100	± 100
AlCuMGPb	5000	± 100
Aluminium	5100	± 200
Monel annealed and quenched	4350	± 150
1550 steel (RT 11) tempered	5250	± 50
Ferrotitanite WFN hardened	6950	± 150

Table 4: Sound velocity of various sonotrode materials

Output diameter of the sonotrode with circular section (to the moulding)	D_2
Input surface of the sonotrode	A_1
Output surface of the sonotrode	A_2
Output diameter of the booster (Coupling surface to the sonotrode)	D_3
Output surface of the booster (Coupling surface to the sonotrode)	A_3
Output amplitude of the booster	ξ_3
Input amplitude of the sonotrode	ξ_1
Output amplitude of the sonotrode	ξ_2
Transformation or speed ratio	β

Christopher Francis Cheers M.A.

A doctoral thesis submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy of the Loughborough University of Technology

June 1995

(go to contents)

To my father

"It is an important and popular fact that things are not always as they seem. For instance, on the planet Earth, man had always assumed he was more intelligent than dolphins because he had achieved so much - the wheel, New York, wars and so on - whilst all the dolphins had ever done was muck about in the water having a good time. But conversely, the dolphins had always believed they were far more intelligent than man - for precisely the same reasons."

Douglas Adams
The Hitch Hiker's Guide to the Galaxy
1979

ABSTRACT

A new manufacturing process has been developed for reducing the diameter of one end of a tinplate can by over 30%. Conventional processes are limited to a maximum of 10% reduction and typically operate at less than 5%. The improvement was achieved by using special tooling and ultrasonic excitation of the die to reduce the forming force.

Ultrasonics have been used in this way before but without a full understanding of the numerous modes of vibration of the die, and how they interact, the efficiency of earlier systems was low. Finite element analysis has been used to characterize the natural modes and frequencies of radial-mode ultrasonic dies and this has led to the development of highly efficient systems. In special cases a non-round die has been required to overcome undesirable modal characteristics; optimum shapes have been developed. A completely new method of mounting the ultrasonic dies was designed and its geometry optimized (again using finite element analysis) to further improve the efficiency of the system.

The new system operates at an amplitude under load approximately three times greater than the earlier equipment. The reduction in forming force (between 30 and 60%) makes the difference between success and failure for the manufacturing process.

ACKNOWLEDGEMENTS

The work has been carried out at CarnaudMetalbox Technology, Wantage and in the department of Mechanical Engineering, Loughborough University of Technology between January 1987 and June 1995. The work was supervised by Professor Graham Chapman and Professor Mike Preston, and directed successively by Professor Jim Hewit, Professor Ray Vitols and Dr John Tyrer, whose support and advice have been much appreciated. The work was undertaken as part of a research project funded by the Science and Engineering Research Council and CarnaudMetalbox Technology.

The author would like to thank colleagues in the Optics group (Dr Mike Shellabear) and the Dynamics group (Dr Margaret Lucas) of the Mechanical Engineering Department for their help and advice during the course of the project. Thanks are also due to the management at CarnaudMetalbox (Fred Price, Bob Barr, Sid Nayar, Mike Alderson) for providing time, support and facilities for the work and during the long writing-up period. Thanks also to the library staff for finding many obscure references. Special thanks to Paul Porucznik for starting the whole project and for numerous stimulating discussions throughout.

Principles and results of ESPI analysis described in section 6.3, including figures 6.08 to 6.16 are reproduced courtesy of Dr John Tyrer and Dr Mike Shellabear.

CONTENTS

3. ULTRASONIC DIE DESIGN (not yet on-line)

4. SIMPLIFIED DIE DESIGN PROCEDURE (not yet on-line)

Chapter 1 - Introduction
Chapter 6 - Results

The following values should be indicated by the manufacturer of the instrument and strictly observed:

Sound frequency	f ± tolerance
Amplitude of the booster	ξ_3
Output surface or output diameter of the booster	A_3 or D_3

9.5 Determining the sound velocity

If the sound velocity of the sonotrode material is not known, it can be established with the measuring device (figure 50), the frequency of a 130 mm long sample without rolling scale or draw scale being measured. The sound velocity is obtained from the function

$$\boxed{v = 2 \cdot l \cdot f}$$

in which the function $l \geqslant 3 \cdot D$ must be fulfilled, as sound velocity depends upon shape.

By coordinating a cylinder with a diameter of about 40 mm made of the sonotrode material with the unknown sound velocity as given under section 9.9 the sound velocity and the resonance length can be established.

9.6 Determining the length of stepped sonotrodes

Stepped sonotrodes are made up of

$$\boxed{l_0 = l_1 + l_2}$$

(figure 47a).

The junction to the smaller cross-section is on the nodal plane. The junction should have a radius, as there is a danger here of cracks forming. With sonotrodes with maximum cross-sectional dimensions of 60 mm a R = 10 mm has been found to be satisfactory. The length l_0 can be calculated from the function for the simple cylindrical body:

$$l_0 = l_1 + l_2 = k_1 \cdot \frac{v}{4 \cdot f} + k_2 \cdot \frac{v}{4 \cdot f}$$

The correction factors k_1 and k_2 depend upon the give sonotrode cross-section.

Transformation ratio $\beta = \frac{A_1}{A_2} = \left(\frac{D_1}{D_2}\right)^2$

The sound velocity v can be seen from Table 4 and l_1 or l_2 in Table 5. To make it easier to coordinate sonotrodes by shortening their lengths, the established length of the sonotrode should be increased by 2-3 mm. With increasing practical experience and correct use of Table 5 this additional amount can be reduced or dispensed with.

9.7 Calculating the length of a rotationally symmetical sonotrode with an e-function

Exponential form

$$l_0 = \frac{v}{2 \cdot f} \times \sqrt{1 + \left(\frac{\ln D_1/D_2}{\pi}\right)^2}$$

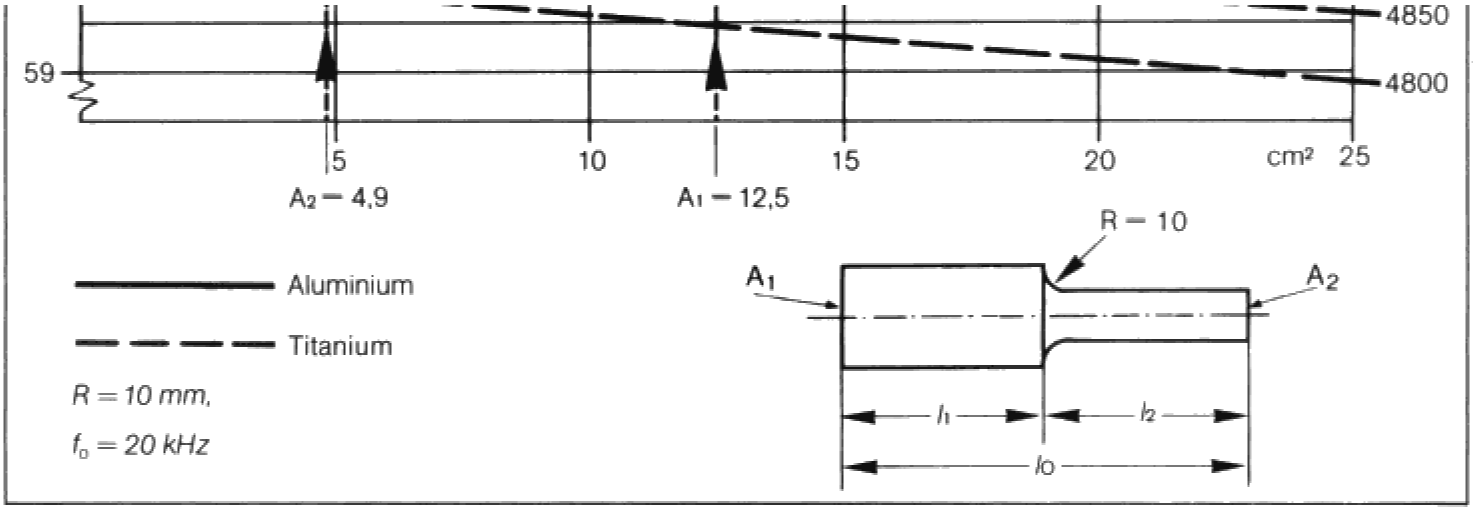

Table 5: Determining diagramatically l_1 and l_2 with stepped sonotrodes.

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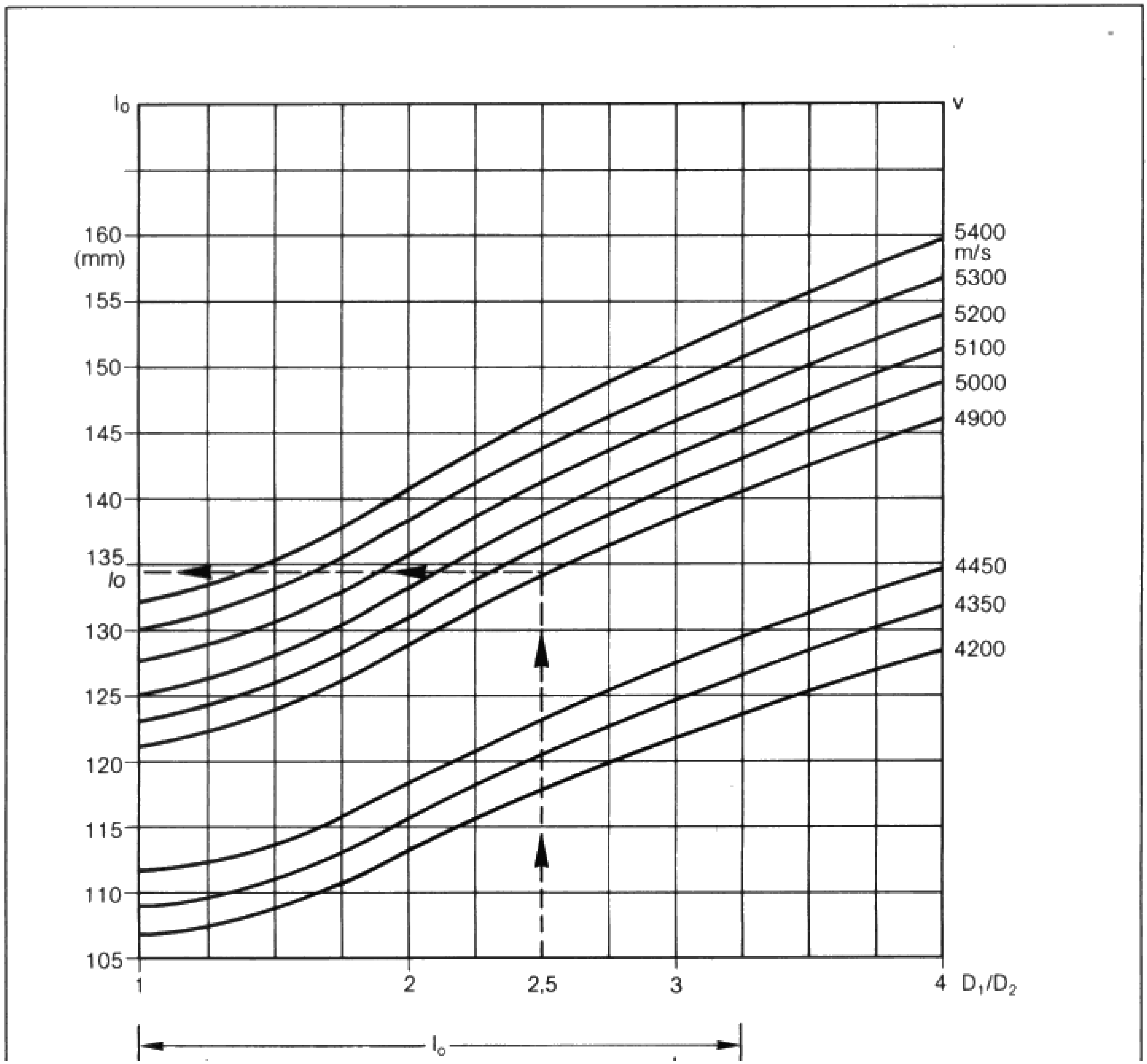
The e-function sonotrode is very good in terms of sound, but expensive to manufacture and is therefore only used to a small extent, especially as most sonotrodes are used in practive with a speed ratio smaller than 1 : 4.

Transformation ratio $\beta = \sqrt{\frac{A_1}{A_2}} = \frac{D_1}{D_2}$

9.8 Establishing the length of a conically shaped sonotrode with rotationally symmetrical and rectangular cross-section

The conical sonotrode is the most difficult to calculate of the three shapes mentioned. In practice, therefore, the function of the exponential sonotrode is generally used and multiplied by a safety factor of 1.1. Table 6 makes it possible to determine the length of the cone for different sound velocities with diametrical ratios up to 1 : 4 in the case of sonotrodes



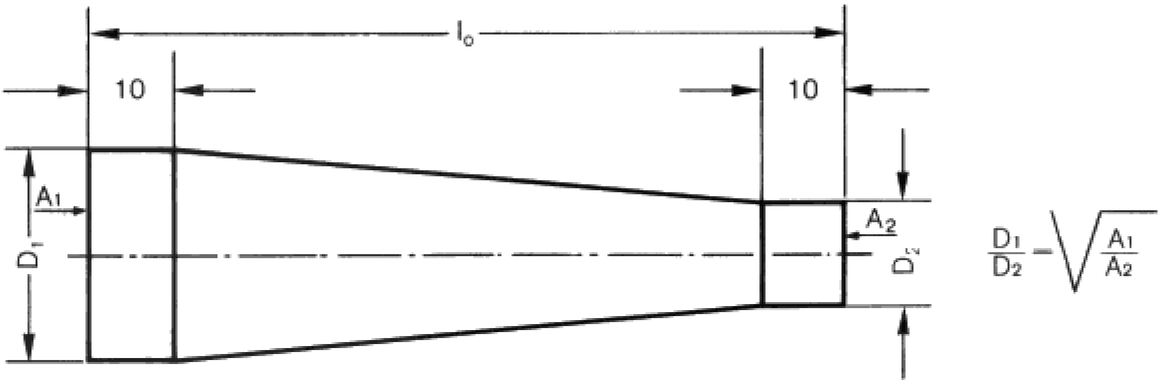


Table 6: Diagram for establishing the length of conical sonotrodes depending upon diameter ratio and sound velocity f = 20.0 khz. The above formula applies to designs with rectangular cross-sections. Insertion thread M16 x 1.5; depth of thread 15 mm. It is necessary to have additional length of 3 mm for checking.

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Reproduced with permission of the German Electrical Manufacturers Association (ZVEI) from their handbook *Ultrasonic assembly of thermoplastic mouldings and semi-finished products - Recommendations on methods, construction and applications* with threads M 16 x 1.5 and thread depths of 15 mm. With larger thread diameters there should be additional length on the thread side.

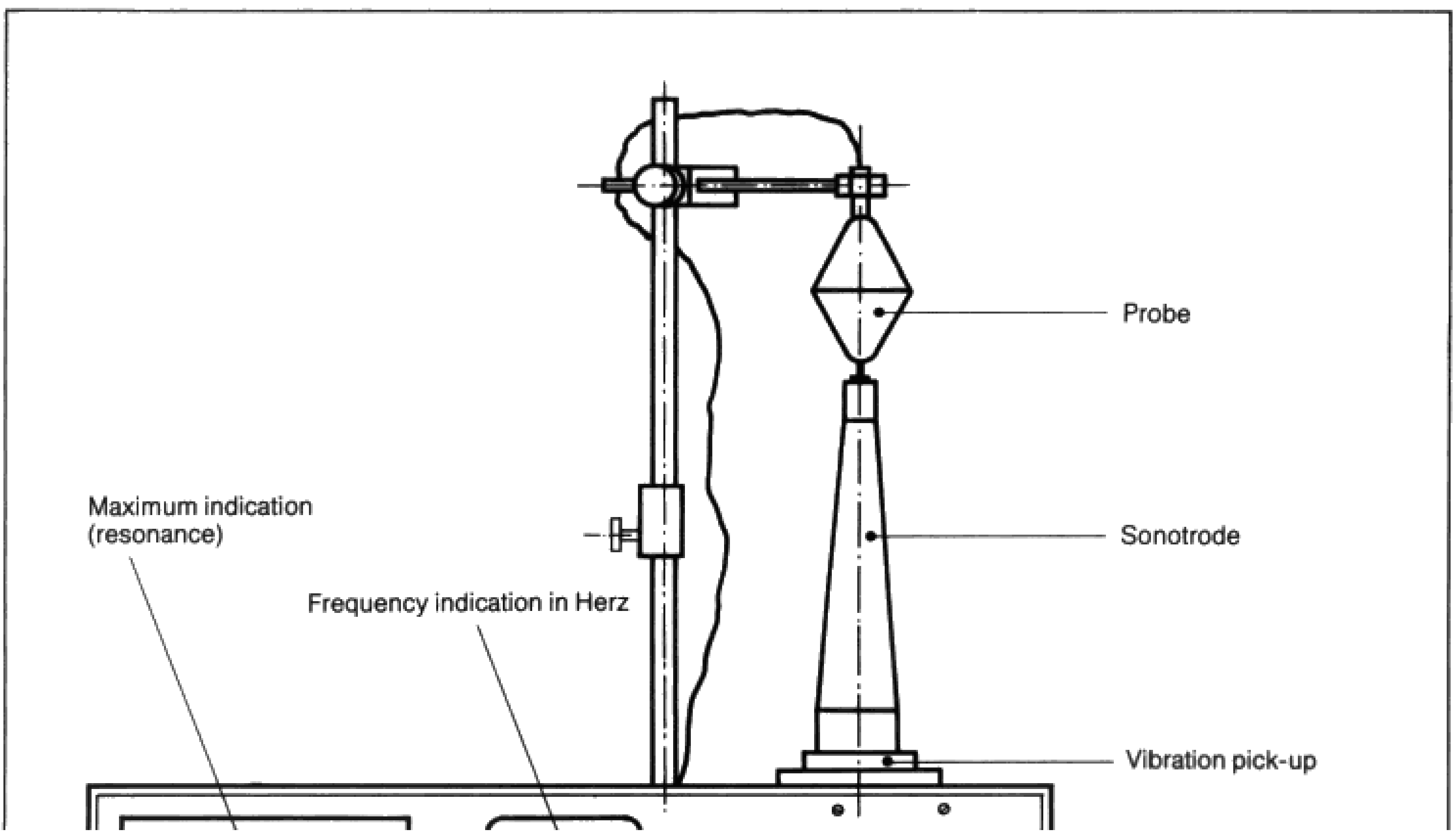
Transformation ratio

$$\beta = \sqrt{\frac{A_1}{A_2}} \cdot \cos\frac{\omega \cdot l}{v} + \frac{v}{\omega \cdot l}\left(1 - \sqrt{\frac{A_1}{A_2}}\right) \sin\frac{\omega \cdot l}{v}$$

9.9 Tuning the blank sonotrode

The frequency of the blank sonotrode is as a result of added material of 2-3 mm generally 0.5 to 1 kHz below the desired resonant frequency. The sonotrode reaches the required frequency as a result of being shortened and remeasured several times. The sonotrode measuring device is used to measure the natural frequency (figure 50). It consists of an RC generator, a measuring transducer and frequency indicator. Sonotrode measuring devices are also marketed as compact devices with built-in RC generator.

For measuring, the sonotrode is placed as shown in figure 50 on the measuring transducer or in the case of other types of instrument screwed to the measuring transducer, which is connected to the RC generator. The probe (vibration receiver) coupled with the tuning instrument touches the tip of the sonotrode. The frequency range in which the sonotrode is assumed to lie must be gone through on the RC generator. The resonant frequency has been obtained when the maximum amplitude reading is observed on the tuning instrument or when the indicator reading of the instrument is observed on the compact instrument.



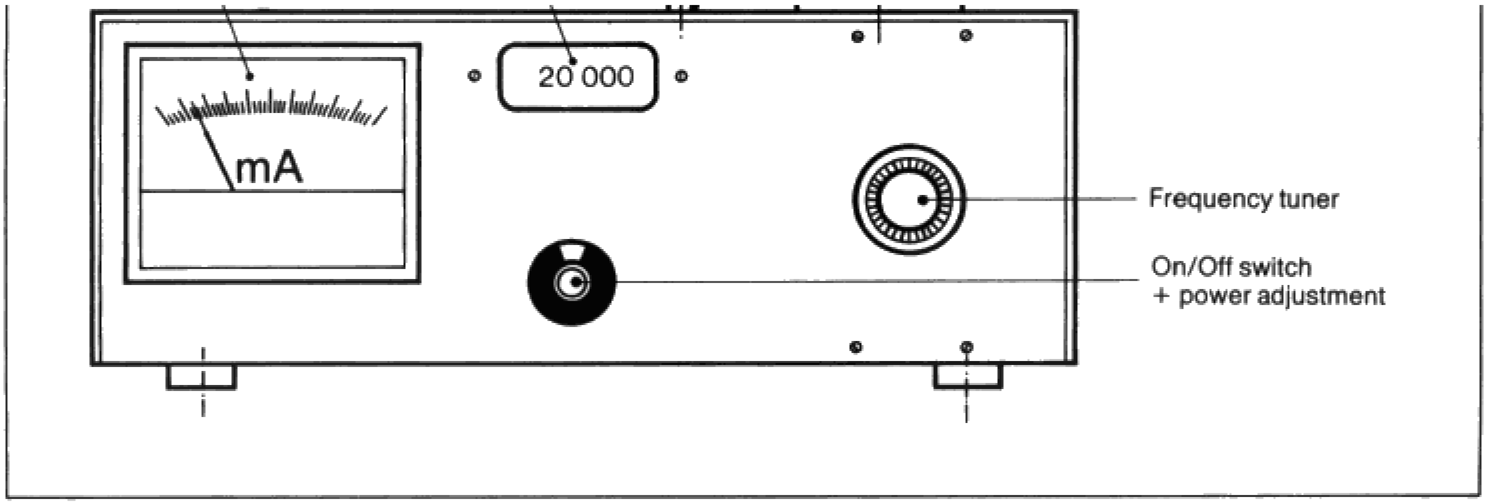


Figure 50: Sonotrode measuring device

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9.10 Practical example

Calculation of a sonotrode made of titanium for a moulding made of polystyrol with a diameter of 25 mm.

Data given by the manufacturer of the machine:
Amplitude of the booster $\xi_3 = 10\ \mu m$
Coupling diameter of the booster $D_3 = 35$ mm
Working frequency $f = 20$ kHz $\pm$ 0,2 kHz

Required amplitude for the moulding made of polystyrol, Table 3, page 34, $\xi_2 = 25\ \mu m$ (selected)

for an ideal coupling surface: $\xi_1 = \xi_3$

Amplitude transformation $\beta = \frac{\xi_2}{\xi_1} = \frac{25\ \mu m}{10\ \mu m} = 2{,}5$

1. Sonotrode with stepped shape (circular section) diagrammatic solution, Table 5, page 35.

$$\beta = \frac{A_1}{A_2} = \left(\frac{D_1}{D_2}\right)^2$$

$$D_1 = \sqrt{\beta \cdot D_2^2} = \sqrt{2{,}5 \cdot 25^2} = 39{,}53 \sim 40 \text{ mm}$$

D_1 = 4 cm
A_1 = 12.57 cm²
D_2 = 2.5 cm (adapted to the part)
A_1 = 4.9 cm²
v = 4950 m/s for the titanium selected, Table 4, page 34
l_1 = 61.4 mm Table 5, page 35
l_2 = 61.7 mm Table 5, page 35
$l_0 = l_1 + l_2$
l_0 = 61.4 + 61.7 = 123.1 mm
+ allowance of 2 mm at l_2

Arithmetical solution

$$l_0 = K \cdot \frac{v}{2 \cdot f} = \frac{4950}{2 \cdot 20} = 123{,}75 \text{ mm}$$

+ allowance of 2 mm

The correction factor K is adopted with 1.

2. Conical form

Diagram solution, Table 6, page 36

Aproximate calculation of the transformation ratio

$\beta \approx \frac{D_1}{D_2}$ only applies for small diameters.

The divergence for $\frac{D_1}{\ }$ = 3 is approximately

9.11 Reworking sonotrodes

When sonotrodes which have already been attuned are reworked on the front surface (adjustment of the front surface of the sonotrode to the outline of the moulding) the frequency f_0 becomes higher. Afterwards the sonotrode can be outside the permissible tolerance and may no longer be operated on the ultrasonic welding instrument. It is possible to reduce the frequency again slightly.

9.11.1 Frequency correction

The frequency should be increased:
- ☐ Shortening of the complete length (applies to all shapes of sonotrode). Attention: not linear!

The frequency should be reduced:
- ☐ Conical shape (figure 51), exponential form, cylinder – making a groove at the centre of gravity.
- ☐ Stepped shape (figure 52) – shortening of length l_1.
- ☐ Square or rectangular shape – widening of the slots b_1 (figure 49).

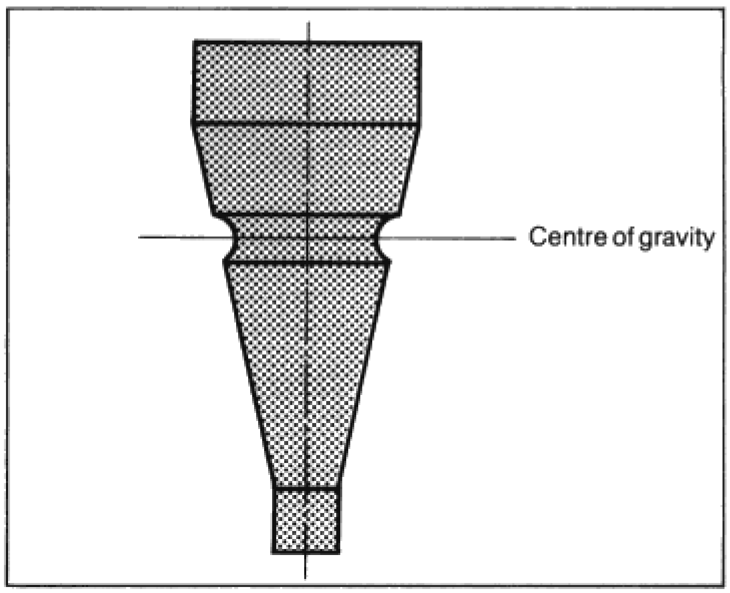
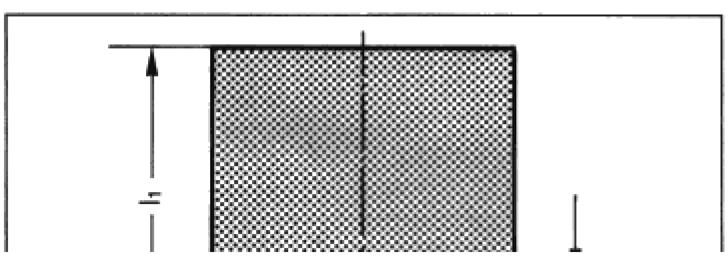


Figure 51: Reduction of the resonant frequency of a conical sonotrode by a groove at the centre of gravity.



The divergence for $\frac{D_1}{D_2} = 3$ is approximately 10% and at $\frac{D_1}{D_2} = 5$ is approximately 30%.

$\beta = \frac{\xi_2}{\xi_1} = \frac{25\ \mu m}{10\ \mu m} = 2{,}5$

D_2 = 25 mm (adapted to the part)

$D_1 = \beta \cdot D_2$

$D_1 = 2.5 \cdot 25 = 62.5$ mm

l_o = 134 mm + 3 mm allowance (Table 6)

In the example presented the stepped shape is chosen, as less material is required and the coupling surface is completely covered. The sonotrodes should be attunded to the required frequency as described in point 9.9.

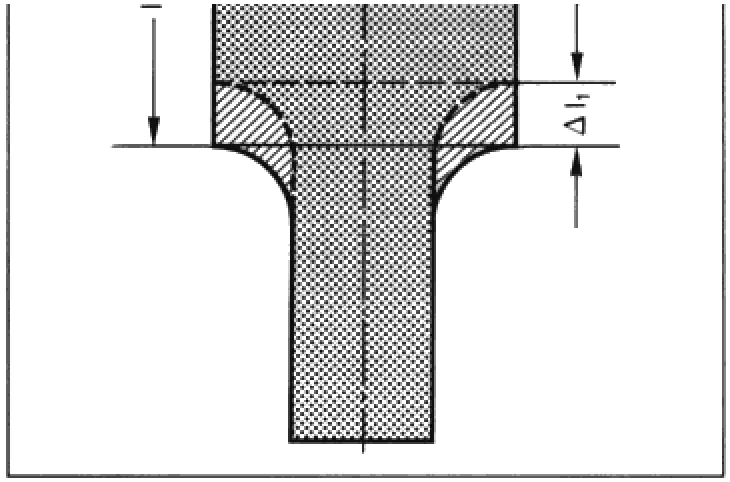


Figure 52: Reduction of the resonant frequency of a stepped sonotrode (stepped cylinder) by shortening length l_1

38

Reproduced with permission of the German Electrical Manufacturers Association (ZVEI) from their handbook *Ultrasonic assembly of thermoplastic mouldings and semi-finished products - Recommendations on methods, construction and applications*

This page is intended as a brief introduction to bulletin boards for those who haven't used them before. If that isn't you please go straight to the boards, or if you need detailed information please see the YaBB help pages instead.

Just browsing!

First, feel free to browse the board as a guest - follow the links or use the **Search** link to see what's been said already about the topic you're interested in. If you find the answer you're looking for - that's great! If not, and you think from the messages you've read that someone in this forum might have the answer, then it's time to post a question. (You can also follow these instructions if you **did** find your answer, and just want to say "Thanks" - that's always welcome!)

It's good to belong!

You can post as a guest but it's much better to register first. As a registered user you can:

- Put up a brief profile of yourself (as much or as little information as you like) to give the rest of us some idea where you're coming from.
- Read the profiles of all the rest of us (other group members).
- Get notification by e-mail when a thread changes - eg. when someone answers your question!

To register, just click on the **Register** link (duh!), choose a username (not necessarily your real name, but often based on it) and enter your e-mail address. You must enter a valid address to register, but you don't need to display it on your profile - that's your choice, because if you do show it then there's always the risk that it will find its way onto a spammers mailing list.

A password will be sent to you automatically - when you receive it go to the **Login** page and type in your username and password to log in. At this point you can click on the **Profile** link and enter whatever information you want shown to other registered users.

First post...

So, you've registered, logged in and set up your profile - now to ask your question! You'll notice that the messages are divided into "threads" - that is strings of related questions and answers displayed one after another on the same page. At the bottom of each thread you'll find a **Reply** link. If your question is closely related to one of the threads you've already read, go back to that thread and click **Reply** to enter your question at the end.

If not, click on the **Home** link to get back to the list of boards available, choose the one that seems most relevant and click on its title. This will display a list of threads on that board with a link "**Start new topic**" at the top and bottom. Yes, you've guessed it, click that link to ask your question in a new thread!

If you're replying to an existing thread the title will already be set to "Re: thread subject" but if you're starting a new one you'll need to enter a title of your own. Try to think of a good one - something that will give people a good idea of what your question's all about. Then type in your question or message in the appropriate space. YaBB offers lots of special formatting options but you don't need to worry about them. See the Posting help page if you do want to experiment. You may want to check the box marked "Notify of replies" so you'll get an e-mail notification when someone answers your question. Then click **Post** to put your message up on the board. Before long, with luck, someone will answer your question...

No no's!

We all make mistakes, but these are some things you should really try hard to avoid doing:

Asking irrelevant questions
: This site is generally all about ultrasonics. Registered users are free to discuss other subjects (subject to limits as set out in the rules!) but generally off-topic posts should be ignored.

Asking questions that have already been answered
: Please try hard to find the answer to your question on this site or in the old messages before asking (see Just browsing above). No-one likes answering the same question twice!

Asking questions privately that should be asked publicly
: Once registered, you can send a private message to me or any other registered user, but please do this **only if your question really shouldn't be shown on the board.** Showing questions and answers on the board allows the information to be shared, avoiding the need for someone else to ask the same question later.

That's all folks!

Thanks for reading all the way to the end! Now go back to the bulletin board.

General questions, comments etc.

Now that I've (finally!) put up a discussion board for questions about ultrasonics, comments about the site etc. I'd like to request that you use it wherever possible rather than contacting me directly. The aim is to reduce my workload by allowing others (no doubt better qualified) to answer some of the questions and also to enrich the site with information that would otherwise be locked up in my e-mail client. So unless it's important to you that your comment / question remains confidential, please **see the power ultrasonics discussion forum**.

Confidential questions, patentable applications.

If your question cannot be made public, eg. if it concerns a new application with potential for patenting, please use this page to discuss it with me privately, or e-mail me directly. Any information you enter here will be treated as **confidential** (details on privacy page).

To comment or ask a question privately, please complete the section below or e-mail me (items in red are required).

If you prefer, you can contact me directly by:

Your details:

Your name:	Mr
Company name (if any):	
E-mail address:	
Your comment or question?	

Send this information:

Now click 'Send' to transfer this information to me.

Send

E-mail:

chris@powerultrasonics.com

Mail:

Dr. Chris Cheers,
PO Box 7117,
Mannering Park,
NSW 2259,
Australia.

Phone / fax:

+61 (0) 2 4359 3801

Mobile:

+61 (0) 408 676255

Other issues.

If you want to add your company to the ultrasonic suppliers database, or alter details for one already there, please start with the add supplier page, but if you have problems feel free to contact me here or on the discussion board. The guestbook still exists also, but is now really just an archive - please use the board instead for comments on the site.

Ultrasonics can have a variety of different effects, including heat generation, friction reduction, cleaning and erosion (see the basics page for more information) but to have **any** useful effect they must be properly applied. For some applications, eg. probes for plastic welding, there is a well-established design already available which just needs to be customised to suit the process. In other cases there is no prior art and a new system must be created from scratch. These are the typical steps in designing a new ultrasonic system:

Determine the requirements of the process

There are many important factors determining what effect ultrasonics will have on a process, including direction, amplitude and frequency of the vibrations at the point of application and the method of clamping the workpiece. All of these should be specified with a view to maximising the effect on the process within the constraints of the ultrasonic system (described in the next steps).

Design the sonotrode

Having chosen what vibrations are required at the "working end", the sonotrode (ultrasonic tool) must be designed to generate them. The required movement must be a part of a mode of vibration which has a natural frequency equal to that of the rest of the system. Furthermore there must be a position somewhere on the sonotrode where the forcing vibrations can be applied (losses in the system and energy transfer to the workpiece will always demand that the sonotrode is driven to continue vibrating, even though it is a resonant system). At the point of application the vibrations must be precisely perpendicular to the surface, since any out-of-axis movement of the transducer will cause it to self-destruct!

For anything but the simplest system, finite element analysis will be essential to produce a satisfactory sonotrode design.

Specify the remainder of the system

The rest of the ultrasonic system (simple explanation) will generally consist of:

- a booster (if necessary) to increase or reduce the vibration amplitude according to the needs of the process.
- a transducer to convert electrical power into mechanical vibrations.

- a frequency generator to convert mains electricity into the voltage and frequency required by the transducer.
- a control system (generally built into the generator) to maintain the system at resonance, even when the resonant frequency changes.
- a control system (generally built into the generator) to adjust the power output to maintain a constant vibration amplitude at the transducer.
- measuring instruments to monitor power / amplitude / frequency as required.

Standard systems which meet these requirements are available from many different manufacturers in different frequency and power ranges. These should be specified to suit the needs (known or estimated) of your process.

To discuss ultrasonic system design for your process, please contact me.

POWER Ultrasonics

Please stand by for new developments in the advertising on this site. As a part of the ongoing site development we will soon be offering:

- Text and graphic ads focussed on visitor requirements
- Advanced monitoring and reports
- Free account setup and trial ads

If you'd like more information please contact me.

Chris Cheers - August 2004.

Need a web site for your ultrasonics business? Or an update to that 90s look site? Internet Lynx offers professional web design and hosting to clients around the world.

Choose between economical template-based sites (prices from around $75 per page) or request a free quote for a custom-built interactive site to your precise specification. All sites can include integrated forms, databases and e-commerce. For more information please contact Chris or see www.internetlynx.com.au

POWER Ultrasonics

Home
Introduction
Advanced
Suppliers
Services
Questions?
Register
Add details

Before adding your company to the ultrasonic suppliers database we ask you to register as a user of this site. In accordance with the privacy policy, information entered on this page will be kept strictly confidential.

Enter your e-mail address to register

Username: [ ] Register

When you have your login and password details you can continue to add a new supplier.

If you don't receive the e-mail or have other problems please read this:

1. Check your e-mail address - if it's entered wrongly you won't receive the message.
2. Wait an hour or two - e-mail messages are sometimes delayed for a variety of reasons.
3. Check your spam filter (or ask your system administrator) - as a machine-generated message your password notification may be treated as unsolicited commercial e-mail (spam) and deleted. If you think this is a problem then you may wish to whitelist "auto@this domain dot com" (the address from which password messages are sent). And in case you're wondering, that's an attempt to keep the auto@ address off the spammers' mailing lists - you should replace "this domain dot com" with powerultrasonics.com).
4. If you still have problems please e-mail me (chris@powerultrasonics.com) or see the contact page.

POWER Ultrasonics

Home
Introduction
Advanced
Suppliers
Services
Questions?
Details
Register
Add details

Search error: No supplier specified - first go to the suppliers page to search and select

This page (supplier.html) last updated 18 Feb 2005, rebuilt 13 Aug 2006.

POWER Ultrasonics

This message is sent only to people who have requested it (and rarely even to them!). If you do not wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

Welcome to the PowerUltrasonics newsletter for June 2001. Sorry for the long delay since the last one - there always seems to be something else that needs doing first... Anyway I hope you find something useful, and please feel free to forward a copy to anyone else you think would be interested.

~~~~~~~~~~~~~~~~~~~~~~~ MPI WEB SITE ~~~~~~~~~~~~~~~~~~~~~~~~~

The most recent distraction keeping me from writing newsletters was creating a new web site for Miodrag Prokic - see it at mpi.powerultrasonics.com. Miodrag has 20 years experience in ultrasonic industrial engineering as a freelance technical expert and working for Branson, Krohne and Hamo, and he was able to supply some fascinating technical information for inclusion on the site - see the new articles section below. He's also keen to promote new applications of ultrasonics - here's a brief taster from the proposals page (more applications, and much more detail there):

- Water processing, including ozone injection, in line sterilization, active (ozone-saturated) ice cubes, neutralization of phenolic, cyanide, polymeric and similar dangerous remains.
- Other liquid processing, including mixing, homogenization, degassing, defoaming, liquid metal mixing and alloying
- Powders production and processing, including cold atomizing, pulverizing, in line vapourisation and drying (or solidifying) of very fine powders.
- Surface hardening, impregnation and coating, including implantation of hard particles, capillary surface sealing, impregnation of aluminum oxide
- Accelerated 3-D shock and vibration tests, and ultrasonically accelerated material aging / stress relieving
- Extrusion (of plastics and metals) assisted by ultrasonic vibrations
- Incineration of non-flammable waste and dangerous liquids by ultrasonic vaporisation and mixing with fuel.
~~~~~~~~~~~~~~~~~~~~~~~

~~~~~~~~~~~~~~~~~~~~ NEW ARTICLES ~~~~~~~~~~~~~~~~~~~~~~

Four new entries on the articles page since the last newsletter:

Ultrasonic cleaning in supercritical liquid CO_2 - A paper written for the 2001 UIA symposium by Miodrag Prokic and fellow researchers from ECO_2 SA, and published on Miodrag's new web site. Describes a new multi-frequency system used to drive ultrasonic cleaning in a pressure vessel containing liquid carbon dioxide.

Design and optimisation of an ultrasonic die system for forming metal cans. Chapter 6 - Results. - At long last, another chapter from my PhD thesis converted to HTML and uploaded to the web site. Results include modes and frequencies, ESPI evaluation and force measurements with and without ultrasonics.

Ultrasonic Motor Development - An interesting page about research at MIT to develop a high torque-density solid-state actuator for use in the NASA/JPL Mars Micro Lander manipulator arm, including a general explanation of the principles of ultrasonic motors and some cool animations!

Canon Ultrasonic Motors (USMs) - More ultrasonic motors, this time Canon's description of their development for use in camera auto-focus lenses. Their explanation of the arrangement of piezoelectric elements is particularly good.

~~~~~~~~~~~~~~~~~~ FREE ADVERTISING ~~~~~~~~~~~~~~~~~~~~

The powerultrasonics web site aims to promote the technology while remaining independent of any manufacturer. Anyone is welcome to contribute articles, links or other information - if you can I will gladly include a by-line, e-mail address, and link to your web site (or not if you prefer). There are 3 areas of the site where contributed information is particularly important:

Suppliers database

The database now contains details of 123 supplier organisations (mainly companies) around the world, but it's by no means complete. To check that your companies details are included and correct please go to the suppliers page and search for it by name. If it's not there, or if you want to change the entry just follow the instructions to enter / correct the information.

Articles

The articles page features links to technical articles about ultrasonic technology and research. If your article is already published somewhere on the web, just send me the url and I will add it to the page. If it's not already on the web (and you have the right to publish it) I would be happy to show it on the powerultrasonics site.

Newsletters

If you can make an interesting contribution to a future issue of this newsletter - read by a but select global audience of ultrasonics and other professionals - please e-mail it to me (chris@powerultrasonics.com). It must be relevant to ultrasonics technology and contain something new and interesting (not just a sales pitch please!). A brief summary of a longer article (as above) would also be ok.

~~~~~~~~~~~ LOW-COST BANNER ADVERTISING ~~~~~~~~~~~~~~

The powerultrasonics site also now includes limited advertising, carefully separated from all other content. For a modest $25 per month you can purchase a banner to promote your company to a very specialist audience. See the advertising page for more information.

~~~~~~~~~~~~ POWERULTRASONICS CONTACT DETAILS ~~~~~~~~~~~~~~

I've now made the move from Sydney to a little place on the New South Wales Central Coast. Due to problems beyond my control (builders!) the house still isn't built but it's on the way... Please note the new phone number:
Chris Cheers
PO Box 7240, Mannering Park, NSW 2259, Australia.
Phone / fax 02 4359 3801
Mobile 0408 676255
(to avoid confusion I have removed earlier contact information from previous newsletters)

~~~~~~

That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

If you wish to stop receiving these messages just send an e-mail to unsubscribe@powerultrasonics.com, from the e-mail account to which this message was sent. To start receiving these messages at another e-mail address, send an e-mail from the new account to subscribe@powerultrasonics.com, If you have any problems with the automatic system please e-mail me directly at chris@powerultrasonics.com.
~~~~~~

This message is sent only to people who have requested it (and rarely even to them!). If you do not wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

Welcome to the July PowerUltrasonics newsletter. I'm aiming to put out newsletters every six weeks or so or whenever I have some useful material! Please feel free to forward a copy to anyone else you think would be interested.

The main feature in this issue is an article kindly submitted by Linda McCausland of AEA Technology in the UK. If you would like to make your own contribution to a future issue, please e-mail it to me (chris@powerultrasonics.com). Provided it's relevant and contains something new and interesting (not just a sales pitch please!) I would be delighted to publish it.

~~~~~~~ AEA TECHNOLOGY SONOCRYSTALLIZER (TM) ~~~~~~~~~~~~

New Reactor to Improve Crystal Production in Pharmaceutical and Fine Chemical Industries

The AEA Technology Sonocrystallizer (TM) is a new reactor which helps the pharmaceutical, fine chemicals, and bio-technical products industries produce purer products through the production of better crystals. The Sonocrystallizer (TM) was developed and is now supplied by AEA Technology, the international science and engineering services business.

Sonocrystallization is a non-invasive method of using ultrasound to control the point of nucleation and the number of nuclei formed. Combining technologies of sonochemistry and crystallization sonocrystallization provides "a route to better crystals".

Benefits of sonocrystallization can include controlled initiation of nucleation, enhanced yield, improved crystal habit, improved filtration characteristics, improved product properties including, handling, bulk density and appearance, reduced agglomeration crystals with fewer imperfections and increased process reproducibility.
~~~~~~~

Sonocrystallization can be used to give a variety of desirable characteristics to high-value products. By using ultrasound to induce nucleation, crystal growth can be achieved in a more controlled manner at a lower supersaturation. Improved product size distribution and reduced agglomeration lead to fewer inclusions of impurities and a number of advantages in secondary processing and formulation.

This technology is particularly appropriate for pharmaceuticals and fine chemicals which are amongst the hardest materials to crystallize well because they tend to be high molecular weight organics. These molecules can be difficult to nucleate and often exhibit extreme crystal habits.

To support sales of the Sonocrystallizer (TM) AEA Technology has set up a team which offers a complete service of product screening, process development, scale-up and process equipment supply. A typical laboratory screening programme for a single compound can cost a little as £3,500 and can be performed on the customer's site if necessary.

Contact:
Linda McCausland,
Crystallization Operation Manager,
Hyprotech - AEA Technology
+ 44 (0) 1235 434035
Email: linda.mccausland@hyprotech.com
www.sonocrystallization.com

~~~~~~~~~~~~~ POWERULTRASONICS IS MOVING! ~~~~~~~~~~~~~~~

Well, not really, but I am. Please note my new postal address:
Chris Cheers
PO Box 7240, Mannering Park, NSW 2259, Australia.

Phone, fax and mobile numbers remain the same for the time being: Phone / fax xx xxxx xxxx, mobile 0408 676255

This is the first stage of my move from the big city (Sydney) to a quieter lifestyle on the New South Wales Central Coast. Unfortunately the house isn't built yet but I have a great garage there...!

~~~~~~~~~~~~~ SCHEDULED DOWN-TIME ~~~~~~~~~~~~~~~

The powerultrasonics web-site will be unavailable about three hours on Friday, July 21, 2000, starting 4:00 PM Eastern Time (9:00 PM GMT). I apologise for any inconvenience.

~~~~~~~~~~~~~~~~~~ NEW ARTICLES ~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~

Two new entries on the articles page:

Sonocrystallization - A link to the AEA Technology sonocrystallization site (see above).

Ultrasonic washing of textiles - In development by the Fraunhofer Technology Center Florida and the Institute of Acoustic, Madrid, this process offers significant savings of energy and water usage.

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That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

If you wish to stop receiving these messages just send an e-mail to unsubscribe@powerultrasonics.com, from the e-mail account to which this message was sent. To start receiving these messages at another e-mail address, send an e-mail from the new account to subscribe@powerultrasonics.com, If you have any problems with the automatic system please e-mail me directly at chris@powerultrasonics.com.
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This message is sent only to people who have requested it (and rarely even to them!). If you do not wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

Welcome to the June PowerUltrasonics newsletter. I'm aiming to put out newsletters every six weeks or so when there have been developments on the site to report. Please feel free to forward a copy to anyone else you think would be interested.

Not much news this time - I've been busy with a new site at www.cheers.au.com Nothing about ultrasonics there - it's offering web maps of Australia as a service to other web-sites - but please take a look if you have the time. It needs testing and I'd welcome any comments you can give me... Meanwhile, a question: Could magnetostrictive transducers be making a come-back??

~~~~~~~ GIANT MAGNETOSTRICTIVE MATERIALS ~~~~~~~~~~~~~~~

I'd like to start with a little history lesson if I may (experts can skip the next few paragraphs - I dont want to teach granny to suck eggs!)

Back in the 60's and 70's, when many applications of power ultrasonics were being developed, transducer technology was based on the magnetostrictive principle. Laminated cores of nickel alloy were wound with PTFE-insulated wire (why PTFE? Because the things would get hot enough to melt conventional plastic insulation!). A large alternating current in the coil, often combined with a large dc biasing current, generated a magnetic field in the core which responded by changing shape - the magnetostrictive effect - producing mechanical vibrations.

Then in the late 70's the piezo-electric sandwich transducer was introduced, and this has come to dominate the industrial power transducer market, at least in the west. This transducer uses ceramic disks sandwiched between two metal blocks, with a high-tensile screw through the centre holding it all together. The piezo-electric ceramics respond to an electric field, rather than a magnetic one, so coils are not required - instead an alternating voltage is supplied to electrodes between the disks.
~~~~~~~

The magnetostrictive transducers were extremely robust and relatively easy to manufacture, maintain and repair. Also their low Q allowed them to operate over a wide frequency range, so accurate tuning was not generally required. The one major drawback was their lack of efficiency - they would soak up a lot of power for little effect - and this was exacerbated by the use of power supplies operating at constant power. (While the transducer was running under no load, the power supply would still be pumping in 1 or 2 kW - all of which would be dissipated as heat).

By contrast piezo-electric transducers offered very high efficiency (conversion of electrical power into mechanical), and could run at higher amplitude, provided they were built well. This is not as easy as it sounds - all the interfaces must be VERY smooth and flat to ensure a constant pressure on the ceramics, otherwise they will break. Also this technology demands much more from the power supplies - driving a piezo transducer at constant power is not recommended! As soon as the mechanical load is removed the vibration amplitude will rise high enough to break either the ceramic disks or the clamping screw. Instead power supplies adjust themselves automatically to provide just enough power to maintain the transducer at its design amplitude. Furthermore the high Q means that the transducer only operates in a very narrow frequency band (as little as 1 or 2 Hz) and this changes as the system warms up, so generators must also track resonant frequency automatically.

So piezo-electric transducers came to dominate, offering higher amplitude and output power, their shortcomings largely overcome by careful manufacture and improved power supplies. But could that now be about to change?

New giant magnetostrictive materials (GMMs)

In the past few weeks I've been contacted independently by two suppliers of GMM's, who are again (still?) producing magnetostrictive ultrasonic power transducers: Etrema in the USA and Gansu in China.

The new materials are alloys of iron and rare earth metals - more efficient than the traditional materials, but how the transducers compare to piezos remains to be seen. What really caught my interest was the very high power capacity of the Etrema systems - they are producing a 6kW transducer already with something much larger on the way (whereas piezo transducers tend to be limited to around 3-4 kW max, and with their narrow frequency band it's not easy to use more than one). This could open up new large-scale applications of ultrasonics... Any suggestions?

Links to information on both magnetostrictive and piezo-electric systems are on the articles page.

These companies, naturally, have also been added to the supplier database, bringing the total to 114 suppliers in 16 countries. I have also added a new product category: Giant magnetostrictives (When I set up the system I set an arbitrary limit of 25 characters for each product category. As you can see, I'm not keen to change it...)

If you would like to add this to the database entry for your organisation, or modify it in any other way, go to the database page (link above), find your details and click on "Modify".

~~~~~~~~~~~~~~~~~~~~ VISITOR STATS ~~~~~~~~~~~~~~~~~~~~~

The number of visitors to PowerUltrasonics continues to grow. April was a bit flat - just a slight increase over March - but May brought a bumper 50% increase in visitors. Who would have thought there was a market for such an esoteric subject? Where are you all coming from?!!

As it happens, I do know at least which countries you are coming from...

Here's the combined list for April and May:

Argentina, Australia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Ireland, Israel, Italy, Japan, Lithuania, Malaysia, Malta, Mexico, New Zealand (Aotearoa), Netherlands, Norway, Poland, Portugal, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, South Korea, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, US Commercial, US Educational, US Government, US Military, Venezuela, Yugoslavia.

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That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

If you wish to stop receiving these messages just send an e-mail to unsubscribe@powerultrasonics.com, from the e-mail account to which this message was sent. To start receiving these messages at another e-mail address, send an e-mail from the new account to subscribe@powerultrasonics.com, If you have any problems with the automatic system please e-mail me directly at chris@powerultrasonics.com.

[Old news (to Jan 2000)]
[Newsletter February 2000]
[Newsletter April 2000]
NEWSLETTER JUNE 2000
[Newsletter July 2000]
[Newsletter June 2001]
[Newsletter August 2004]

This message is sent only to people who have requested it (and rarely even to them!). If you do not wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

Welcome to the April PowerUltrasonics newsletter. I'm aiming to put out newsletters every six weeks or so when there have been developments on the site to report. Please feel free to forward a copy to anyone else you think would be interested.

~~~~~~~~~~~~~~~~~~~ NEW ARTICLES ~~~~~~~~~~~~~~~~~~~~

New on the articles page since last issue:

Numerical calculation of pressure fields in sonochemical reactors, by Sascha Dähnke and Frerich J. Keil.

> A mathematical analysis aimed at calculating theoretically the oscillating pressure fields in various sonochemical reactors. The results (so far based on linear analysis only) include pressure maps for several different designs, one of which is available as an animation. Did you think the amplitude in your sonochemistry reaction vessel was uniform?!

Theory of ultrasonic metal welding from American Technology (AmTech) Inc.

> With AmTech and Stapla both providing high-quality information, ultrasonic metal welding is particularly well served on the web. AmTech's articles are aimed particularly at wire-joining applications, including welding aluminium to copper.

Creating Sonoluminescence, by Hiroshi

> A clear account of the equipment required to generate and study sonoluminescence - a surprisingly simple set up suitable for a high-school laboratory. If anyone has tried it please let me know.

Ultrasonic homogenisers from Reson Ultrasonics

> Remarkably, mixing water with the fuel can be good for large diesel engines and boiler installations. Of course the water must be very thoroughly mixed... This article from Reson describes their ultrasonic homogeniser which breaks down the droplets of water to 3 microns diameter - hard to achieve by any other method!

~~~~~~~~~~~~~~~~~~~ WHAT ELSE IS NEW? ~~~~~~~~~~~~~~~~~~~~

The suppliers database (www.powerultrasonics.com/cgi-bin/suppliers.pl) is now up to 112 suppliers. There are 2 new product categories:

- Ultrasonic homogenizers (ok, I admit it - I didn't have Reson in the database until now!)
- Books and Publications

If you would like to add any of these to the database entry for your organisation, or modify it in any other way, go to the database page (link above), find your details and click on "Modify".

To make it easier to select multiple products / services, I have now (finally!) added a sub-form with check-boxes for each category. Just click on "Help selecting multiple products/ services" on the Contact page to get the new form. Using it should be self-explanatory but if you have any problems please let me know.

~~~~~~~~~~~~~~~~~ BANNER ADVERTISING ~~~~~~~~~~~~~~~~~~

You can hardly fail to notice one change on the site - by way of an experiment I've started putting in banner ads. The aim is to promote the site through banner exchanges (other sites show my banner ad in exchange for my site showing theirs) and ultimately to try to earn a little money to cover site maintenance (I live in hope!). Inconvenience to users should be fairly minor - the ads are no more than 10k in file size, and only one ad is loaded per page view (I really hate web-sites that automatically reload the adverts so often that it interferes with normal browsing).

~~~~~~~~~~~~~~~~~~~ BOOKS PAGE ~~~~~~~~~~~~~~~~~~~~

The other significant improvement to the site is the books page. I searched all the major on-line bookshops for relevant titles and Barnes and Noble had by far the best selection, so I joined them as an affiliate. On my pages you will find lists of ultrasonics books in several categories, showing covers (where available), titles and authors, linked to the Barnes and Noble site where you can get more information on each one. Start at the main index or go straight to a category:

- sonochemistry
- ultrasound physics
- transducers and materials
- industrial applications

~~~~~~~~~~~~~~~~~~~ VISITOR STATS ~~~~~~~~~~~~~~~~~~~~
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PowerUltrasonics visitor stats for February and March continue to improve, although things do seem to be levelling off a bit - I must get some promotion done! Getting lost from several search engines at the beginning of March didn't help, but at least using WebPosition (see internet page) I was able to see what had happened and correct it quickly.

Here's where February's visitors came from:

Austria, Australia, Bulgaria, Canada, Czech Republic, Finland, France, Germany, Hungary, India, Indonesia, Israel, Italy, Japan, Malaysia, Mexico, Netherlands, Niue, Peru, Portugal, Singapore, South Africa, South Korea, Switzerland, Tanzania, Thailand, Turkey, Ukraine, United Kingdom, United States, US Educational, US Government, Yugoslavia.

And March's:

Australia, Belgium, Brazil, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Iceland, India, Israel, Italy, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Singapore, Spain, Sweden, Thailand, Turkey, United Kingdom, United States, US Educational, US Military.

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That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

If you wish to stop receiving these messages just send an e-mail to unsubscribe@powerultrasonics.com, from the e-mail account to which this message was sent. To start receiving these messages at another e-mail address, send an e-mail from the new account to subscribe@powerultrasonics.com, If you have any problems with the automatic system please e-mail me directly at chris@powerultrasonics.com.

Old news (to Jan 2000)
Newsletter February 2000
NEWSLETTER APRIL 2000
Newsletter June 2000
Newsletter July 2000
Newsletter June 2001
Newsletter August 2004
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This message is sent only to people who have requested it (and rarely even to them!). If you do not wish to receive any more of these messages, please see the instructions at the bottom of the page.

Dear subscriber;

Welcome to the first PowerUltrasonics newsletter. This occasional publication is designed to keep you up to date with developments on the site. Please feel free to forward a copy to anyone else you think would be interested.

~~~~~~~~~~~~~~~~~ POWER ULTRASONICS ~~~~~~~~~~~~~~~~~

The PowerUltrasonics web-site (www.powerultrasonics.com) provides an independent information resource in this field which is surprisingly lacking in books and academic research. Some of the best information comes from the equipment manufacturers, but they are naturally reluctant to provide links to other information sources on their competitors' sites!

The most popular features are:

- Introduction to power ultrasonics (www.powerultrasonics.com/intro.html) - gives newcomers a basic understanding of the underlying physics and the practical applications.
- Articles about power ultrasonics (www.powerultrasonics.com/articles.html) - links to technical information on the web. I am always looking for more of these so if you know of any please let me know.
- Database of suppliers (www.powerultrasonics.com/cgi-bin/suppliers.pl) - searchable by name, country, product or service and giving contact details and links to the web-site (if any). Entry to the database is free to anyone providing a relevant product or service.

~~~~~~~~~~~~~~~~~~~ WHAT'S NEW ~~~~~~~~~~~~~~~~~~~

Just one new item on the articles page (www.powerultrasonics.com/articles.html) in January. It's a brief report from the Campden & Chorleywood Food Research Association in the UK. "Power ultrasonics improve food quality - Reducing the degree of processing of heat-preserved foods using power ultrasound". Click the link above for more details.

The suppliers database (www.powerultrasonics.com/cgi-bin/suppliers.pl) now contains details of 107 suppliers. There are 2 new product categories:

- Food cutting machinery
- Fluidsonic equipment

and 1 new service:

- Customer funded R&D

If you would like to add any of these to the database entry for your organisation, go to the database page (link above), find your details and click on "Modify". After this, you can select additional products / services from the list by holding down the "Control" key (is it the "Command" key for Mac users?) while clicking on the item.

~~~~~~~~~~~~~~~~~~ VISITOR STATS ~~~~~~~~~~~~~~~~~~~

Analysing the server log can extract information about visitors which is vital to the site's future: How many visitors came to the site? How long did they stay, Which pages are popular / unpopular etc. It can also provide a fascinating glimpse of guests dropping in from around the world! At some stage I plan to create a new page sumarising the latest visitor stats and publish it on the site - I think it might be popular. Here's a quick preview:

PowerUltrasonics visitor stats for January 2000 were most encouraging, despite the server logs going missing for half the month. Irritating, because the last week was the busiest the site has ever been, as the daily record book shows:
Most Hits: 1,672 (Jan 26, 2000)
Most Bytes: 6,574,932 (Jan 27, 2000)
Most Visits: 61 (Jan 29, 2000)
Most Page Views: 638 (Jan 26, 2000)

Here's the visit summary for that week (01:48:25 23 Jan 2000 to 01:36:55 31 Jan 2000):
A total of 3,238 pages were accessed by 212 unique hosts. There were approximately 315 distinct visitors; the typical visitor seems to have spent about 46 minutes visiting the site and to have viewed some 10.3 pages. There were a total of 8,370 hits and 31 errors related to Power Ultrasonics, consisting of 29,290 kilobytes of information.

And here's where January's visitors came from: Australia, United Kingdom, Canada, Turkey, Bulgaria, France, South Africa, United States, Italy, Spain, US Military, Mexico, US Educational, Brazil, Poland, Switzerland, Jordan, Romania, United Arab Emirates, Thailand, Israel, New Zealand (Aotearoa).
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~~~~~~~~~~~~~~~~~~~~ WEB POSITION ~~~~~~~~~~~~~~~~~~~~

PowerUltrasonics is a highly specialised web-site looking for a world-wide audience with a zero advertising budget! In this situation, search engine positioning is VERY important.

I use WebPosition Gold to manage submissions and automatically track where the site appears in results for lots of popular seach phrases - a task that would be a full-time job if done manually. It will also analyse web pages and suggest ways of improving their ratings! If you think your web-site could benefit from this kind of service, you can download a free version (limited to only 3 search engines) by following the link below:

http://www.webposition.com/cgi-local/index.pl?DS1=RP&DS2=ELG-55E5

Note - This is an affiliate programme. If you download, and subsequently decide to buy the product I will receive a small commission. Nevertheless, I endorse Web Position because I really believe in it and use it regularly myself (honest! ;-)

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That's all for this time. Feedback is always welcome...

Chris Cheers (chris@powerultrasonics.com)

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January 10, 2000

I hear there's a problem with the top image viewed on Navigator for Macintosh (thanks Don). I'm working on it...

January 01, 2000

Happy New Year to powerUltrasonics' visitors from all around the world!

December 09, 1999

With the log files still showing people are failing to find suppliers through the search page, I checked out the search software again and found a bug which was causing it to fail to find some suppliers with multiple products / services. I'm really sorry for the inconvenience to you searchers - please try again now that it's fixed!

October 29, 1999

Checking the log files it seems several people are failing to find suppliers through the search page. With relatively few entries in the database (now around 100) it's important not to overspecify your requirements. See the new tips for more details.

October 10, 1999

Power Ultrasonics is now beginning to get some traffic, thanks to search engines around the world and a bit of work with WebPosition Gold - a brilliant little program for submitting your site to all the major search engines, and then monitoring and improving its position. If you want to encourage more visitors to your web-site, get a free trial!

OLD NEWS (TO JAN 2000)

Newsletter February 2000

Newsletter April 2000

Newsletter June 2000

Newsletter July 2000

Newsletter June 2001

Newsletter August 2004

Introduction
Cleaning
Cutting
Machining
Metal forming
Metal welding
Plastic welding
Sieving
Sintering
SONOCHEMISTRY

The effects of ultrasonically-induced cavitation in a fluid can be fascinating. Any chemical reaction is likely to be affected by extremes of pressure and temperature, even if they are highly localised. Rates of reaction can be greatly increased, and in some cases the reaction products may be changed. There is also great potential for modifying biological reactions e.g. in food processing.

I would love to feature some industrial examples from this rapidly-expanding field. Please let me know if you can contribute, or why not announce your application to the world via the ultrasonics discussion board!

Introduction
Cleaning
Cutting
Machining
Metal forming
Metal welding
Plastic welding
Sieving
SINTERING
Sonochemistry

The powder-metallurgy process is used to manufacture top-quality steels and other metals. The powder must be packed as closely as possible before the sintering process begins to prevent the formation of voids or other weaknesses in the finished product. Published research papers indicate that a significant increase in the packing density can be achieved using ultrasonics. Can anyone confirm that this process is in production?

Introduction
Cleaning
Cutting
Machining
Metal forming
Metal welding
Plastic welding
SIEVING
Sintering
Sonochemistry

Industrial sieves are normally agitated at low frequency to help the product to distribute itself evenly over the surface and to help the small particles go through. Vibrating the mesh at ultrasonic frequencies (in addition to this low-frequency oscillation) can improve the rate of flow dramatically, preventing the product from blocking the holes in the mesh and helping to separate the small particles from the large.

Introduction
Cleaning
Cutting
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Metal welding
PLASTIC WELDING
Sieving
Sintering
Sonochemistry

Plastic welding is used for a huge variety of products ranging from blister packs, cartons and small consumer goods up to car fuel tanks and dashboards. It works by generating heat exactly where it is needed - at the interface between the components to be joined. The components are clamped between a vibrating sonotrode and a fixed mounting. Strangely, the vibrations are usually applied perpendicular to the contact surface, although much of this vibration may be converted to in-plane movement. This also has the advantage that the clamping pressure will keep the sonotrode in contact with the component - serrated surfaces are generally not required. Best results are achieved when the components are clamped close to the interface ("near-field" welding) but if this is not possible then the process can still work at a distance ("far-field").

Staking, or insertion, is a variation of this process in which a metal part (generally a threaded bush) is driven into a hole in a plastic component, which then solidifies around it to form a permanent join. This is a convenient method of producing strong tapped holes in a plastic part.

More information:

1. Which materials are suitable for ultrasonic welding?
2. What are the limitations?
3. What other ultrasonic joining methods are there?
4. How does ultrasonic compare to other plastics joining methods?
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6. How do I control the plastic welding process?
7. How can I monitor the plastic welding process?
8. How do I design and build a plastic welding horn (sonotrode)?

Ultrasonic horns look simple. They're not.

Even the simplest small-diameter round sonotrode has been dimensioned to resonate at precisely the right frequency and provide a specified gain. To make something similar you need to follow the procedure detailed below. For larger horns, complex shapes and anything else out of the ordinary the same steps will become very difficult and you should seek expert advice.

1. **Select a frequency**

   If you're making a sonotrode for an existing ultrasonic system you must match its frequency. If you're starting from scratch you will need to purchase equipment with a particular operating frequency. The lowest available frequency is usually 20kHz - this gives the largest components and highest available power, so is most versatile. Constraints on size may force you to go to a higher frequency.

2. **Select a suitable material**

   Your application may dictate certain requirements, such as wear resistance. If so, these will be in addition to the common requirements for sonotrode materials: high fatigue resistance and low acoustic losses (meaning that they shouldn't absorb too much energy from the vibrations). High strength alloys of aluminium and titanium are ideal; many other materials might be used but at the risk of high power losses.

3. **Calculate the wavelength**

   First calculate sound velocity in the chosen material. Then using the frequency selected at step 1 you can find the wavelength - the sonotrode calculator can help you with these simple calculations.

4. **Calculate theoretical dimensions**

   For axial-mode sonotrodes of certain shapes, the length of the sonotrode should be half of the wavelength you calculated. This is generally true for straight rods and stepped sonotrodes, provided the step is in the middle of the length. There's also a correction factor (taking account of the inaccuracy of the plane-stress assumption implied in this calculation), but it can usually be ignored for sonotrodes that have a relatively small diameter compared to their length. Other shapes will have different lengths - in some cases standard formulae or tables may be available, otherwise finite element analysis will be necessary.

It is common to add a "tuning allowance" of a few mm - material which should be machined off during the tuning process (step 6).

5. **Consider unwanted modes of vibration**

   So far we've only looked at the desired mode of vibration, and it's common to think of a sonotrode as having only this one resonance which may or may not be at the right frequency. But in reality this is just one of many modes of vibration which all sonotrodes have. For simple shapes ignoring the other "unwanted" modes may cause no problems but for complex shapes or larger diameters you are very likely to an unwanted resonance close to the operating frequency. This can be disasterous for the welding process, with amplitude at the sonotrode tip being unevenly distributed and / or in the wrong direction. Now finite element analysis becomes vital - by testing multiple possible designs in the computer problems can be identified and solutions (perhaps) found.

6. **Manufacture prototype, tune and test**

   No matter how much analysis is done the ultimate test is to make the sonotrode and test it. Specialist test equipment is required - at least a horn analyser capable of driving the sonotrode over a range of frequencies and measuring its response. Tuning is the process of gradually removing material from the sonotrode until its measured resonant frequency is within tolerance on the target frequency - a tolerance of 1% or less is common. At this time the unwanted resonant frequencies can also be measured - anything too close to the operating frequency may require a complete redesign.

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Several techniques can be used to monitor the plastic welding process as it happens, allowing for 100 % quality control and even process adjustment for each individual weld. The most important are generator power and sonotrode displacement.

Ultrasonic power

Power is transmitted from the generator to the weld in many stages (electrical power to the transducer, conversion to mechanical vibrations, transmission of mechanical power to the tip of the sonotrode, transmission through the component). Some power losses can be expected at each stage, but for modern systems that have been properly set up these losses are small compared to the power dissipated in the welding process. Thus power measured electronically at the generator is a good indicator of power transmitted to the weld, and can be used as a quality control measure.

Suppose the mating surface of one component is contaminated with lubricant (perhaps mould-release) that reduces the friction coefficient at the contact points. The effect of this is to reduce the power demanded by the process, since vibration amplitude (hence velocity) is unchanged but force is reduced - power is the product of force and velocity. The reduced power demand can be monitored by the ultrasonic system and used to trigger an alarm or reject the parts.

A further refinement is to automatically adjust the weld time to compensate for the lower power - ensuring that enough total energy is supplied to perform the weld. This approach is particularly useful when parts may be slightly contaminated because welding may suffer a delayed start but then proceed normally. This "Constant energy" approach is often used in combination with pre-set time limits that will detect particularly extreme conditions (very long or short weld times) and reject these parts.

Sonotrode displacement

As discussed on the component design page, the parts are usually designed to direct or concentrate ultrasonic energy to the weld zone, which softens and flows during the welding process allowing the parts to move fully together. The small movement of the top component, and hence the sonotrode, can be readily measured, providing an automated control system with a direct measure of the progress of the weld. As with power measurement this technique can be used to extend weld times on components that require it as well as detecting fault conditions for rejection.

More information:

Many factors determine the success of an ultrasonic welding process long before it gets to a welder, most notably component materials and joint design. However at this stage we look at adjustment and set up of the welding equipment, for which the most important factors are amplitude, clamping force, timing and trigger force.

It may seem strange that power is not included in this list, but this was deliberate. Ultrasonic equipment for plastic welding invariably works at constant amplitude, with generator power being adjusted automatically as required to maintain the chosen vibration amplitude (known as "Power by Demand"). Thus power may be a limitation on the process (if the equipment is unable to supply as much power as the process demands) or a measure of weld quality (by studying the variation of power with time) but power is not a variable that can be set by the operator.

Amplitude

Some ultrasonic generators feature an electronic amplitude control - this is a convenience for small changes but is generally much less efficient than the traditional method of setting up amplitude - horn gains. A typical plastic welding "stack" may comprise transducer, booster and sonotrode. Both the booster and sonotrode will have a known gain - the ratio of amplitude output to input. The total gain of a stack is found by multiplying the individual gains, eg. using a 1.5 : 1 booster and a 2 : 1 sonotrode the total gain will by 3 : 1, and given 20 microns peak to peak at the transducer we can expect 60 microns peak to peak at the tip of the sonotrode.

Increasing amplitude will provide more energy to perform the weld, but beware of overloading the generator (if the process demands more power than it can supply) or overstressing the sonotrode - stress is proportional to amplitude and fatigue fracture is always a danger.

Clamping force

Since ultrasonic welders generally use pneumatic cylinders to provide clamping force this is normally set by adjusting air pressure. Like higher amplitude, increased clamping force should provide more energy to the welding process, and for the same reason it is possible to overload the generator by setting clamping force too high. Another issue is to avoid clamping the joint rigidly - if there's no relative movement to generate friction then welding won't take place. This is most likely in far-field welding where the component have a limited capacity to transmit vibrations to the joint.

Timing

Welding equipment allows selection of (at least) weld time and hold time. Weld time is critical, and will generally be the last setting adjusted (and the first to be re-adjusted when something goes wrong!). Obviously, weld time should be increased if the weld is weak and poorly formed, or reduced if the weld shows excessive melting and flash. A good process will have a useful operating window between these extremes.

Hold time (the delay after the ultrasonics are turned off before clamping force is released) tends to be less critical, provided it's long enough for the weld to cool and harden.

Trigger force

The setting of trigger force (the clamping force that triggers the ultrasonic system to switch on) varies enormously with the process. Some welding processes (eg. staking) benefit from a pre-trigger, ie. the ultrasonics are turned on before the sonotrode contacts the part. Others require the components to be firmly clamped before ultrasonics are applied.

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Joint design for ultrasonic plastic welding depends on the specific application. These are some common examples. Note that staking and reforming techniques are not included here - for these see the other methods of ultrasonic plastics joining.

Weld concentrator

In this joint design the mating surfaces make initial contact only along a thin line, ensuring that the ultrasonic energy is concentrated into a small area. As welding proceeds this material softens and flows to form the weld, allowing the rest of the contact surfaces to come together forming a natural stop. This technique is good for continuous hermetic seals. "Flash traps" are often used to contain the excess material from the weld, so that a neat external appearance is maintained.

Shear joint

Shear joints are often used for joining round components, although this is not essential to the process. One part fits into the other with a significant interference so that initial contact is only on the interfering surfaces. Again, this concentrates the ultrasonic energy at the location to be welded. During the welding process the material of both surfaces softens and flows, allowing the components to come together. Often a clearance is used at the entry to the interference, allowing easy initial alignment - this region may also be used as a flash trap to contain molten material ejected from the joint.

Stud welding is a variation on this technique where several small cylinders (studs) on one component are welded into matching holes in the other.

Spot welding

In contrast to the methods above, spot welding generally needs no special shape or form on the components. Instead a small sonotrode with a special tip profile clamps though one component to the other. For this to work both components must be relatively thin - the upper one to pass vibrations through, the lower to permit rigid support by the weld fixture. Spot welding sonotrodes may feature special designs to trap and shape the molten plastic ejected from the weld, but in comparison to other methods the appearance of a spot-welded joint is usually inferior.

More information:

Ultrasonic welding is generally a clean, fast and reliable method of joining plastics but in some cases other joining methods should be considered, particularly if the limitations of ultrasonic plastic welding make it unsuitable for a particular application. Here some other (non-ultrasonic) techniques are listed along with their likely advantages and disadvantages compared to ultrasonic welding.

Method	Advantages	Disadvantages
Mechanical fasteners	• Usable on any materials • Low capital cost - good for prototypes and small batches	• Multiple small components to assemble - extra cost, labour intensive. • Appearance may be unsightly. • May loosen in use. • Potential for consumer to disassemble.
Adhesive bonding	• Adhesives may be available for materials not compatible for welding • Low capital cost - good for prototypes and small batches	• Longer time to join - parts may need to be clamped or held together until bonded. • Possible safety issues with emissions. • Possible problems recycling mixed materials.
Spin welding	• Capacity for larger components than ultrasonic	• Relatively complex equipment. • Only suitable for axi-symmetric welds. • Limited to same chemically-compatible material combinations.

Vibration welding (low frequency)	• Capacity for larger components than ultrasonic	• Relatively complex equipment. • Limited to same chemically-compatible material combinations.
Hot plate welding	• Capacity for larger components than ultrasonic • Good for thin, conductive materials eg. laminated metal-plastic foils.	• At least one component must be thin to permit heat transfer. • Limited to same chemically-compatible material combinations.

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Where the limitations of ultrasonic plastic welding make a job impractical, some other ultrasonic joining techniques may be applicable.

Staking

Ultrasonic staking is like a riveting application for moulded plastic components, but without the disadvantages of separate fasteners. It can join dissimilar plastics or metal to plastic. Typically one part has a number of plastic studs which fit through holes in the other part. A sonotrode is pressed onto the end of each stud, softening and reforming it, often into a dome shape (like a rivet head) that locks the other component in place. Depending on the shape of the components it may be possible to perform multiple staking operations simultaneously using a single sonotrode. In any case the operation is quick and simple since ultrasonic energy is transferred directly to the part being reformed.

ULTRASONIC STAKING

Re-forming (swaging)

Where a staking process is not practical ultrasonic reforming may be an option - generally changing the shape of one part so it traps the other in place. Again one of the materials needs to be a thermoplastic; the other may be an incompatible plastic, metal or almost anything else. The exact nature of the reforming will depend on the application but a typical example would be reshaping the edge of a plastic container to trap a lid in place.

Insertion

Where a strong thread is needed in a plastic component ultrasonic insertion can be used to fit a metal bush. This is normally threaded internally with a knurled external surface. The insertion process involves pressing the bush into a hole in the plastic moulding which is initially too small. Vibrations transmitted through the bush to the plastic heat and soften it, allowing the bush to be pressed in without damaging the component. As the plastic cools it hardens around the bush, holding it firmly in place.

More information:

Component materials

The materials for ultrasonically welded components are possibly the most important limitation - the process works best when both components are made from similar amorphous polymers. If only one of your components is suitable for welding (or they are incompatible) you should consider related ultrasonic joining techniques. If neither material is suitable for welding (eg. you are joining thermoset plastics) then you need to look for another joining method.

Dimensions

The size of a continuous ultrasonic weld depends on the horn (sonotrode) that makes it. But sonotrodes are limited in size by physical constraints based on the wavelength of the ultrasound used. Some typical "rules of thumb" for axial-mode sonotrodes (as used in plastic welding) are:

- sonotrode length is half a wavelength
- maximum diameter (or other lateral dimension) is one third of a wavelength, to avoid interference from other modes of vibration

But what is the wavelength? This depends on the operating frequency and sound velocity of the sonotrode material. In most cases (using a minimum frequency of 20kHz and common materials such as aluminium, titanium or stainless steel) the maximum wavelength is around 250mm (10 inches). So according to the rules above the lateral dimension of a sonotrode cannot ever be larger than about 80mm (just over 3 inches). For more on these calculations please see the sonotrode calculator.

Of course, these rules can be broken, or at least avoided! Lower frequencies, down to 15kHz or less, permit a larger sonotrode size but with significantly increased audible noise. Larger sonotrodes are often constructed using a series of slots, dividing them up into sections each of which individually obeys the rules. Or alternative modes of vibration (eg. radial) may be used which completely eliminate these limitations. In most cases though larger sections will have further, more complicated rules of their own - finite element analysis and a significant amount of prototyping work will be required to arrive at a successful sonotrode design.

To avoid the need for complex sonotrodes, or when very large components make a full-size sonotrode impossible, there are other approaches such as spot welding and scanning (moving the component under the horn), and rotating horns are sometimes used to create continuous linear welds.

Power

The power required for an ultrasonic welding process depends mainly on the size of the weld, the materials being welded and the efficiency of transmitting power through to the weld. Most ultrasonic systems use control systems to adjust power input automatically as the process demands it, but obviously within the capability of the generator and transducer. With modern electronics used in ultrasonic generators it is the transducer that dictates the maximum power the system can handle, because of the same constraints on physical size discussed above for sonotrodes. Modern ultrasonic transducers can often handle 3kW, and some claim as much as 6kW, which should push out the boundaries of ultrasonic welding viability.

Using multiple transducers might be thought to be a solution to this issue but in practice it's difficult to achieve in axial-mode systems, as used for plastic welding, unless the transducers can be applied to completely separate ultrasonic sytems. Thus multiple ultrasonic systems can make discrete welds in several locations on the components.

To some extent it is possible to compensate for limited power by increasing the weld time, but this is at best non-ideal and in some cases may not work at all. The main problem is that more time permits greater heat transfer out of the weld zone.

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Thermosets vs thermoplastics

Ultrasonic welding depends on the materials softening (but generally not melting) with increased temperature. Therefore it is suitable **only** for thermoplastic polymers, not thermosets.

Amorphous vs crystalline

Most thermoplastic polymers have a generally amorphous structure with some degree of crystallinity - that is in small regions of the material the chain molecules are aligned in an orderly fashion like a crystal. In the ultrasonic welding process crystallinity is a disadvantage for 2 reasons:

- Crystalline materials tend to absorb vibration energy before it can be passed through to the welding zone. This means more power is needed to weld them, with far-field welding being a particular problem.
- Amorphous materials melt gradually over a range of temperature, whereas crystalline materials have a sharper melting temperature. This makes it harder to achieve a good quality weld without damaging the components.

ABS, Acrylic, Polycarbonate and PVC are amorphous polymers - with little or no crystalline structure, they are ideal for ultrasonic welding. Polyethelene, Polypropylene, Polyester and Nylon are semi-crystalline - much more difficult to weld with ultrasonics.

Reinforcing and filling materials and additives

Different fillers and additives affect the welding process either positively or negatively. There may be advantages from increased component rigidity and melt viscosity (ie. the molten material is more viscous), for example using glass fibre fill. Alternatively reduced friction and lower melt viscosity will reduce the effectiveness of plastic welding, eg. when using lubricants or talc filler. One further consideration is the potential for abrasive fillers to rapidly wear out the sonotrode.

The range of possible fillers and additives is enormous - contact your material supplier to discuss the likely effects.

Welding dissimilar materials

In general best results are obtained when both components to be welded are made from identical material, but in some cases dissimilar materials can be welded using ultrasonics. For this to work the materials must be chemically compatible and have similar melting points (easier for amorphous materials - see discussion of amorphous and crystalline materials above). One of the best combinations is ABS - Acrylic (PMMA) though others are also possible to different degrees. Probably the most requested combination is Polyethelene - Polypropylene (PE to PP) but general wisdom seems to be that these are chemically incompatible.

Joining incompatible materials may still be possible using other techniques related to ultrasonic welding, such as staking or reforming. These processes soften and reshape only one of the components, trapping the other in place. Strong structural joints can be achieved in these processes but not a hermetic seal - for this you would need some supplementary seal (eg. gasket or o-ring).

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POWER Ultrasonics

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Ultrasonics can be used to weld different metals together, without solder and flux or special preparation. The process is different to plastic welding in that the two components are vibrated parallel to the interface. This is a more intuitively logical method of generating friction between them, but frictional heating is not thought to be the prime mechanism of the process - the temperature needed to melt (or even soften) most metals would be very difficult to achieve. Instead the mechanism is thought to be diffusion-bonding: atoms of each part diffuse into the other when the two surfaces are brought together in close contact. The ultrasonics promotes this close contact by breaking down the surface oxide layers, allowing the "raw" metals to make contact.

The process has some limitations. It is only suitable for relatively small components (a prime example is welding connectors to car battery leads) since the power required to weld larger parts would be higher than can practically supplied by this method. Also the process tends to mark and deform the components, since high clamping forces and sonotrodes with serrated working faces must be used to grip the workpiece firmly.

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Back in the 1970's, ultrasonic tube- and wire-drawing was a popular research subject, and some equipment was put into production. More recently these heavy-industrial applications seem to have dropped out of sight. Can anyone tell me of equipment still in use today?

My own experience of power ultrasonics is mainly in this field. CarnaudMetalbox R&D (now a part of Crown Cork and Seal - the biggest packaging company in the world) and Loughborough University developed a new aerosol can using a number of novel metal-forming processes, starting with ultrasonic necking (i.e. reducing the diameter of the can at one end). The advantage of using ultrasonics in this case was to minimise friction between the can and the die, thus reducing the forming force. Without ultrasonics the force was so high that the can body would buckle and collapse during the necking process. With ultrasonics a 30% reduction in can diameter could be achieved in a single operation (in conventional necking processes the maximum is typically about 5%).

The ultrasonics were only effective when the vibrations were perpendicular to the surface - for a cylindrical can this meant developing a round die that would vibrate in the radial direction. As with other high-power applications, all tooling had to be resonant, so the desired mode of resonance was a uniform hoop expansion / contraction. We quickly found that while it was fairly easy to design a die to resonate in this mode at the frequency of the ultrasonic equipment, excluding other modes of vibration was a major challenge!

Another difficulty was that with the whole die expanding and contracting there was no convenient nodal (stationary) point which could be used for mouning it. This was solved by the use of a tubular mounting system which was itself resonant at the same frequency as the die.

The ultrasonic forming process went into production making small-diameter aerosol cans in a UK factory. The production line still runs intermittently, making promotional packaging for several prominent customers. One of its products ("Fleurs de Paris" parfum deospray can) won a silver in the 1997 Metal Packaging Manufacturers Association awards.

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Ultrasonics have been used in several ways for machining metals. Lathe tools may benefit from deliberately-induced vibrations to prevent "chatter" which compromises the surface finish of the finished component. Ultrasonic drills, used on very hard ceramics, work by grinding or eroding material away - a liquid slurry around the drill bit contains loose hard particles which are smashed into the surface by the vibrations, eroding material away and creating more loose hard particles.

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Imagine a knife which moves itself backwards and forwards in a sawing action, thirty thousand times a second. True the distance moved is very small but the acceleration is so high that nothing can move with the blade or stick to it. Ultrasonic scalpels are used by surgeons where they want to cut without exerting any pressure. In industry ultrasonic cutting tools are used for products that are difficult to cut by other means.

The heat generated by the ultrasonic vibrations can also be useful. Some man-made fabrics are cut and simultaneously sealed using ultrasonic knives to prevent fraying.

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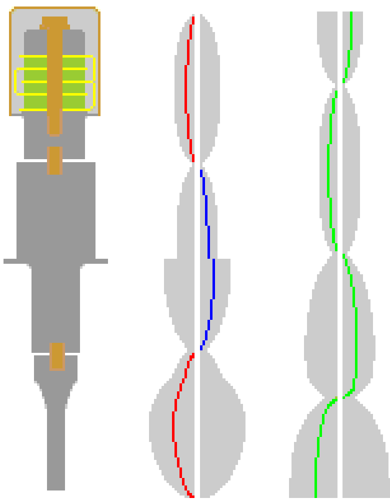
Cleaning was one of the earliest industrial applications of ultrasonics. Objects to be cleaned are placed in a bath of fluid which is violently agitated by a number of ultrasonic transducers. The fluid may be water or solvent based, depending on the application. Traditionally the transducers were fitted around the walls of the cleaning bath, but some modern equipment uses an external transducer attached to a resonant probe which transmits the vibrations to the fluid.

The ultrasonics may affect the cleaning process in several ways. Rapid movement in the fluid can help to de-wet surfaces, overcoming surface tension, and may also help to dislodge dirt particles and carry them away from the surface. Cavitation is probably the most interesting (and potent) effect - the shock waves generated by tiny implosions of vapour bubbles can be devastating at close range. The bubbles are so tiny that they can penetrate even the smallest crevices, making the process ideal for parts which could not be cleaned by other methods. Note also that the process must be well controlled to minimise erosion of the surfaces of the parts being cleaned. The standard test of ultrasonic intensity in a cleaning bath is to immerse a standard foil strip for a set time, then remove it and count the number of holes!



Congratulations on reading this far. Now see the anatomy of an ultrasonic system - a diagram of the equipment used to generate high-power ultrasonic vibrations, along with brief descriptions of all the parts, or the applications page for a discussion of the industrial applications.

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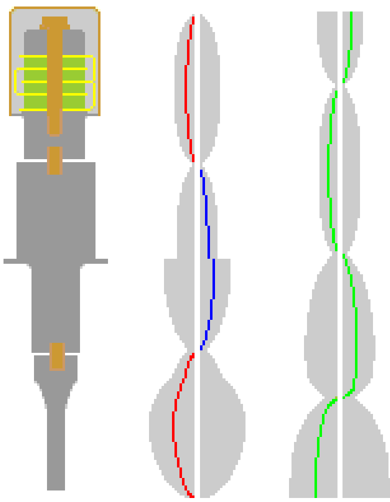

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MEASURING TECHNIQUES
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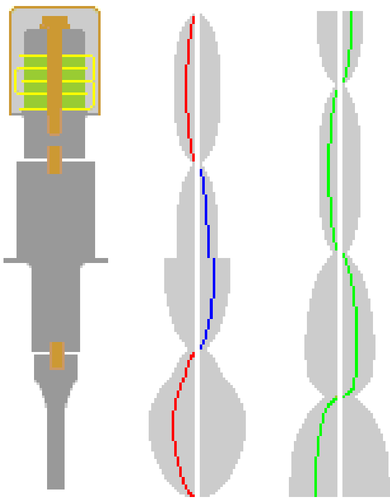
Along with many other thing in life, ultrasonic systems can only be controlled if you can measure what they are doing. There are three important parameters: resonant frequency, resonance mode and vibration amplitude. These are normally tested for a complete ultrasonic system - transducer, booster (if used) and sonotrode. The resonant frequency can be determined electronically from the power supply to the transducer, ideally using equipment which scans through a range of frequencies so that multiple resonances can all be measured.

Finding out the vibration mode-shape and amplitude is more difficult. How do you measure movements so small and so fast? The traditional method is to gently touch the sonotrode with the fingertips and feel the vibrations (it's a kind of oily sensation). Hardly quantitative, but surprisingly effective for comparing the vibration amplitude in different areas. Just be careful not to press too hard, or it will burn! For safety reasons this method cannot be recommended. A safer traditional option (for flat surfaces only) is to set the surface up horizontal and sprinkle talc on it. The talc flows over the surface from areas of high amplitude to stationary or low amplitude regions.

Modern methods include non-contact sensors working on capacitive, inductive or optical principles. These should give quantitative results (after calibration if required) but tend to be expensive - at least compared to talc or touch! The other disadvantage is that you can usually only measure the amplitude perpendicular to the surface (in-plane movement is ignored) and only at a single point.

The "Rolls Royce" of ultrasonic measuring systems is ESPI (electronic speckle pattern interferometry). The system developed by Loughborough university is capable of quantitative amplitude measurement in three orthogonal directions over the complete system.



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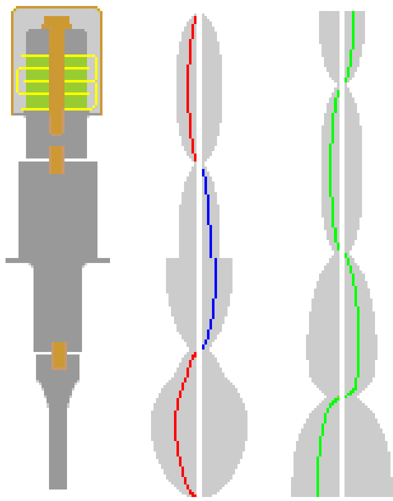
Friction reduction

One consequence of the immense accelerations generated by high-power ultrasonics is that unless surfaces are held very firmly together they will tend to separate. Where one surface is required to move over another with minimum friction, this effect can be exploited - while there is no contact between the surfaces friction is reduced to zero. Furthermore the relative movement may cease during the time when the surfaces are in contact, allowing *all* movement to happen under zero friction while they are apart. This is one of the effects used for ultrasonic metal forming - the tools vibrate so that the workpiece can move over them with little or no friction.

Stress superposition

This is the other effect used in ultrasonic metal forming. In order to deform a metal workpiece the stress within it must be sufficient to cause yield. Normally this stress is generated by an external mechanical force only (e.g. from a press tool). If the workpiece is also subjected to ultrasonic vibrations, these will generate alternating stresses which are superimposed on the constant stress due to external force. The workpiece will begin to deform when the total stress exceeds the yield limit, during that small part of the vibration cycle when the vibration stress is at a maximum, and the external force can be much lower than would normally be required. This effect is usually only useful where the external force is limited by some feature of the process itself e.g. if force must be transmitted through the workpiece itself, and it has insufficient strength.



Depending on the circumstances, high-power ultrasonics can have different effects (or sometimes no useful effect) on a process, so it's important to understand what effects are possible and why they happen. These are the main (possible) effects:

Heat generation
High-energy mechanical vibrations can very easily be converted to heat, either by friction at interfaces between different parts or by damping ("internal friction") within the materials. This effect is exploited in welding, where plastics and metals are welded with great efficiency because the heat is generated precisely where it's needed - at the surfaces to be joined. The effect can also be a limitation - we talk about power "losses" caused by energy being converted to heat within the transducer, booster and sonotrode and at the interfaces between them.

Cavitation

Whenever ambient pressure is reduced, the boiling point of a liquid is also lowered. If the pressure is reduced far enough then the liquid will begin to boil without needing to be heated (because the boiling point is reduced to below room temperature). When this happens on a small scale, due to localised pressure reduction, small bubbles of vapour are formed - this is called cavitation. It can happen in a liquid subjected to ultrasonic vibrations or in other circumstances where movement creates areas of low pressure (e.g. ship's propellors). Most of the effects are caused not by the formation of vapour bubbles but by their destruction. The low-pressure areas are highly localised and changing all the time (for an ultrasonic standing wave the time between lowest and highest pressure is typically 10 to 25 microseconds). The bubbles can exist only when the pressure is low - they are extremely unstable when it is high so they collapse violently, momentarily creating immense temperatures and pressures. Of course, the collapse of each bubble happens in a microscopically small volume but given a strong, uniform ultrasonic field millions of them throughout the liquid will be formed and destroyed thousands of times per second, so they can affect the bulk properties of the liquid. The effect is exploited in sonochemistry and ultrasonic cleaning.

6. MEASUREMENTS - DIES AND MOUNTINGS

MEASUREMENTS - DIES & MOUNTINGS

The die design work described in the previous chapters has been largely theoretical. This was backed up by practical verification at the time, to ensure the validity of the theoretical models. Some of this verification work was by comparison with other theoretical models, and this was described in chapter 3. The work described here is the ultimate verification - the physical testing of dies manufactured for various processes during the course of the project.

For the ultrasonic dies and mountings designed by finite element analysis the essential verification involved simple checks on the performance and the longevity of a component. More detailed testing was also used to help estimate the likely accuracy of future finite element models.

The purpose of this chapter is to describe methods of testing the ultrasonic equipment, to record the measurements made and to compare the measurements where possible with the theoretical expectations.

6.1 EVALUATION OF MODE AND FREQUENCY

Electronic equipment for the measurement of frequency is readily available. This can be used to measure the driving frequency of the power supply to the die, but to be meaningful this information must be related to the response of the die.

The simplest method of evaluating vibrations is using a power meter to monitor the electrical power being supplied to the transducer. Provided that the high frequency power supply operates at (approximately) constant voltage the input power will peak at resonance. Voltage is effectively equivalent to force, and current to amplitude. This is a useful method of finding a resonance but gives no information on the mode of vibration.

There are several 'traditional' physical methods for determining the die's motion as illustrated in figure 6.01. The relevant ones will be described in turn.

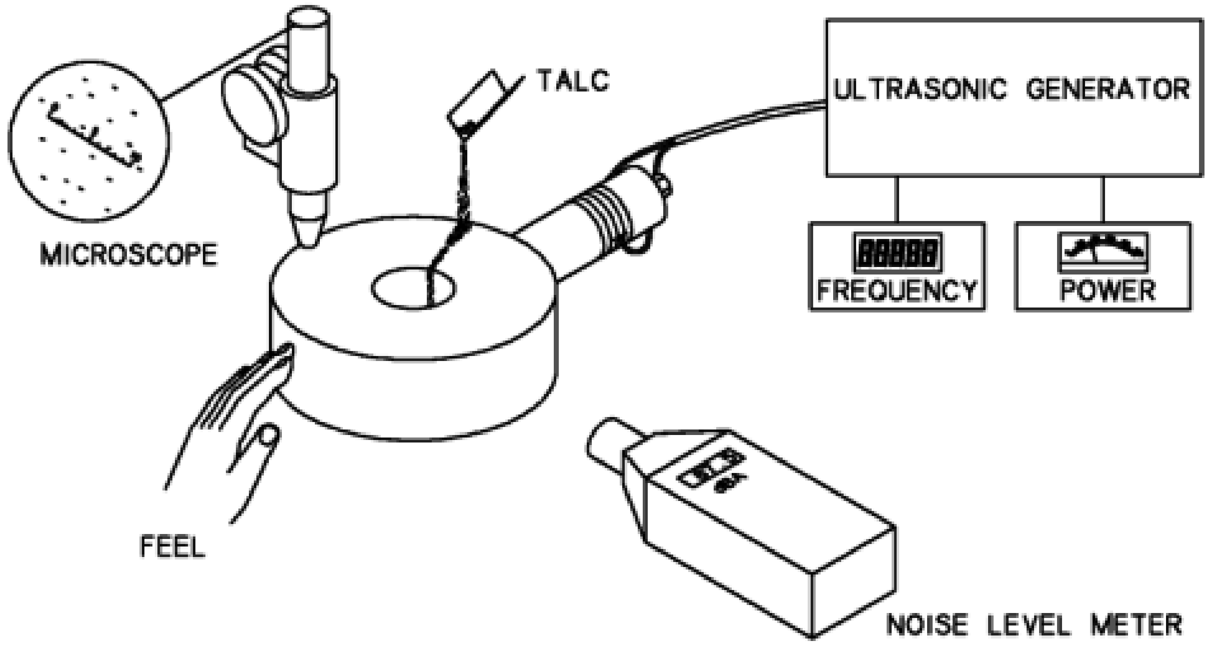


Figure 6.01 - "Traditional" methods of measuring die vibration

6.1.1 Physical methods for evaluating mode of vibration

One simple and sensitive method of testing the vibrations is the 'feel' of the die surface - activity can be gauged roughly by gently touching the vibrating surface. High amplitude vibration is indicated by an oily, frictionless feel. Note that this technique is not generally recommended because of possible medical effects which may include tissue damage due to vibrations and / or burns from energy transfer. Ultrasonics are used in physiotherapy but at higher frequency and much lower power. Some of the physical / safety effects of ultrasonics are discussed in section 1.4.

Another physical output of most ultrasonic systems which also has obvious safety implications is the airborne noise. Using a sound level meter at a fixed distance this can be used as a measure of die activity. By moving the meter around the die at a fixed distance it is possible, in theory, to find areas of high and low activity. In practise, however, picking out different modes of vibration by this method is very difficult because of the radiation of noise in all directions from all parts of the die.

Use of a sound level meter will also show whether the operator is at risk from the noise emitted - hearing protection should be worn if the operator is to be close to unshielded equipment for a significant time. Again, see section 1.4 for a discussion of the safety aspects of ultrasonic noise.

A simple, non-hazardous method of indicating the mode of vibration is using fine powder (talc).

The die must be set up with its axis vertical and while it is vibrating in some unknown mode the talc is sprinkled on the flat top face. The vibrations cause the talc to move over the surface and each mode of vibration shows a characteristic pattern of talc flow. The use of this technique to evaluate vibrations of circular plates (producing "Chladni figures") was described by Waller [113]. For example, if the die was working properly in the R0 mode (as described in chapter 3) then the talc would flow smoothly inwards to the hole in the centre, whereas if the die was vibrating in the R3 mode there would be six areas (corresponding to the nodal points) where the talc would not move or would move tangentially. Figure 6.02 shows some talc patterns observed, and these are discussed in section 6.2.1.

A more sophisticated method used for measuring the amplitude on the outside surface of the die was the Telsonic amplitude meter. This device uses an eddy-current sensor for sensitive measurement of distance and electronic processing to produce a digital readout of amplitude perpendicular to the surface. No special mounting is required - the probe is simply held close to the vibrating surface. The measurements depend on the electrical properties of the material so the system is only applicable to aluminium and titanium (the materials for which it was calibrated). Because of its high purchase price this piece of equipment was obtained only on hire to evaluate the motion of a specific die when required. See the work of Chapman and Lucas [114, 115] for some results obtained from this equipment and used in modal analysis.

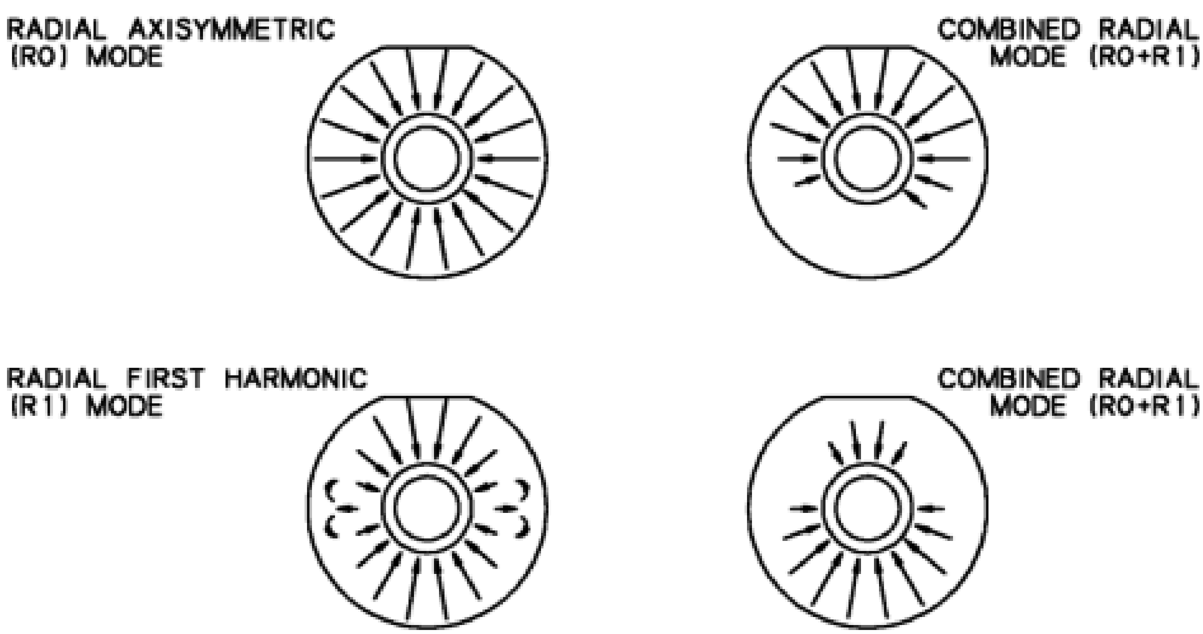


Figure 6.02 - Patterns of talc movement

All of the methods described above were used in early work on ultrasonics at CarnaudMetalbox. The high frequency power supply used at that time offered full manual control of frequency. This allowed the user to drive the ultrasonic tooling over a wide range of frequencies and determine its response, using a power meter and by physical methods. For later work, however, ultrasonic systems from the plastic welding industry were used. The single-frequency dedicated ultrasonic generator and transducer were capable of operating at much higher efficiency than the earlier system (and hence providing greater amplitude) but were not suitable for operating over a wide frequency range. Furthermore the operating frequency is not under the control of the operator, instead an automatic frequency control 'latches on' to resonance. These systems are therefore not suitable for full testing of the ultrasonic tooling. Appendix 7 contains specifications for the ultrasonic generators and transducers used in this work.

6.1.2 Admittance / Impedance Plotter

Following the adoption of single-frequency ultrasonic systems there was a need for a dedicated test system to perform the measuring functions which the new equipment could not handle. The equipment selected (called an Admittance / Impedance Plotter and supplied by Sonic Systems [116]) comprises a variable frequency generator with output voltage suitable for piezo-electric transducers. A digital frequency meter gives an accurate measure of the output frequency, which can be adjusted manually or set to scan automatically over a range at variable scan rates (for specifications see Appendix 7).

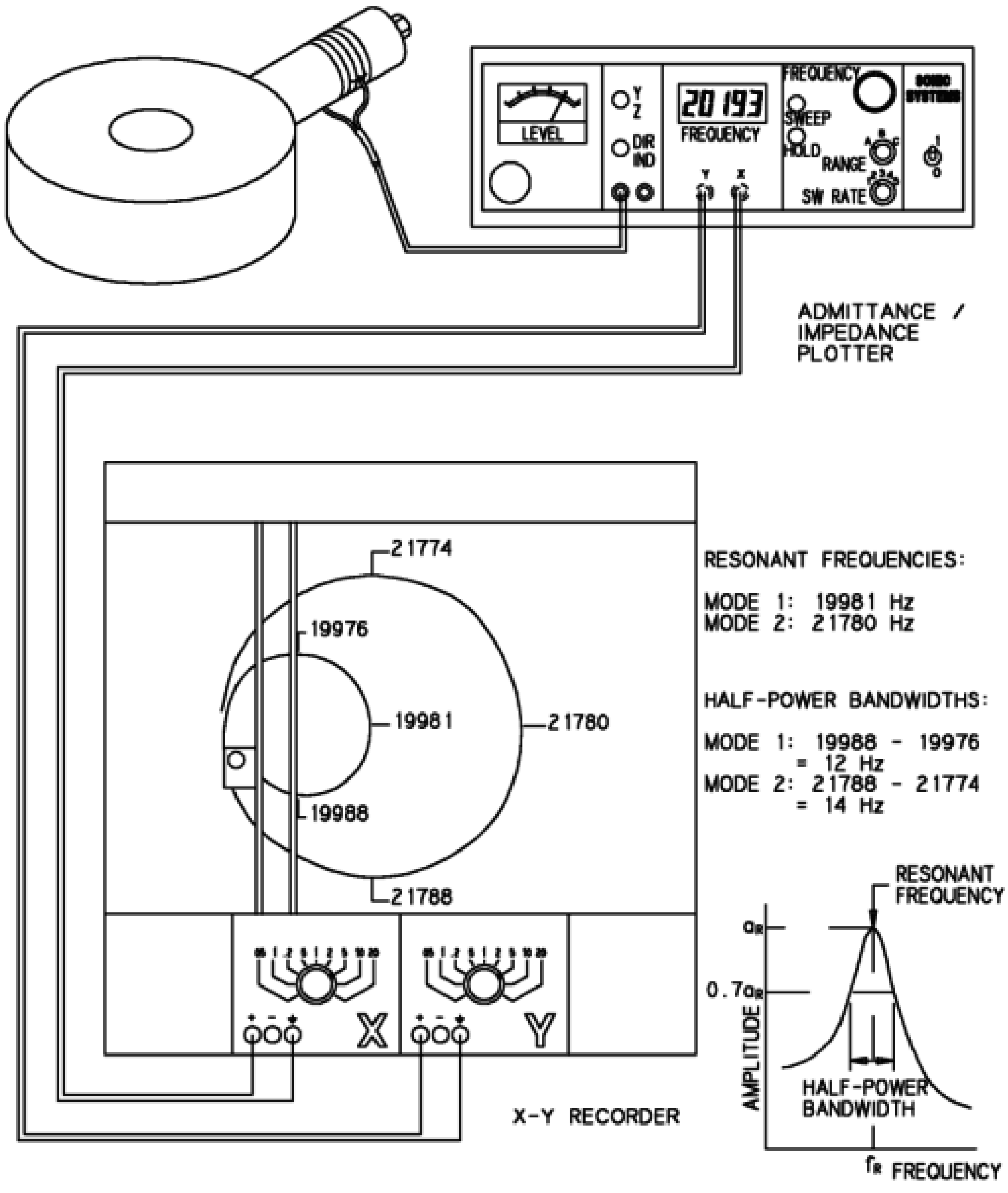


Figure 6.03 - Measurements using Admittance Plotter

The most useful feature however is the signal output of the electrical admittance (or impedance) of the transducer. Two signals are provided, corresponding to the real and imaginary parts of the admittance / impedance and these should be connected to the X and Y inputs of a chart recorder. Thus the complex admittance or impedance is displayed as a point on a polar plot (a conventional form of display for complex numbers) and the variation with frequency is displayed as a curve.

This is useful because over a wide frequency range (eg 16 to 24 kHz) the electrical properties of the ultrasonic transducer change only gradually. The observed variation in electrical admittance or impedance depends almost entirely on the mechanical resonances of the transducer and anything attached to it. As the frequency is scanned through a resonance the admittance plot describes a circle, while scanning through an antiresonance causes the impedance plot to describe a circle.

Of these, the admittance plot is generally the more useful. It can be shown [68], [116] that the point of zero imaginary admittance corresponds to resonance while the points of minimum and maximum imaginary admittance (at 90° on the circle) correspond to the half-power points. Furthermore the size of the circle is inversely proportional to the power losses in the system. (Note however that this information should be treated with caution - this is an indication of power loss at low amplitude but material damping can be very non-linear so results at high amplitude may not correspond.) Figure 6.03 shows the general arrangement of equipment and a typical circle plot with the significant features marked for clarity.

By careful study of the admittance plot and the frequency meter the following information can be obtained for each resonance:

Resonant frequency

Half power bandwidth

'Q' factor

System losses

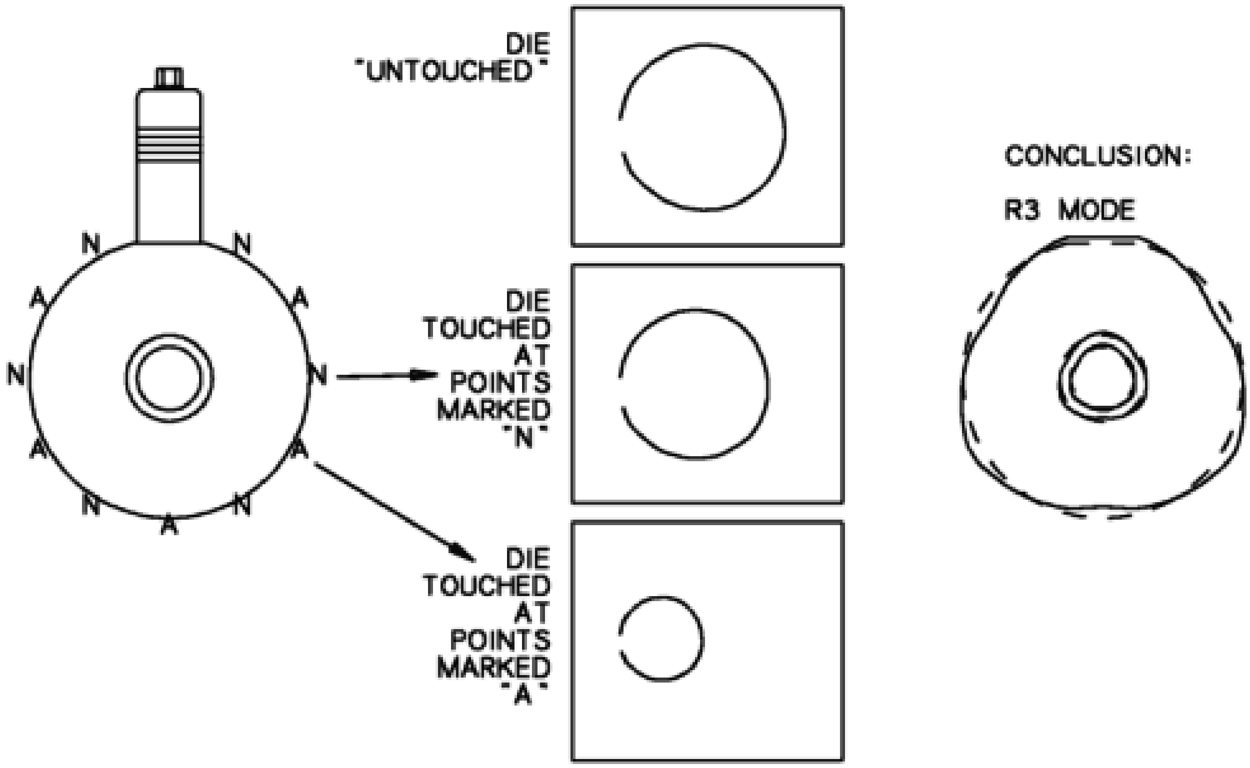


Figure 6.04 - Mode identification using Admittance Circle Plotter

With a little further effort the user can also gain a clear idea of the mode of vibration. The generator frequency should be set to resonance with the pen plotter (or a simple voltmeter) indicating the real component of admittance. When the die is touched the extra losses introduced by a human finger are detectable by a reduction in admittance (the circle becomes smaller). The safety concerns about touching vibrating tools described in the previous section are not relevant here because the power output of this generator is very much smaller. The reduction in admittance depends on the mode of vibration and where the die is touched. Touching at a vibration node will have little or no effect on the admittance while touching at an antinode will have most effect. Thus by touching the die and watching the admittance display the user can quickly identify nodal areas (if any) and hence establish the mode of vibration. Figure 6.04 demonstrates the principles of this method.

6.2 RESULTS OF MEASUREMENTS ON ULTRASONIC DIES

6.2.1 Mode evaluation using talc

Figure 6.02 shows some typical talc patterns found in early work on this project. In these diagrams the arrows show the direction of the observed talc flow and the relative size of the arrows indicates roughly the speed of flow.

Note that while the relative amplitude of different areas of the die is clearly shown (by the size of the arrows) all phase information is lost. In both the radial axisymmetric (R0) and the radial first harmonic (R1) mode the areas at the top and bottom of the die (in this view) appear identical. The arrows indicate that for both modes the talc moves quickly towards the centre of the die. The important difference is that in the R0 mode these areas are in phase, moving inwards and outwards together, whereas in the R1 mode they are 180° out of phase ie. the top moves inwards while the bottom moves outwards. (See section 3.1 for a detailed description of these modes.) It is this phase difference which accounts for the cancellation of amplitude over a part of the die which is seen in the combination modes. Depending on the phase angle between the R0 and R1 modes and their relative amplitude, cancellation of movement can occur at either top or bottom of the die or anywhere in between, while in other areas the movement due to the two modes will add to give increased motion.

At the time these measurements were made the unwanted harmonic modes of vibration were not understood and the uneven modes of vibration were blamed (wrongly) on a poor interference fit between the inner and outer parts of the die.

6.2.2 Admittance plotter measurements

In later work finite element analysis was used to help in understanding the unwanted modes of vibration and in predicting their natural frequencies. The admittance plotter measurements were so complete and accurate that most work in evaluating the performance of ultrasonic dies was done using this method. Tables 6.01 to 6.05 and 6.12 to 6.13 show many of the results obtained. In each case the resonant frequency, half-power bandwidth and circle diameter (in mV) is recorded for each resonance, along with any other relevant measurements obtained (eg. power input at a given amplitude level). Note that power and amplitude measurements must be treated as approximate indications because of unknown calibration of the various meters, although comparisons should be valid between measurements using the same ultrasonic equipment.

The measurements taken, and the corresponding descriptions / comments have been divided into four categories: transducers, die tuning and miscellaneous dies and mountings are included here. Use of the admittance plotter in evaluating the mounting is described in section 6.4.2.

6.2.2.1 Admittance plotter measurements - transducers

Table 6.01 shows measurements of various transducer systems used for this work (see appendix 7 for equipment details).

Items 1 to 7 are all measurements of the same component (the Kerry Ultrasonics transducer serial number 757). Multiple measurements were made because a circle plot of the transducer alone was usually made as a reference at the beginning of each series of tests (eg tuning a die). This shows some variability in the measurements. The transducer varies in frequency from 19911 to 20035 Hz and in circle diameter from 56 to 63 mV. The measurements were made with the transducer resting on a flat surface (eg a table or bench) so the changes in circle diameter (indicating changes in power losses from the component) could be caused by differences in its positioning or in the coefficient of friction on the surface. This would not account for the changes in resonant frequency, however. Some variability would be expected as a result of temperature variations but there is also a general trend of frequency rising with age. This might be caused by gradual aging of the piezo-ceramic crystals or by "bedding in" of the interfaces. In any case the rate of frequency rise is not great enough to cause any problems.

Items 8 and 9 are measurements of the second Kerry transducer, serial number 786, which was apparently identical to the first. These show a slightly higher resonant frequency and a smaller circle diameter (average 51 mV compared to 60 mV). This indicates a slightly greater power loss from the second transducer. The greater half-power bandwidth of transducer 786 (34 Hz compared to 27 Hz average) also indicates higher power losses. Note that the half-power bandwidth can only be used to compare power losses in this case because the two components are nominally identical. At constant frequency the power loss is proportional to half-power bandwidth and to stored energy. The stored energy is a function of size, shape and material so it should be the same for two identical transducers.

Item 10 is another transducer from a different manufacturer (Telsonic Ultrasonics) which also features an integral "can" to guard the electrical connections to the transducer (useful because high voltages are used) and also to protect the transducer from damage due to accidental knocks. Despite this extra component which must absorb some power, the large circle diameter indicates lower power losses than for either of the other transducers. In fact this transducer is made from aluminium alloy, whereas the others are made from titanium alloy and steel. The moving mass of the Telsonic transducer is therefore less than that of the Kerry transducers and hence its stored energy is less. It is this that allows the Telsonic transducer to operate with lower power losses. The difference in stored energy could also be deduced from consideration of the half-power bandwidth of the Telsonic transducer - it has a larger half-power bandwidth (49 Hz compared to 34 or 27 Hz) but a smaller power loss (indicated by the circle diameter) so its stored energy must be less.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREOENCIES /Hz. BANDWIDTH /Hz. CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry transducer 757	9/86	-	-	19960	26	62	21219					
02	Kerry transducer 757	9/86	-	-	19911	25	56	21263					
03	Kerry transducer 757	10/86	-	-	19966	25	57						
04	Kerry transducer 757	2/87	-	-	19991	28	62						
05	Kerry transducer 757	2/87	-	-	20015	?	63						
06	Kerry transducer 757	3/87	-	-	19987	28	62						
07	Kerry transducer 757	11/87	-	-	20035	29	60						
08	Kerry transducer 786	9/86	-	-	20029	34	52	21387					
09	Kerry transducer 786	2/87	-	-	20116	?	50						
10	Telsonic transducer + "can"	11/87	-	-	20332	49	65						
12	Kerry 786 + Magnetostrictive system	9/86	-	-	20037	277	1.7	20239					
14	Kerry 757 + Inv Gold booster (1:1.4)	9/86	-	-	19726	31	35						
15	Kerry 757 + Inv Gold (1:1.4) + case	3/87	-	-	19705	44	27						
16	Kerry 757 + Inv Red (1:1.75)	9/86	-	-	19854	19	59	20703					
17	Kerry 757 + Inv Red (direct)	9/86	-	-	19893	44	26	20728					
18	Kerry 757 + Inv Red (indirect via cable	9/86	-	-	19894	47	26	20674					
19	Kerry 757 + Inv Red (1:1.75) + case	10/86	-	-	19885	48	27						290W at 27.5u
21	Kerry 786 + Inv Titanium 1:1.25	10/86	-	-	19854	22	46						170W at 27.5u

TABLE 6.01 - ADMITTANCE PLOTTER MEASUREMENTS - TRANSDUCERS AND BOOSTERS

Item 12 shows the result of fixing the Kerry transducer (number 786) to the magnetostrictive transducer system used for the early work on this project. This result is remarkable for the huge half-power bandwidth and the tiny circle diameter which indicates very high power losses. The inefficiency of the magnetostrictive system in comparison with the piezo-electric ones has also been demonstrated by direct measurement of power and amplitude so this type of result is to be expected. Note also that the large half-power bandwidth has a positive benefit in allowing the transducer to operate over a wide frequency range, as discussed in section 1.1.5.

Items 14 to 21 show the results of fitting various interstage horns ("boosters") to the Kerry transducers. The aim was usually to give a reduction in amplitude because the transducer was vibrating at approx 27 μ whereas the die design indicated a limit of 20 μ. Measurements with the booster alone (items 14,16,21) show a slight reduction in circle diameter, indicating a small increase in the power loss. The other reason for using a booster was to fit a guard (case) around the transducer. This was fixed to a nodal flange on the booster so that (theoretically) no energy would be transmitted from the vibrating system to the case. In practise the measurements indicate a further increase in the power loss and the system with booster and case had a circle diameter about half that of the transducer alone (ie twice the power loss). Measurements were also made of the power and amplitude (using the meters on the Kerry system). Reference to these and the circle diameters suggests that approx 150 W is required to operate the Kerry transducer at 27+ μ, with a further 150 W lost in the case, if fitted.

One further comparison is also shown in this series of measurements (items 17 and 18). A system comprising transducer, booster and case was measured with the Admittance plotter connected directly to the transducer, and connected via a cable 3 m long (this cable was used to supply the transducer while it was used for can necking in the hydraulic press). The direct / indirect switch on the admittance plotter was also changed accordingly. There was no significant difference between the readings, indicating that the use of the extra cable did not impair the performance of the ultrasonics.

6.2.2.2 Admittance plotter measurements - die tuning

Tables 6.02 to 6.04 show the tuning procedure for six ultrasonic dies. The method of tuning a new die is described in detail in section 3.8, but the essential point is that the die must be manufactured oversize on outside diameter and gradually machined down until the resonant frequency meets the requirement (usually 20 + 0.1 kHz).

Items 1 to 7 in table 6.02 show the tuning of a die constructed from a titanium alloy outer with a ferro-titanit insert, used for necking a 45 mm diameter aerosol can to 33 mm diameter. Note that for this system (die and transducer) three resonances have been found at each stage of the tuning process. By widening the frequency range many more resonances could have been found for all systems tested. In general only those in the range 18 to 22 kHz have been noted because outside this range the other resonances have not been found to cause a problem.

For the initial measurement of the die as manufactured resonant frequencies were found at 18.1, 19.6 and 21.5 kHz. From the finite element analysis it was expected that the R1 (first harmonic) would appear below the R0 (axisymmetric) and the R3 (third harmonic) above it. It was therefore expected that the three resonant frequencies corresponded to R1, R0 and R3 modes respectively. Touching the die and noting the response of the admittance plotter (as described in section 6.1.2) confirmed this. In general the resonant frequencies have been recorded with the R0 frequency first, followed by the unwanted resonances.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz, BANDWIDTH /Hz, CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + Ti/Fe 45-33 die	10/86	156	Initial	19622	12	10		21456	17	18		
					18108	10	2						
03			154	-2	19811	10	13		21625	14	23		
					18372	7	2						
05			153	-3	19899	10	13	19984	21705	14	23	21928	
					18518	10	2	18988					
07			152	-4 complete	19981	12	13	20075	21780	14	23	22005	
					18647	13	2	19079					
10	Kerry 757 + Ti/Nk 45-31 die #2	2/87	162	Initial	19250	10	7		21064	19	16		
					17240	9	2						
12			160	-2	19385	6	13		21161	10	19		
					17470	9	2						
14			158	-4	19543	9	13		21294	19	14		
					17721	10	2						
16			156	-6	19754	8	16		21490	18	17		
					18022	9	3						
18			155	-7	19825	10	14		21563	21	14		
					18138	12	2						
20			154	-8 complete	19959	11	17		21686	21	15		
					18324	14	2						

TABLE 6.02 - ADMITTANCE PLOTTER MEASUREMENTS - DIE TUNING (1 OF 3)

As manufactured the R0 frequency was too low. This is normal because the die is made oversize with an allowance for tuning. During tuning the outside diameter of the die was progressively machined down, in this case from 156 mm diameter to 154, 153 and finally 152 mm. As a result the R0 frequency increased towards 20 kHz and the tuning process stopped when the frequency was 19.98 kHz (well within the specified limits). The relationship between frequency and diameter is fairly linear, as shown in figure 6.05. Typically the frequency rises by about 90 Hz per 1 mm reduction in diameter.

Note that during the tuning process both the R1 and R3 frequencies also rise. This is the reason why, in general, the problems experienced with interference from the unwanted harmonic frequencies cannot be solved by a change in the working frequency.

Note also that the circle diameter increased slightly as the tuning progressed. There are two likely reasons for this. Firstly as metal is removed from the die there is less moving mass and hence less energy loss. Secondly when the resonant frequency of the system is low there is a significant mismatch between the frequencies of the die and the transducer. Since the transducer is forced to operate away from its resonant frequency the interface between the die and transducer is not at an antinode (a stress node). This gives rise to power losses from friction at the interface.

Items 10 to 20 are the measurements made while tuning a similar die for necking a 45 mm aerosol can to 31 mm diameter. The die is again constructed from a titanium alloy outer with a ferro-titanit insert. The tuning is similar and the comments above apply equally well to this die also. The final die diameter achieved is 2 mm greater than the earlier die, probably because the inside diameter is smaller in this case.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz, BANDWIDTH /Hz, CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + Al/Nk 45-33 Diemounting	3/87	173	Initial	19464	7	13		20505	13	21		
					19581		2		20477		<1		
03			171	-2	19646	8	13		20647	15	20		
					19550	7	2						
05			169	-4	19786	7	17		20797	10	19		
					19555		<1						
07			167.5	-5.5	19878	8	18		20893	20	17		
08			166.5	-6.5 complete	19971	10	18		20964	18	17		
					21116		2						
11	Kerry 757 + Ti/Sy 45-31 Diemounting	8/87	167	Initial	19542	6	14		21418	21	12		
12			164	-3	19820	10	12		21728	30	13		
					20708	3	1.5		21653		1.5		
14			163	-4	19903	9	13/18		21814	28	11		
					20710	6	1.5		21663		1.5		
16			162.3	-4.7	19968	7	18		21896	48	11		
					20713	6	1.5		21645		1		

TABLE 6.03 - ADMITTANCE PLOTTER MEASUREMENTS - DIE TUNING (2 OF 3)

In table 6.03 items 1 to 6 are the measurements made while tuning another die for necking 45 mm aerosol cans to 33 mm diameter. In this case a ferro-titanit insert has been fitted in an aluminium "diemounting" (combined die and tubular mounting in one piece). Note that the tuned diameter (166.5 mm) is considerably larger than the earlier die (152 mm). This was predicted by the finite element analysis (and could also have been predicted by the design graphs of chapter 4 and appendix 5), so the initial, as manufactured, diameter of the die was increased accordingly.

The power loss for this die (as indicated by the circle diameter) is comparable, or slightly better than, the earlier dies. Aluminium is inherently a less "lossy" material but extra losses were introduced by the mounting tube and these effects approximately cancel. This is a good result for the mounting, indicating a relatively small power loss. Mounting performance is discussed further in section 6.4 and results are given in tables 6.12 and 6.13.

Note how close the unwanted harmonic frequency appears in this die (20.964 kHz after tuning). This is the third harmonic (R3) frequency which for the two earlier dies appeared at about 21.7

kHz. This is a particular problem for this combination of materials and geometry, leading to "mode switching" in use (see section 3.3.2). In this case the problem can be avoided by simply using other combinations of materials as shown by the results for the other die in table 6.03 and both dies in table 6.02.

Items 11 to 16 in table 6.03 show the results for another die, in this case constructed from a titanium alloy diemounting with a Syalon insert (see section 3.7 for a detailed description of the materials used for these dies). This again shows a relatively large circle diameter (provided the die was held at the mounting flange not placed on its face) and the R3 frequency at 21.9 kHz is separated from the working frequency far enough to avoid mode switching. Two new circles have also appeared at 20.7 and 21.6 kHz but these are very small (1.5 and 1 mV respectively) and so would not be expected to cause any problems. These are probably resonances of the mounting tube, remnants of the multiple resonant frequencies of the free mounting. Some tiny circles were often found in the circle plots of dies with mountings but circles of diameter less than 1 mV were generally not recorded.

Table 6.04 shows the results recorded while tuning two "shaped dies" (for further details see section 3.6). Items 1 to 9 are for a die made from aluminium alloy with a ferro-titanit insert with a profile suitable for necking 45 mm aerosol cans to 31 mm diameter. This is very similar to the diemounting (items 1 to 8 of table 6.03) which showed problems with the closeness of the R3 frequency. In fact this was deliberate. Knowing the problems with this combination of materials and geometry this die was constructed specifically for the purpose of testing a theoretical solution - the three-flat shaped die.

The initial results were recorded for the die before the three-flat shape was machined onto it. This shows the R0 and R3 frequencies where they would be expected (the R0 lower than 20 kHz before tuning, the R3 uncomfortably close). Using the rate of increase of the resonant frequencies observed for the earlier die during tuning an estimate of the tuned frequencies can be calculated. This calculation yields the following:

At diameter 170.3, R0 frequency 20.0 kHz, R3 frequency 20.76 kHz.

This would not be satisfactory because of the low R3 frequency, but in fact this tuning operation was not done. Instead the die was remachined to the three-flat shape. The three flats were made to equal dimensions, 74.0 mm from the centre of the die. This dimension was calculated to make the included angle of each flat 60° when the die diameter reached the predicted 171.0 mm (see figure 6.06). This procedure was used so that the tuning operation could be carried out by simple turning of the outside diameter of the die in a lathe, rather than repeated machining of the flats in a milling machine.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz, BANDWIDTH /Hz, CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + Al/Nk 45-31 Die (exp'l)	10/87	177.5	Initial	19438	8	13		20248	7	32		
					24232	19	42						
03			177.5	Initial	19726	9	26		22271	11	24		
					24208	15	17		24991	25	26		
05			176.5	-1	19756	11	29		22252	12	20		
					24248	14	16		25045	21	24		
07			174.5	-3	19886	13	29		22266	12	21		
					24388	20	15		25164	21	20		
09			173.5	-4	19951	14	30		22277	10	20		
					24454	16	14		25226	26	19		
12	Kerry 757 + Al/Sy 66-58 Diemounting	11/87	175	Initial	19265	11	9		20291	13	18		
					24831	34	17		25096	27	18		
14			175	Initial	19659	14	19		22238	17	9		
					24979		4		25326		4		
16			173	-2	19765	21	21		22176	25	5		
17			170	-5	19927	14	20		22229	15	12		
18			169	-6	19986	15	18		22233	12	12		

TABLE 6.04 - ADMITTANCE PLOTTER MEASUREMENTS - DIE TUNING (3 OF 3)

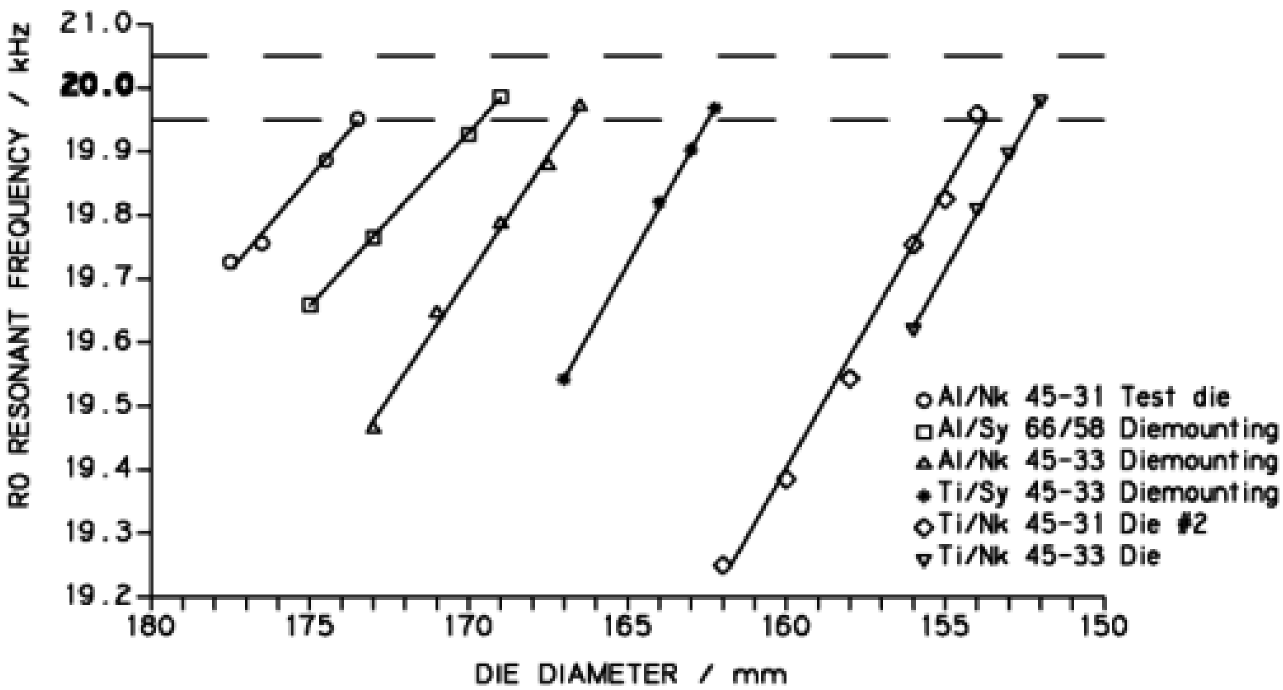


Figure 6.05 - Frequency increase during die tuning

When the die was retested the change in measured performance was dramatic, as shown by the results of item 3. The separation between the R0 and R3 frequencies has been increased from 0.8 to 2.5 kHz, and at the same time the size of the R0 circle has increased while the R3 circle has shrunk. The prime aim of using the shaped die was to increase the frequency separation but both of these effects act to reduce the chances of mode-switching.

Remember, however that there is a price to be paid for this improvement in the frequency performance of the die. The axisymmetric (R0) mode becomes distorted as if by addition of some R3 mode, causing a variation in the vibration amplitude around the die. This is described in more detail in section 3.6.

The subsequent tuning of the die was accomplished as normal but some differences from the tuning of round dies were noted. The rate of increase of the R0 frequency as the diameter was reduced is less than normal (see figure 6.05). This would be expected because when machining down a shaped die less material is removed than from a round die (the flatted areas are not touched). Also the R3 frequency did not change significantly during the tuning process (ie the rate of increase of the R3 frequency is effectively zero). Finally note that the tuned outside diameter is greater than that predicted earlier for the round die. Extra material is needed between the flats to make up for what is lost.

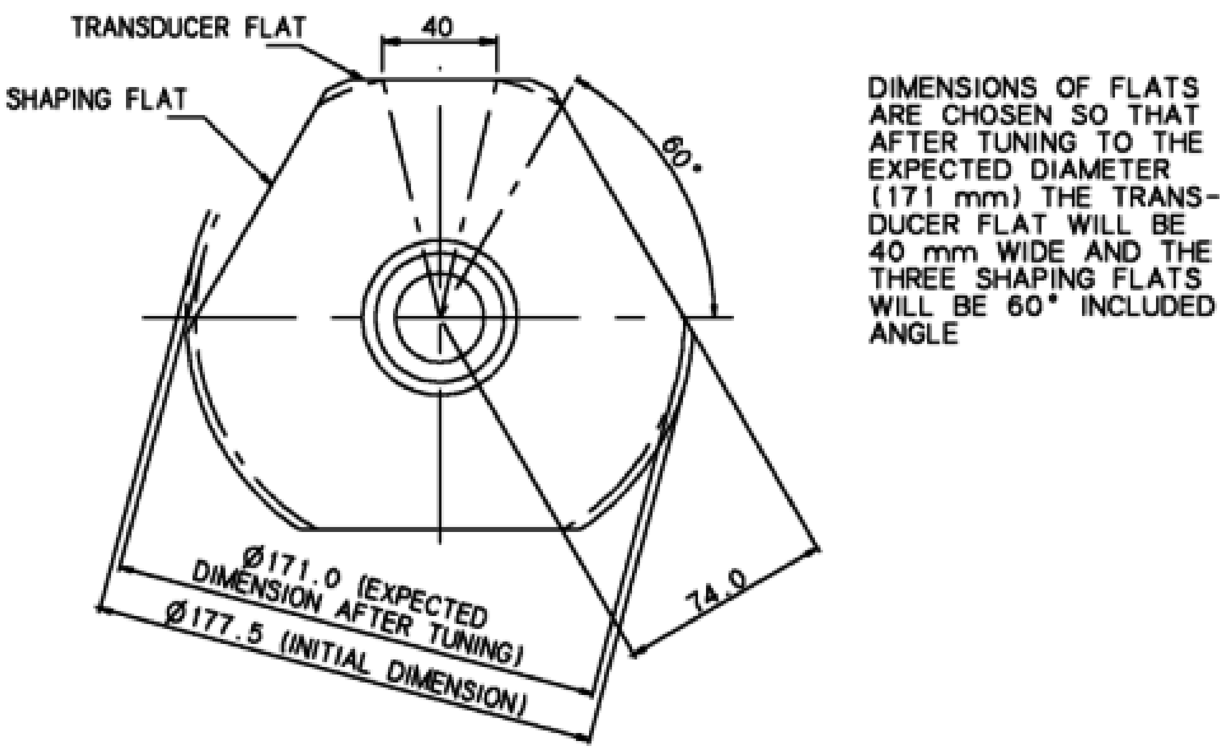


Figure 6.06 - Example of 3-flat shaped die design

The die described above was made as a test of the shaped die concept. For that application other material combinations were known which would give perfectly satisfactory results using the simple round die. There are other applications, however, for which no combination of the known materials would be satisfactory without using a shaped die. This is described in section 4.5.3. One such application is the necking of 66 mm beverage cans to 58 mm diameter. For this purpose a diemounting (combined die and mounting) was constructed using an aluminium outer die with a syalon insert. This was the first real application of the three-flat concept.

The results for this diemounting are listed in table 6.04, items 12 to 18. Again measurements were taken before and after machining the three flats, and during subsequent tuning by reducing the outside diameter. Again the flats were specified with the aim of achieving a 60° included angle after tuning. The distance from the centre to each flat is 73 mm, giving a theoretical 60° included angle at 168.6 mm diameter. The tuned diameter of 169 mm gives an included angle of 60.5°. The listed results for this die are almost identical to those of the experimental three-flat die described above. The final measured performance (based on circle diameter and frequency separation) is perfectly satisfactory.

6.2.2.3 Admittance plotter measurements - dies and mountings

Table 6.05 shows miscellaneous measurements made on a wide variety of ultrasonic dies from all stages of the project. In this section their characteristics and performance will be compared.

Items 1 and 2 are measurements of a solid aluminium test die, taken first with the die placed on the bench on edge, and second with the die suspended by a piece of string through its centre. Comparing these measurements shows no significant change in the resonant and antiresonant frequencies but a significantly smaller circle for the die placed on edge and a correspondingly

larger half-power bandwidth. These two cases tend to represent the extremes of fixing losses - for dies placed on one face (the usual method of testing) a circle diameter somewhere in between would be expected.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz. BANDWIDTH /Hz. CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + Al Test die 1 (on edge)	9/86	155	complete	20091	9	19	20193					
02	Kerry 757 + Al Test die 1 (suspended)	9/86	155	complete	20087	6	29	20194					
03	Kerry 757 + Al Test die 2 (forged)	9/86	155	complete	20063	6	30	20166					
04	Kerry 757 + 316/M2 die 2 (on edge)	9/86		complete	20019	6	6.5	20055					
05	Kerry 757 + 316/M2 die 2 (suspended)	9/86		complete			9.5						
06	Kerry 757 + MS die 9 (on edge)	9/86		complete	19852	17	4.5	19888					
07	Kerry 757 + MS die 9 (suspended)	9/86		complete			5						
08	Kerry 757 + EN41 die 9.1	9/86		complete	19962	6	7	20003					
10	Kerry 757 + 45-33 Al/Nk Diemounting	11/87	166.5	complete	19966	7	21		20942	15	12		
					21028	16	7		24017	7	9		
12	Telsonic + 45-33 Al/Nk Diemounting	11/87	166.5	complete	20011	10	18		20998	16	2		
					21125	14	23		24052	9	12		
14	Kerry 757 + 45-33 Al/Nk Diemounting + can + plunger	11/87	166.5	complete	20011	16	9		20952	16	11		
					21032	15	8						
16	Telsonic + 45-33 Al/Nk Diemounting + can + plunger	11/87	166.5	complete	20047	14	9		20992		1		
					21153	23	15						
18	Kerry 757 + 66-58 Al/Sy Diemounting (clamped at flange)	11/87	169	complete	19992	14	19		22202	20	6		
					17845	3	8						
20	Telsonic + 66-58 Al/Sy Diemounting (clamped at flange)	11/87	169	complete	20004	13	19		22270	10	12		
					17803	3	7						

TABLE 6.05 - ADMITTANCE PLOTTER MEASUREMENTS - MISCELLANEOUS DIES AND MOUNTINGS

Items 2 and 3 can be used to compare the test die (number 1) with another (test die 2) which was manufactured from a billet of aluminium which had been forged to give a grain structure which was expected to be more favourable to the radial vibrations. The forging was done by taking a 5 inch diameter bar of aluminium alloy and forging it axially to half its original length, causing the diameter to grow to about 7 to 8 inches. The same grade of aluminium was used for both dies and they were geometrically identical. Comparing items 2 and 3 it is clear that there is no significant difference between the measurements made of these two dies. It is possible that the modified grain structure of the forged die could make it more fatigue-resistant but this could not be verified without testing to destruction at high amplitude (which was not done).

Items 4 and 5 again show a comparison of measurements made with the die on edge and suspended. The die in this case is one of the early design dies intended for necking a 45 mm aerosol can to 25 mm diameter (this process was never successful). The die was constructed using an M2 insert in a stainless steel (316) outer. Neither of these materials has been commonly used in more recent dies, the M2 because alternatives are available which are harder or more convenient to use (see section 3.6) and the 316 because it is far more lossy than the preferred titanium and aluminium alloys. This is shown by the admittance circles which are less than half the size of those of comparable dies made in the preferred materials. Again a smaller circle results from placing the die on edge while taking the measurements.

Items 6, 7 and 8 are the results for two more early dies used for necking the 45 mm aerosol to

33 mm diameter. For a quick, cheap trial the first die was made from solid mild steel (die 9) and a duplicate was subsequently made in EN41 tool steel (die 9.1). The small circle diameters (5 to 7 mV) indicate heavy losses, particularly for the mild steel die.

It is interesting to compare the circle diameters measured for these early dies with the circle diameter of the transducer system which was used at the time (table 6.01 item 12, discussed in section 6.2.2.1). Neglecting losses in the piezo-electric transducer (reasonable considering its much larger circle size) it can be said that the losses in the magnetostrictive transducer system are approximately three times greater than in the worst die (based on the ratio of circle diameters). This would indicate that the early dies were in fact perfectly adequate in that system. The need for more efficient dies only becomes apparent when an efficient piezo-electric transducer is used.

Items 10 to 16 show some measurements of the aluminium / ferro-titanit die for necking 45 mm aerosols to 33 mm diameter. The poor performance of this die (ie the closeness of the unwanted R3 frequency) has been discussed previously. In this series of tests the die was

installed in the forming rig using an aluminium tuned mounting. It was not possible to measure admittance while forming a can (the necking process is too fast) but to simulate the type of loading this would impose on the die a fully formed can was pushed into the die and held there by the internal forming tool (plunger). Pressurized air in the pneumatic cylinder which operated the plunger ensured that a constant force (approx 3 kN) was applied to clamp the can into the die. Two types of transducer (Telsonic and Kerry) were also tested. The aim of these measurements was to gain a better understanding of the problem of mode switching (particularly for this die) and why the Telsonic system did not seem to suffer from it.

Without the can and plunger loading the die the results are mostly similar for the two transducers. In each case the R0 circles (at approx 20.0 kHz) are satisfactory, and two unwanted frequencies appear, close together at approx 21.0 kHz. Another harmonic frequency appears at 24.0 kHz in both cases. The interesting feature here is the pair of harmonic frequencies at 21 kHz. Analysis predicts only the R3 near this frequency, but in general a pair of resonant frequencies could be expected for every non-axisymmetric resonance. One of the resonant frequencies would correspond to the R3 mode aligned with an antinode at the transducer, and the other aligned with a node at the transducer.

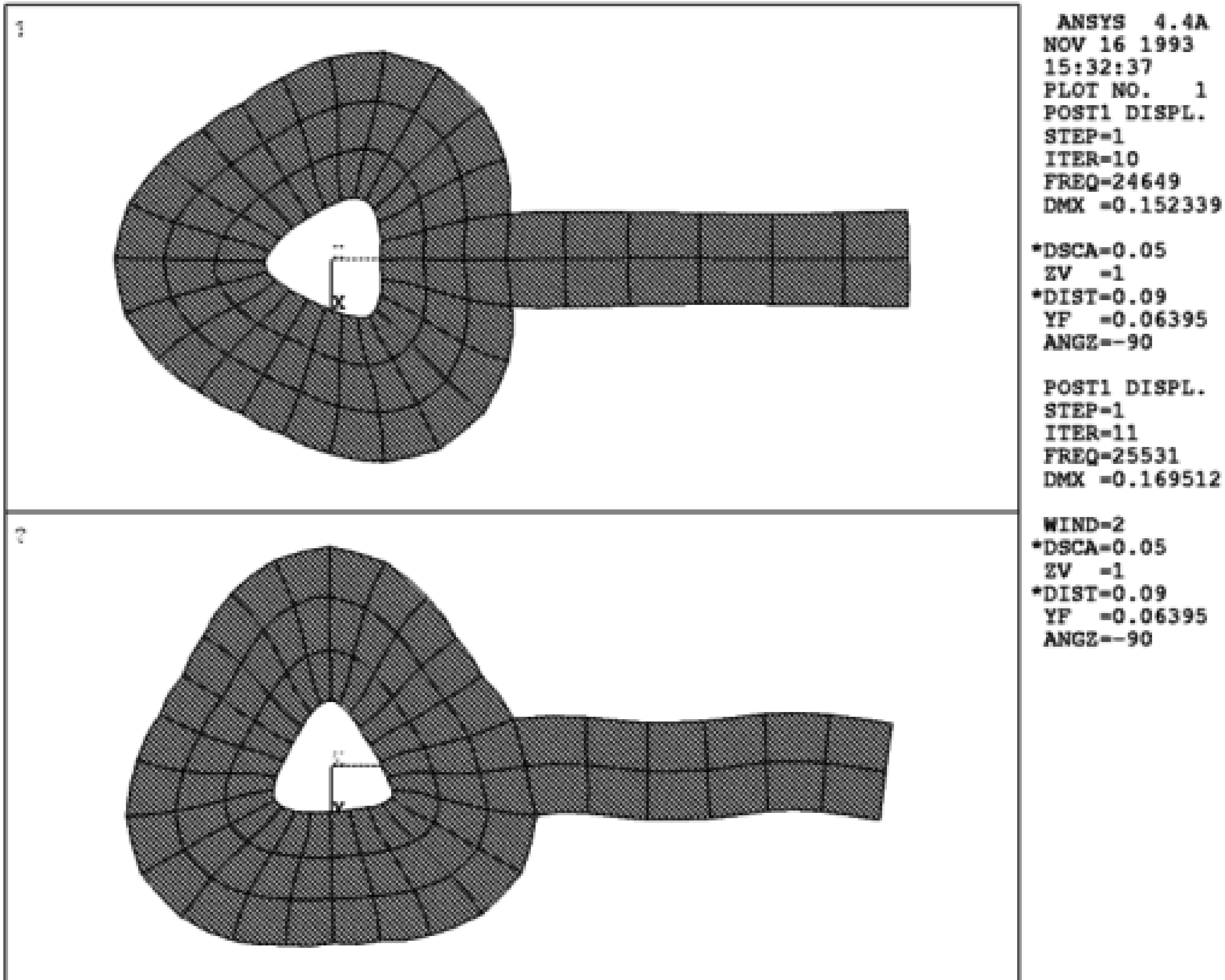


FIGURE 6.07 R3 MODE PAIR AND TRANSDUCER MOVEMENT

Normally the first mode should be driven by the transducer and the second one filtered out because the die motion will not match that of the transducer. This effect is also discussed in section 2.4.1 The only significant difference between the results for the two transducers concerns the relative sizes of the circles for the pair of R3 frequencies. For the Telsonic transducer the lower frequency resonance has a very small circle diameter (2 mV) but using the Kerry transducer both circles are relatively large (12 and 7 mV). This indicates that the transducer is vibrating unevenly, at least for some of the time, and this may have contributed to the mode-switching problem. Figure 6.07 shows (much exaggerated) how the two modes could look and the sort of uneven motion the transducer would need in order to excite them.

Comparing the results for the die with the can and plunger inside it the two transducers again give very similar results, again with the exception of the relative sizes of the two R3 frequencies. Using the Telsonic transducer one of the R3 pair is large (15 mV) while the other is small (1 mV), but using the Kerry transducer the two circles are again of similar size (11 and 8 mV).

Comparing results for the die loaded (by the can and plunger) and unloaded the following observations can be made: The circle diameter for the R0 mode is reduced when the die is loaded.

The circle diameters for the R3 mode pair are not much reduced, particularly for the Kerry transducer.

The R0 resonant frequency is increased by about 40 Hz when the die is loaded.

The resonant frequencies of the R3 pair are not increased much (on average 10 Hz) when the die is loaded.

All of these effects will, in general, tend to promote mode switching by bringing the unwanted resonances closer to the working frequency and increasing the size of the unwanted resonance relative to the R0. The magnitude of the changes is small in proportion to the relatively small amount of loading applied by the plunger (compared to the necking process). Nevertheless trends are apparent which must tend to destabilize the R0 mode, and the Kerry ultrasonics system is measurably less stable than the Telsonic. Whether mode switching takes place will depend not only on the stability of the transducer and die (as indicated by these measurements) but also on the quality and stability of the control system used to maintain resonance. The fact that mode switching has been observed in this die using the Kerry system indicates that for this equipment the limit has been reached. For the Telsonic equipment (which probably also employs a superior control system) the limit has not yet been found.

Finally, items 18 and 20 of table 6.05 show measurements of the aluminium diemounting with syalon insert for necking 66 mm beverage cans to 58 mm diameter. The tuning of this die was described in the previous section (items 12 to 18 of table 6.04). These measurements differ only in that the diemounting was clamped by its flange. Comparing these measurements with the final tuning measurement shows no significant differences, indicating that clamping the flange has minimal effect on the die vibrations. Comparing the results for the two transducers shows no major differences.

6.2.2.4 Admittance plotter measurements - mounting evaluation

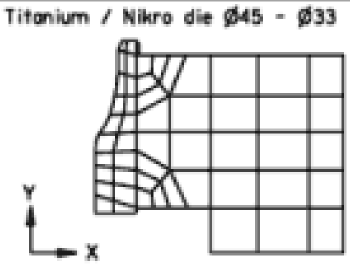
Tables 6.12 and 6.13 show evaluations of the performance of a number of tubular tuned mountings. These are discussed in section 6.4.

6.2.3 Comparison with FE predictions

For the results shown in tables 6.02 to 6.04 (the die tuning operations) corresponding information from the finite element analysis has been summarized in tables 6.06 to 6.11 to give an indication of the normal levels of accuracy. In each case the type of finite element model and the number of elements and master degrees of freedom is indicated, followed by the predicted natural frequencies (for the die alone) categorized by the system of mode nomenclature described in section 3.1. The actual outside diameter and measured frequencies (as also shown in tables 6.02 to 6.04) have also been included in heavy type. Note that for some models (the round versions of the three-flat dies) no real measurements have been included because no equivalent die was produced.

Tables 6.06 and 6.07 show the analysis of conventional (round) dies. This type of analysis is straightforward and efficient using two-dimensional axi-symmetric harmonic elements (see section 2.4.3 for a full description of this type of element). The number of elements ranges from 52 to 62 and the number of masters from 100 to 130. Comparing the predicted and actual results shows that the predictions were generally good, with the maximum difference on diameter only 1.3 mm and the agreement on R0 and R1 frequencies well within 1%.

The only significant error is the consistent overestimating of the R3 frequency (by about 0.5 to 1 kHz, or 2.5 to 5%). There are two sources of error contributing to this. Firstly the tendency of the FE model to overestimate the frequencies, particularly of the harmonic modes (as discussed in detail in section 2.8). Secondly the finite element model does not include the transducer, whereas all measurements inevitably do. The effect of the transducer is to "pull" frequencies towards its own working frequency, 20 kHz. These two sources of error will tend to cancel out for frequencies below 20 kHz (typically the R1 frequencies) but will add together for frequencies above 20 kHz (ie the R3).

FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Titanium / Nikro die Ø45 - Ø33 	151.0 152.0	MODEL OF...	CROSS-SECTION (2D)	0	10520	20013 19981			
		ELEMENT NAME	STIF83	1	17038	18672 18647			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6486	11894	27303	26529	
		NO OF ELEMENTS	52	3	14061	22196 21780			
		NO OF MASTERS	130	4	21821	29903			
				5					

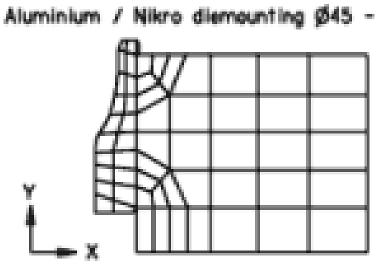
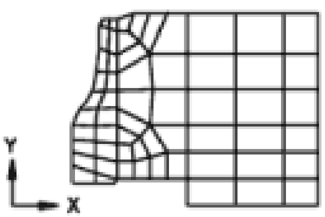
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Nikro diemounting Ø45 - Ø33 	167.0 166.5	MODEL OF...	CROSS-SECTION (2D)	0	9616	20033 19971			Unidentified small resonance also found at 21116 kHz
		ELEMENT NAME	STIF83	1	17049	16684			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6099	11893	24209	26793	
		NO OF ELEMENTS	56	3	12814	21415 20964			
		NO OF MASTERS	130	4	19479	28219			
				5					

TABLE 6.06 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL (DIAMETERS)	AB AXIAL BENDING	COMMENTS
Titanium / Nikro die #2 Ø45 - Ø31	154.0 154.0	MODEL OF...	CROSS-SECTION (2D)	0	10501	19981 19959			
		ELEMENT NAME	STIF83	1	17612	18462 18324			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6632	12196	26852	27978	
		NO OF ELEMENTS	58	3	14158	22621 21686			
		NO OF MASTERS	100	4	21729				
				5					

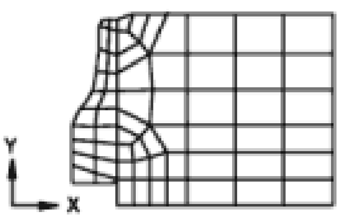
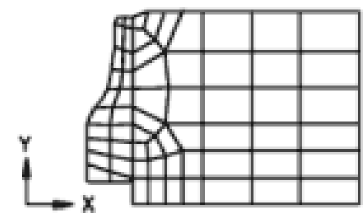
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL (DIAMETERS)	AB AXIAL BENDING	COMMENTS
Titanium / Syalon diemounting #2 Ø45 - Ø31	161.0 162.3	MODEL OF...	CROSS-SECTION (2D)	0	10962	20030 19968			Unidentified small resonances also found at 20713 kHz and at 21645 kHz
		ELEMENT NAME	STIF83	1	18956	18006			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6552	12628	25978	28492	
		NO OF ELEMENTS	62	3	13789	22678 21896			
		NO OF MASTERS	100	4	20902	29960			
				5					

TABLE 6.07 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

Tables 6.08 to 6.11 show the results for the FE models of the two 3-flat designs (for which the measured results are shown in table 6.04). Modelling this type of die is more difficult because the axi-symmetric elements are no longer applicable. A similar analysis of the die using a full three-dimensional model was required but limitations on the computing power available made this impossible to analyse. As a compromise a simpler 3-D model with a coarse mesh was analysed and the results compared with 2-D axi-symmetric models.

The results of this analysis for the experimental Aluminium / Nikro die are shown in tables 6.08 and 6.09. Table 6.08 (top) shows the axi-symmetric model similar to those used for the four round dies described previously. In this case the predicted R3 frequency was 21.2 kHz (lower than any previous die). This is well within the "danger zone" around 20 kHz and it is likely that the actual frequency would have been even lower, for the reasons described above. This was confirmation that the 3-flat design was required.

Table 6.08 (bottom) shows the results for the same model and the same axi-symmetric elements but with a much coarser mesh (only 18 elements compared to the 62 used earlier). This was done because it was known that a coarser model would be needed for the 3-D analysis and the coarse mesh 2-D model would provide a better comparison. Comparing the results for the two 2-D models shows that all the coarse model frequencies were higher (less accurate), and the largest discrepancies were in the torsional mode frequencies and the higher harmonic radial modes. The predicted R3 frequency was increased by 0.5 kHz in the coarse model, indicating the necessity of a reasonably fine mesh.

FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Nikro die #2 (experimental) Ø45 - Ø31 	171.0	MODEL OF...	CROSS-SECTION (2D)	0	9281	19841	29375		
		ELEMENT NAME	STIF83	1	16945	16287			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	5947	12041	23808	26404	
		NO OF ELEMENTS	62	3	12420	21168			
				4	16873	27789			
		NO OF MASTERS	100	5					

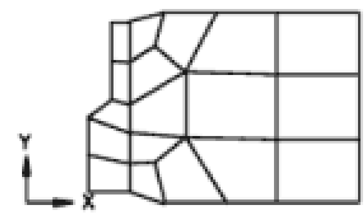
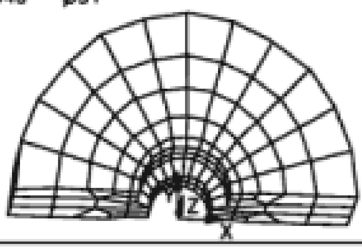
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Nikro die #2 (experimental) Ø45 - Ø31 	171.0	MODEL OF...	CROSS-SECTION (2D)	0	10037	19951	29380		This rough model is approximately the 2D equivalent of the later 3D models
		ELEMENT NAME	STIF83	1	17984	16301			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6395	12326	23909	28174	
		NO OF ELEMENTS	18	3	13271	21668			
				4	20132	28589			
		NO OF MASTERS	100	5					

TABLE 6.08 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

Table 6.09 (top) shows the results for the 3-D model round die. This was equivalent to the two axi-symmetric models and permitted a further comparison of probable accuracy of the different models. The predicted frequencies for the 3-D model were all higher again (even less accurate) than those of the coarse 2-D model and in this case the predicted R3 frequency was 22 kHz which, if true, would have been acceptable.

Table 6.09 (bottom) shows the results for the 3-D model 3-flat die. Knowing the inaccuracy of these models, these results were treated with caution, but comparison with the round die model was expected to indicate the true results. Comparing the most important (for this die) R0 and R3 frequencies, the effect of the 3-flat design is to raise the R0 slightly (by 0.3 kHz) and to raise the R3 considerably (by 1.8 kHz). This indicated that the separation between R0 and R3 frequencies should be increased by 1.5 kHz.

The measured results for this die are also shown in table 6.09 (bottom). Comparing these, the predicted die diameter is 2.5 mm less than the actual (not enough allowance was made for the flats increasing the R0 frequency) and the R3 frequency was, as expected, greatly overestimated (by 1.6 kHz). The most important point to note, however, is that the R3 frequency, at 22.3 kHz, was fully acceptable. The 3-flat design had increased the frequency separation as predicted.

FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		PREDICTED MODES AND FREQUENCIES: HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Nikro die #2 (experimental) Ø45 - Ø31	171.0	MODEL OF...	HALF DIE (3D)	0	10139	20111			
		ELEMENT NAME	STIF45	1	18488	16569			
		ELEMENT TYPE	8-NODED BRICK	2	6481	12472	24570	28602	
		NO OF ELEMENTS	216	3	13647	22003			
		NO OF MASTERS	400	4	21194	29428			
				5	29266				

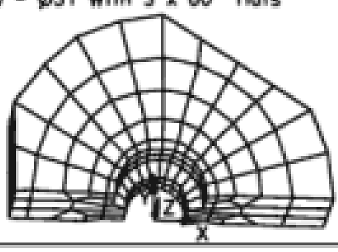
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		PREDICTED MODES AND FREQUENCIES: HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Nikro die (experimental) Ø45 - Ø31 With 3 x 60° flats	171.0 173.5	MODEL OF...	HALF DIE (3D)	0	10356	20449 19951			Unidentified large resonances also found at 24454 kHz and at 25226 kHz
		ELEMENT NAME	STIF45	1	18781	16402			
		ELEMENT TYPE	8-NODED BRICK	2	6826	12883	25937	28595	
		NO OF ELEMENTS	216	3	15666	23829 22277			
		NO OF MASTERS	400	4	22612	30538			
				5	31885				

TABLE 6.09 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

A similar procedure was used for the design of a die for necking 66 mm beverage cans to 58 mm diameter. As discussed in section 3.7, choosing alternative materials for the construction of this die did not produce any results which would be acceptable. The use of a shaped die was therefore essential, and the predicted natural frequencies indicated that the (3-flat) design would be suitable. The results in tables 6.10 and 6.11 are for three models, one 2-D axi-symmetric (coarse mesh), one 3-D round and one 3-D with flats. As before the frequencies are significantly overestimated by the 3-D models but increased separation between R0 and R3 frequencies is achieved, much as predicted. During tuning the die diameter was machined to exactly the size predicted (169 mm) and the measured R3 frequency was then found to be 22.2 kHz - fully acceptable.

6.2.4 Accuracy of FE predictions

The potential accuracy of the FE models is discussed in section 2.8, but comparison with real measurements (as described here) introduces some further sources of error:

1) Tolerances on dimensions and variations in material properties may result in the die failing to match its finite element model perfectly.

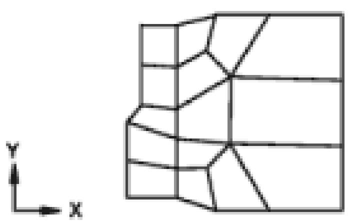
2) The presence of a transducer on the die during frequency measurements will itself affect the resonant frequencies.

From the results described in the previous section it appears that these sources of error can account for up to about 3 mm discrepancy in the tuned outside diameter of a typical die. To allow for this the dies are initially manufactured about 6 mm oversize and then tuned by gradual machining down. The 6 mm "tuning allowance" could be reduced but there is little advantage in doing this because the dies are usually manufactured by turning down a stock size bar (eg 7" diameter).

The two-dimensional axi-symmetric harmonic elements offer good accuracy and efficiency.

To analyse the shaped dies only a full three-dimensional model is suitable, but limitations on available computing power required the use of a much coarser mesh for this type of model which was far less accurate. The technique adopted, using both 2-D and 3-D models gave satisfactory results.

Harmonic frequencies above 20 kHz tend to be overestimated by the FE model, while harmonic frequencies below 20 kHz are generally reasonably accurate.

FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		PREDICTED MODES AND FREQUENCIES: HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Syalon diemounting ø65 - ø58 	169.0	MODEL OF...	CROSS-SECTION (2D)	0	11935	19930	36127		
		ELEMENT NAME	STIF83	1	18820	18285			
		ELEMENT TYPE	8-NODED QUADRILATERAL	2	6296	10494	24864	30256	
		NO OF ELEMENTS	15	3	13573	21897			
		NO OF MASTERS	150	4	20631	30721			
				5					

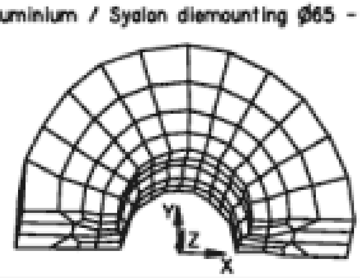
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		PREDICTED MODES AND FREQUENCIES: HARMONIC NUMBER	T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Syalon diemounting ø65 - ø58 	169.0	MODEL OF...	HALF DIE (3D)	0	12023	20110			
		ELEMENT NAME	STIF45	1	19266	18517			
		ELEMENT TYPE	8-NODED BRICK	2	6388	10722	25357	31047	
		NO OF ELEMENTS	180	3	13938	22610			
		NO OF MASTERS	400	4	21594	31765			
				5	29594				

TABLE 6.10 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

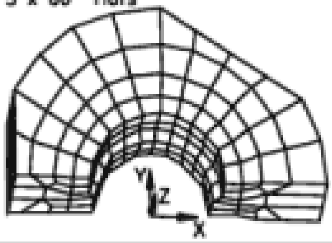
FINITE ELEMENT MODEL	DIE DIA (mm)	MODEL DETAILS		HARMONIC NUMBER	PREDICTED MODES AND FREQUENCIES T TORSIONAL	R RADIAL	D ROTATIONAL DIAMETERS	AB AXIAL BENDING	COMMENTS
Aluminium / Syalon diemounting Ø65 - Ø58 With 3 x 60° flats 	169.0 169.0	MODEL OF...	HALF DIE (3D)	0	12045	20494 19986			
		ELEMENT NAME	STIF45	1	19600	18273			
		ELEMENT TYPE	8-NODED BRICK	2	6693	10893	27324		
		NO OF ELEMENTS	180	3	16547	24188 22233			
		NO OF MASTERS	400	4	23176	33104			
				5	29885				

TABLE 6.11 - COMPARISON OF FE PREDICTIONS WITH ADMITTANCE PLOTTER MEASUREMENTS

6.3 ESPI MEASUREMENTS

One of the most powerful techniques used to evaluate the performance of ultrasonic dies was Electronic Speckle Pattern Interferometry (ESPI). The technique was developed for use on ultrasonic dies by Tyrer and Shellabear [117], [118], [119], [120] along with others at Loughborough University during the course of the SERC-sponsored project. This non-contact measuring system was capable of giving quantitative data for the vibrations of the whole die in real time.

There are however some disadvantages of this system compared to the other systems described previously, particularly the cost and setting up time. Another potential problem is the interpretation of the results produced by ESPI which are not always immediately understandable. To assist in identifying modes of vibration it was necessary to process the finite element results to produce an image equivalent to an ESPI picture.

This section describes the general principles of ESPI and the techniques used to interpret the results by comparison with finite element models.

6.3.1 Principles of ESPI

For a full explanation of the technique see the various publications of Shellabear, Tyrer et al [117], [118], [119], [120]. The die is illuminated by an interfering pair of laser beams, producing a speckle pattern. A video camera is used to digitally record an image of this pattern. Any movement of the die surface causes changes in the speckles, depending on the distance moved. By digitally subtracting the new image from the previous stored one, the changes are shown, with light and dark fringes showing areas where the amount of movement is similar (like contour mapping). By different arrangements of the laser beams the equipment can be made sensitive to movements along three orthogonal axes (ie with the die set up on a horizontal axis, movements can be measured out-of-plane, in-plane horizontal and in-plane vertical).

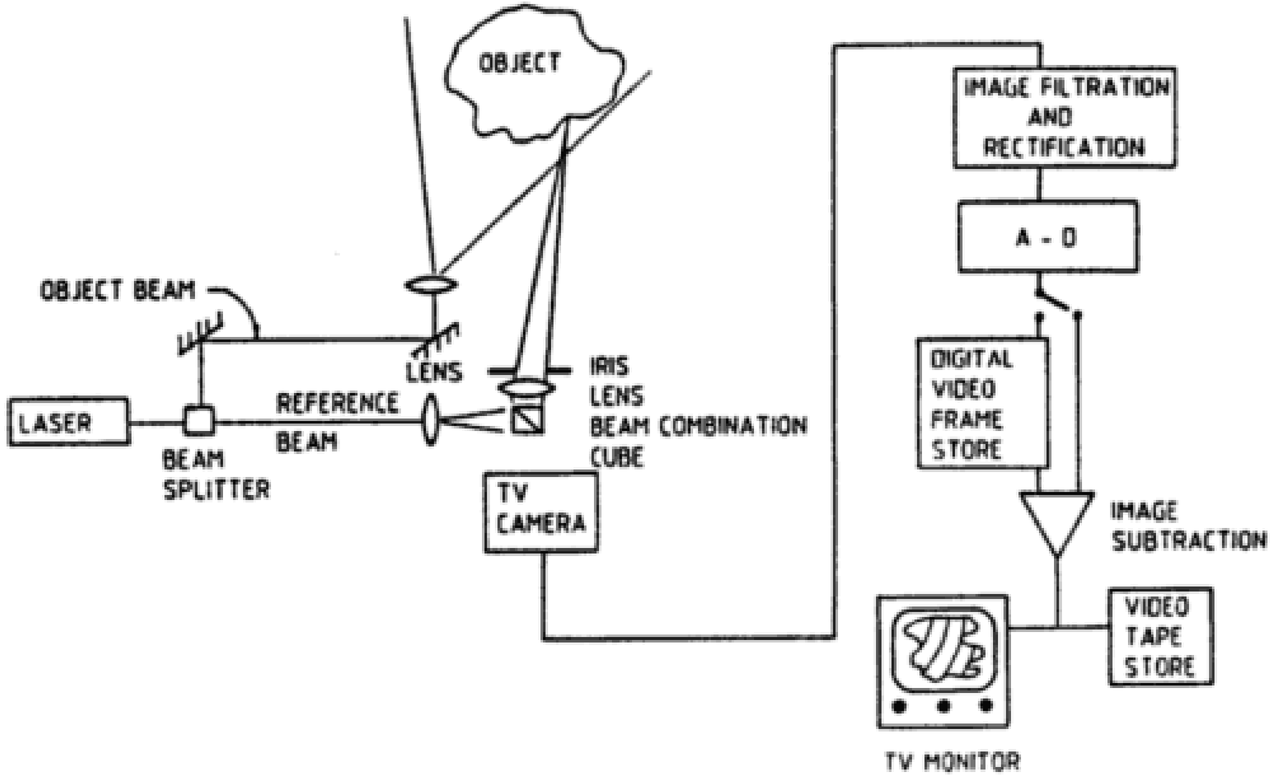


Figure 6.08 - ESPI General Arrangement

For identifying pure modes of vibration the out-of plane image is useful because in most cases the axial motion gives a good idea of the nature of the mode (ie its harmonic number and whether it is predominantly radial or torsional). However it does not show directly the most useful component of vibration (the radial component), and where there is a mixture of two modes one (with predominantly radial motion) may be masked by the other (with significant axial motion).

The two in-plane images will provide the extra information required but they are much more difficult to interpret because they show elements of both radial and hoop motion in different areas of the die. If amplitude and phase information is known then the precise motion of the die at any point can be evaluated from the three images (and Shellabear [120] has done this) but the process is laborious and often the full set of results is not available. The alternative chosen for much of this work was to process the finite element results for each mode into simulated

ESPI images which could be compared with the real ESPI images as they were generated.

When this was done it was found that some images matched well but others seemed to contain elements of the FE images for more than one mode of vibration. It is to be expected that the modes of vibration of a real die, in the presence of imperfections and damping, will not be pure but in general will be combination modes made up of a number of pure modes.

To allow for this in the interpretation of the ESPI results a program was produced to process the FE results, not only converting them to ESPI type images but also allowing the combination of a number of different (pure) modes in proportions chosen by the user. Thus using the program and selecting mode combinations by trial-and-error the user could find a combination which produced a set of images to match the real ESPI results. While not positive proof of the nature of the vibrations of the real die this gives a very good indication.

6.3.2 Converting FE results to simulated ESPI plots

6.3.2.1 Pure modes

The Ansys program produces a huge amount of data for even the simplest model. To avoid wasting processing time and storage the relevant finite element data was first extracted and stored in a series of data files. Each file included a set of data (the radius and three components of displacement) for all nodes along a radial line on one face. The data for each mode was stored in a separate file.

Note that a 2-D axisymmetric-harmonic finite element model was used (section 2.4.3). A 3-D model could have been used but the 2-D model is more efficient. The variation in the components of amplitude over the surface of the die can be accurately predicted using the known harmonic variation as described in section 2.4.3 (the harmonic number is also stored on the data file).

The main program was written in Fortran using the Issco Codebook prototype [123]. This is a program which takes the user through a question and answer session and then automatically generates the Fortran source code to produce the required plots by calling subroutines in the "Disspla" library. The technique is similar to that of example 3.6.6 (appendix 3) for making contour plots of the performance of different die designs. After the plotting program is generated it can be edited to perform other functions (in this case data processing) and recompiled like any other program. The final result is a program which is less tidy than one written specifically for the application but which takes less effort to produce.

To display a pure mode the program must read in the data for that mode from the appropriate data file and then use the data to calculate the component of amplitude in a chosen direction (axial, horizontal or vertical) at points all over the die face. The result is stored in a 2 x 2 array and subsequently displayed using colours corresponding to the light and dark fringes produced by ESPI.

The calculations must take into account:

1) The radial and angular position of the point.

2) The harmonic number.

3) For horizontal and vertical components: both radial and hoop amplitudes.

4) For harmonic number greater than 0: The angular alignment of hoop components of amplitude (hoop amplitude is zero at the radial / axial antinode).

6.3.2.2 Distorted modes

For distorted modes (ie combinations of two or more pure modes) the procedure is the same but the components of amplitude for each mode must be added together.

The program in its latest form allowed the user to select one main mode and one secondary mode. The reference angle for each one can be specified (ie where on the image the mode's antinodes should appear) and for the secondary mode the fraction of that mode which should be added. Future enhancements may include the option to add a third mode if this becomes necessary.

6.3.3 Comparison of results

Figures 6.09 to 6.13 show typical ESPI-equivalent images generated from the finite element data and actual ESPI photos from Shellabear's work. The computer-generated images correspond to the pure modes which are generally of interest, because they typically appear at a frequency close to 20 kHz. The photos (where available) show the closest measured response modes of the die.

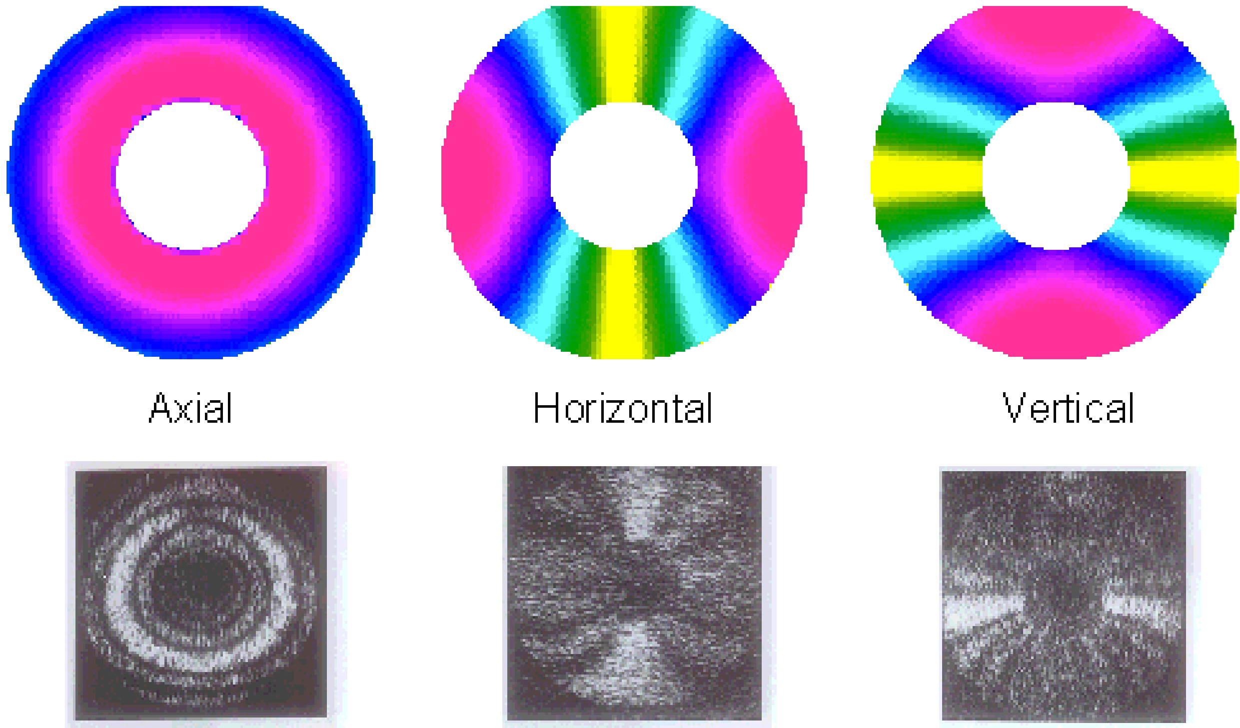
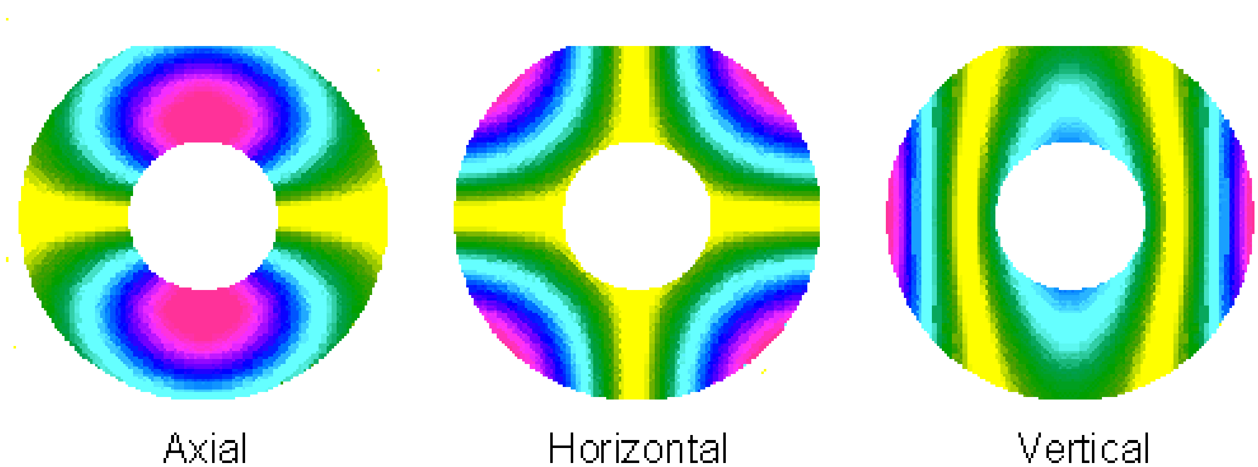


Figure 6.09 - ESPI images (predicted and actual) - R0 mode



(ESPI photos not available for this mode)

Figure 6.10 - ESPI images (predicted) - R1 mode

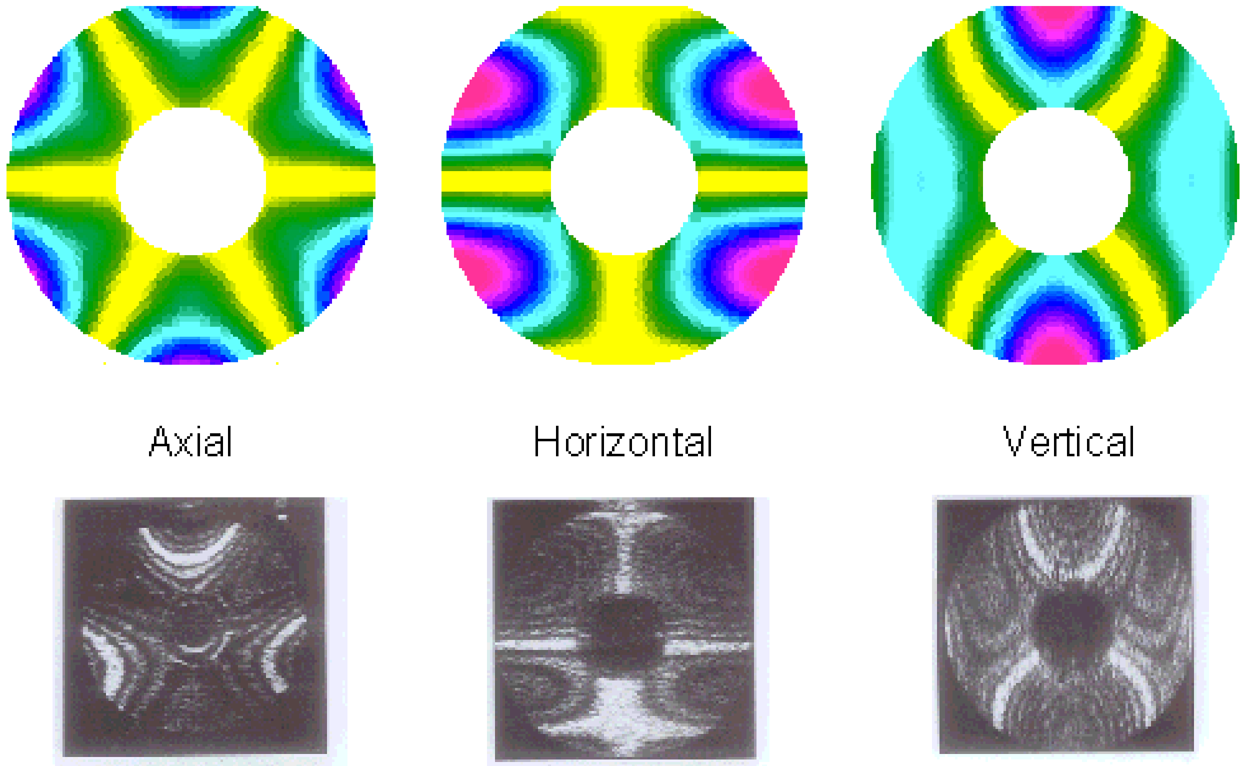


Figure 6.11 - ESPI images (predicted and actual) - R3 mode

(ESPI photos not available for this mode)

Figure 6.12 - ESPI images (predicted) - T4 mode

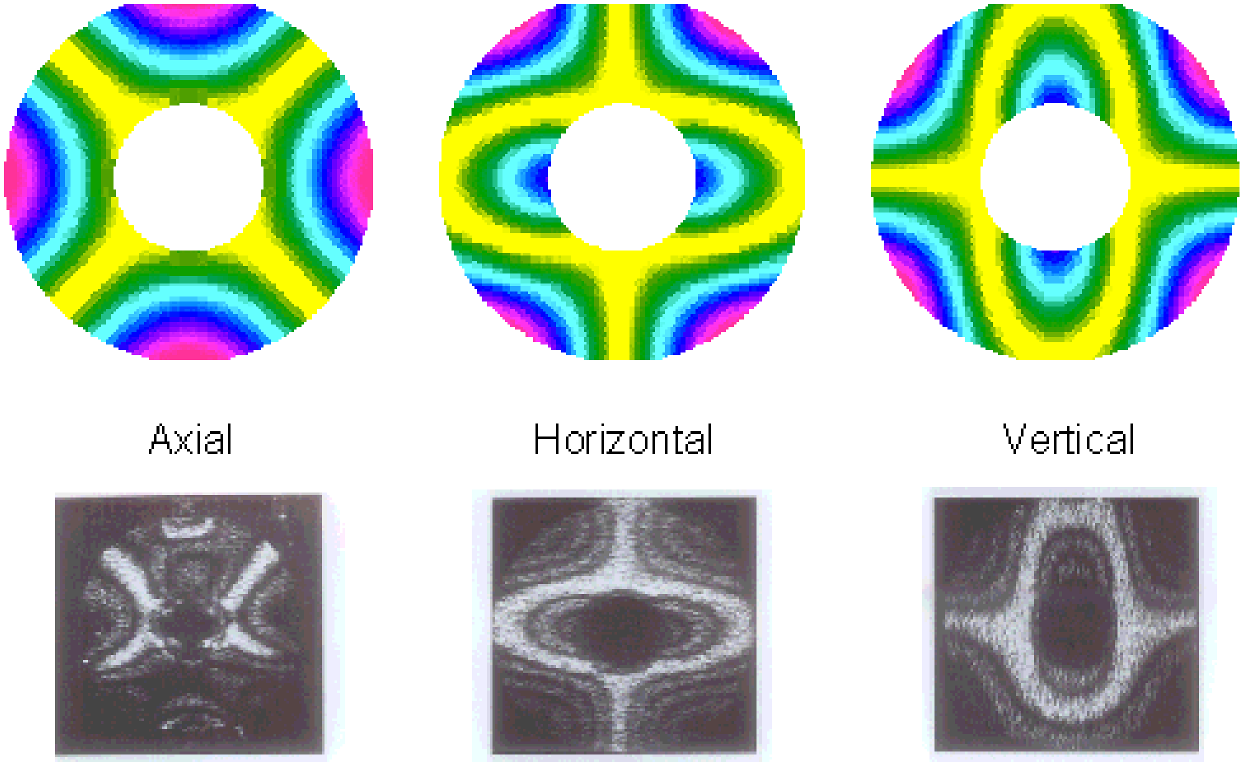


Figure 6.13 - ESPI images (predicted and actual) - D2 mode

These results have been produced for an aerosol necking die comprising a ferro-titanit insert in an aluminium outer (die materials are discussed in section 3.6). Other die designs produce ESPI-equivalent images which are generally similar.

Photos taken from the ESPI video pictures are shown in references 1 (for R0, R3 and D2 modes) and reproduced here, where available, along with the corresponding simulated ESPI image. This allows easy comparison of the theoretical vibrations with the real measurements.

For the R0 and D2 modes (figures 6.09 and 6.13) the correlation with the pure mode FE results is clear, although some vertical distortion of the fringes is apparent. This is to be expected particularly for the D2 mode because the frequency (24 kHz) is significantly separated from the 20 kHz working frequency. This means that the transducer unit which drives the die must be detuned and therefore effectively applies a mass to the outside of the die moving in a vertical direction. Nevertheless the images match well enough to clearly identify both modes.

For the (presumed) R3 mode (figure 6.11) the correlation is less clear. It was believed to be a distorted R3 mode because its natural frequency (20.8 kHz) approximately matched the FE prediction and because the image for axial motion shows a three-way symmetry (although for the pure R3 mode a six-way symmetrical image would have been expected). The closest other mode to this one is the R0 at 20 kHz so it was expected that the distortion would take this form. Figures 6.14 to 6.16 show different combinations of R3 and R0 modes. In figure 6.14 the R0 mode at half-amplitude has been added, but this shows a distortion opposite to that shown by the real measurements. Figure 6.15 shows the R0 mode at half amplitude subtracted from the

R3, and this shows good agreement with the measurements. Note that for each mode the amplitude is normalized but the sign is purely arbitrary. Figure 6.16, shows the combination R3 - 0.2 x R0. Judging by eye, the best correlation is probably somewhere between the last two, ie. R3 - 20 to 50% R0.

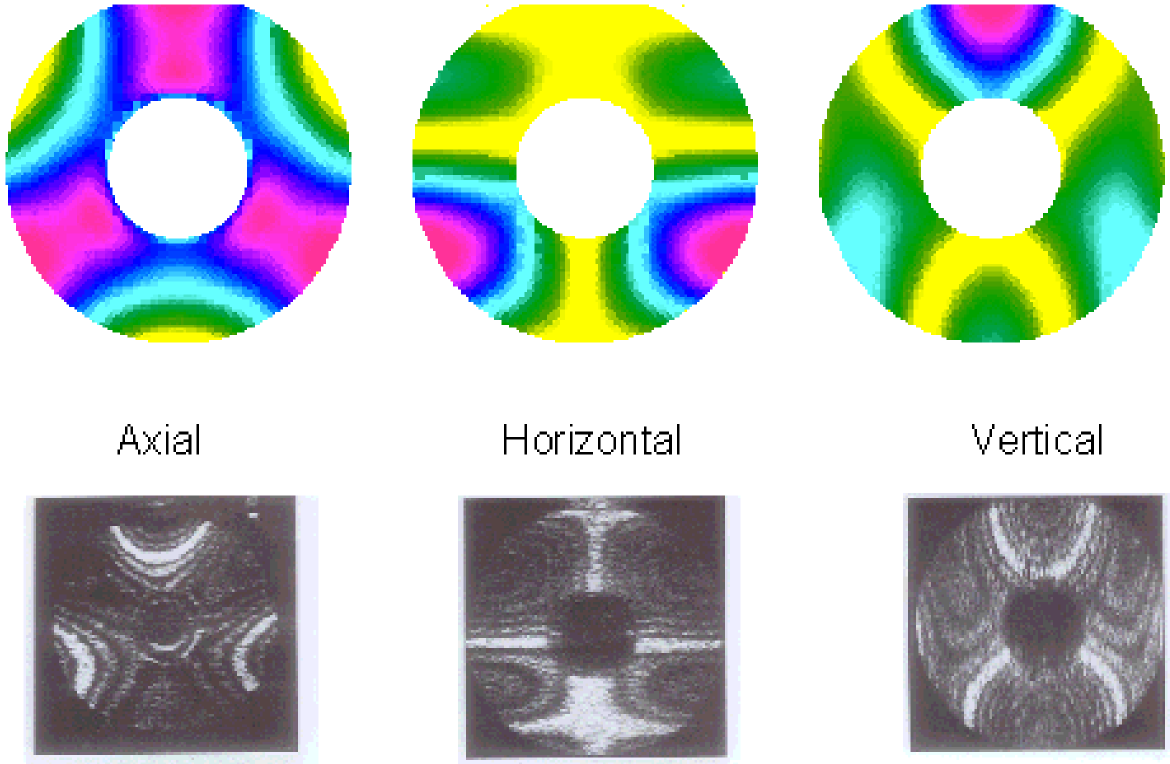


Figure 6.14 - ESPI images - Combination R3 + 0.5 R0 mode

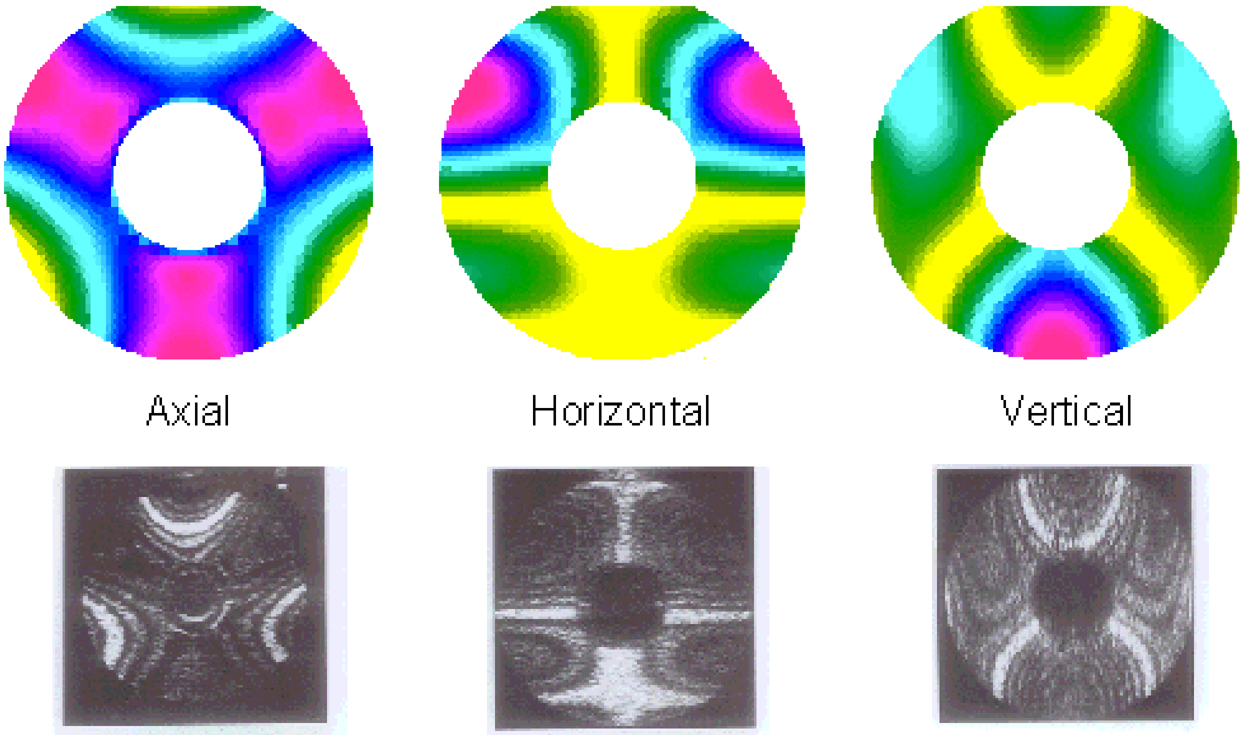


Figure 6.15 - ESPI images - Combination R3 - 0.5 R0 mode

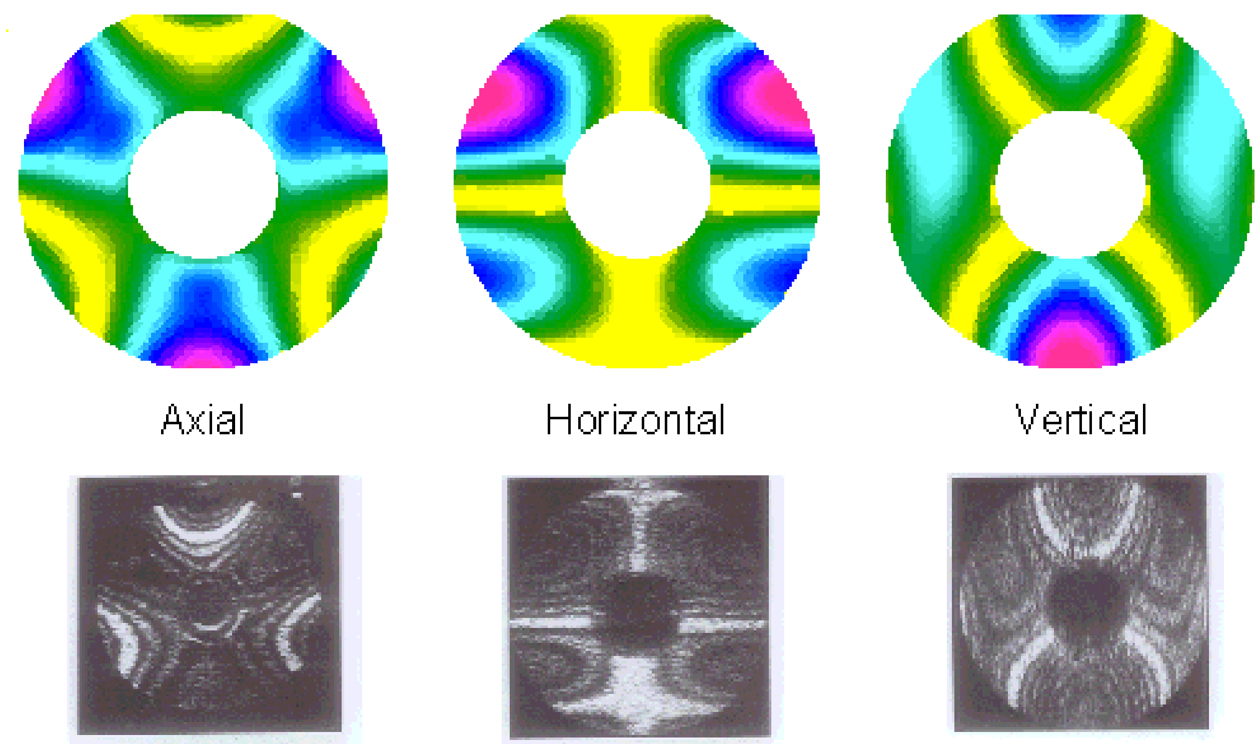


Figure 6.16 - ESPI images - Combination R3 - 0.2 R0 mode

6.3.4 ESPI Summary

A method of processing finite element results has been demonstrated which produces images equivalent to those of the real die produced using electronic speckle pattern interferometry (ESPI).

When used for comparison with the images of a vibrating die these simulated ESPI images allow interpretation of the mode of vibration.

For cases where the mode of vibration is not a pure mode its composition may be evaluated by comparison with an image produced for two pure modes combined in a specified ratio.

6.4 EVALUATION OF TUBULAR MOUNTING PERFORMANCE

Between the initial concept for the thin walled tubular mounting (described in chapter 5) and the final optimized design, several attempts were made to measure its performance. These will be described in turn.

6.4.1 Free vibrations of steel prototype

The first prototype was manufactured in mild steel (for minimum cost). This was a tube of inside diameter 80 mm, outside diameter 85 mm and length 130 mm with a central flange as shown in figure 6.17. This corresponds to the initial concept of a tube resonant simultaneously in both radial and longitudinal modes. Finite element analysis predicted a large number of free vibration modes in the region of 20 kHz. An experiment was planned to measure these frequencies.

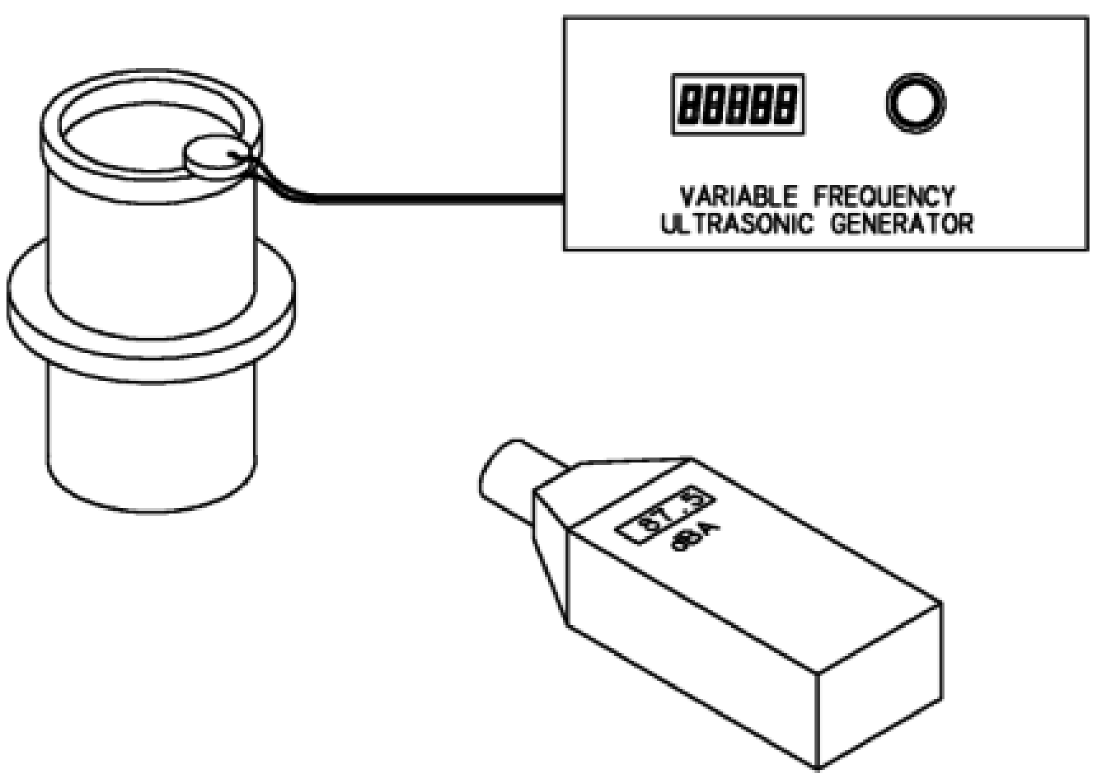


Figure 6.17 - Testing free resonances of tubular mounting

In order to excite vibrations in the die while it was not connected to the die a small piezo-ceramic disk was fixed (using epoxy adhesive) to the free end of the mounting. This was driven electrically by a small variable frequency generator. Motion of the tube walls was sensed by a noise level meter mounted at a fixed distance from the mounting. Thus sensing was entirely non-contact but driving the vibrations involved the addition of a small mass to the system which would inevitably affect the frequencies. The effect was minimal, however, because of the small volume and relatively low density of the piezo-ceramic disk compared to the steel tube.

The measured results are shown in figure 6.18. The points on the resonance curve have mostly been confined to resonances (peaks) and antiresonances (troughs) because of the huge number of resonances involved. Identification of the modeshapes was not possible because of the method of measurement, but the nature of the resonance curve was generally as predicted (ie many resonances around 20 kHz).

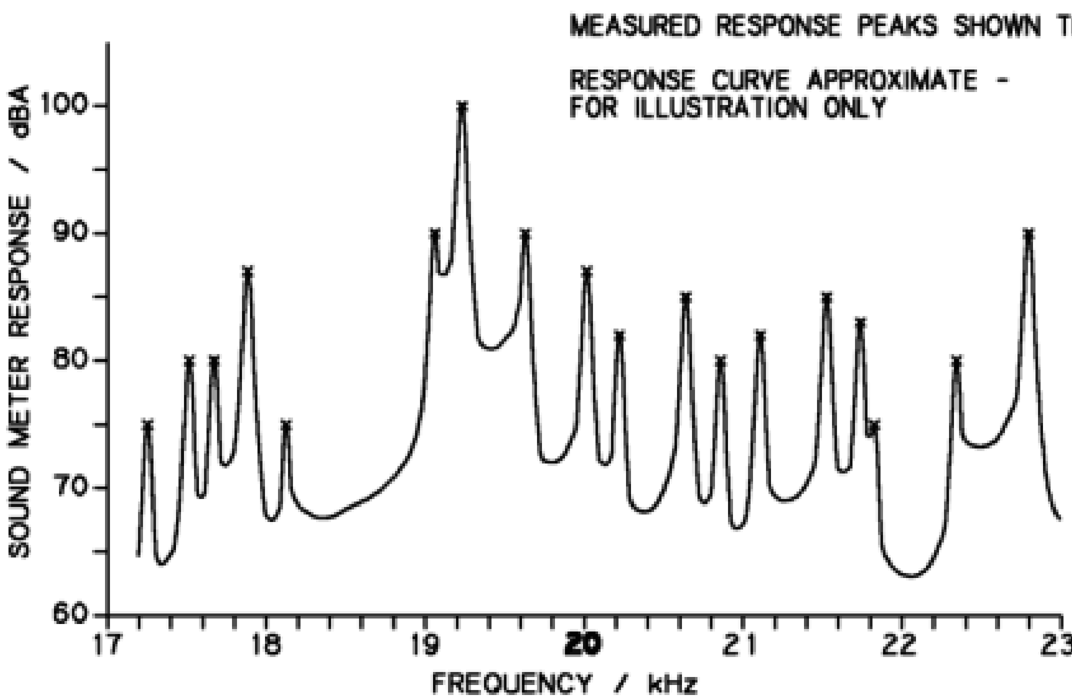


Figure 6.18 - Resonant frequencies of steel tubular mounting

Indeed the number of measured resonances would have been doubled relative to the axi-harmonic FE model because the piezo-ceramic disk would slightly "unbalance" the tube creating a pair of resonances for each of the theoretical ones.

Further trials on the free mounting were not expected to yield any more useful results so all subsequent testing was done on the combined system (die and mounting).

6.4.2 Admittance plotter measurements of mounting performance

The admittance plotter (described in section 6.1.2) gives an accurate and sensitive measure of the characteristics of a mechanical system comprising a transducer and other components connected to it. In order to evaluate the effect of the mounting it was necessary to compare the transducer, die and mounting against the transducer and die alone. The results of this and some other comparisons for several dies and mountings are recorded in tables 6.12 and 6.13, and will now be discussed in turn.

All the measurements listed in table 6.12 are for the aluminium test dies with various early mountings fitted. Other measurements on these dies (section 6.2.2.3 and table 6.05) showed that the dies were effectively identical and that circle diameters for either die with a Kerry transducer would range from 19 to 30 mV depending on the position of the die (resting on the bench or hanging on a string etc).

Items 1 to 4 show some measurements of the test die fitted with the first aluminium mounting. This was dimensionally identical to the steel mounting (ie not optimized) and fitted to the back of the die by screws through a flange (figure 6.19). The measured circle diameters are significantly less than for the die alone, and the smallest circle (10 mV) was measured with the mounting flange clamped in place. This indicates that power losses from this system would be high.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz, BANDWIDTH /Hz, CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + Al Test die 2 (suspended)	9/86	155	complete	20063	6	30	20166					Aluminium mounting 1 was not optimized ie. Ø80, Ø85, 130 long with central flange. Fixing to die was by flange + 8 screws
02	Above + Al mtg 1 (resting on face)			complete	19887	8	14	19961					
03	Above + Al mtg 1 (clamped flange)			complete			10						
04	Above + Al mtg 1 (hand held at flange)			complete			18						
05	Kerry 757 + Al Test die 1 (on edge)	9/86	155	complete	20091	9	19	20193					
06	Above + steel mtg (fixed by 8 screws)			complete	19674		3		19729		5		Steel mounting was not optimized ie dimensions as above
					20425		2.5						
08	Above + steel mtg (fixed by 3 screws)			complete	19837		4						
					20445		6						
10	Above + steel mtg (no screws)			complete	19650		3.5		19703		6		
					20245		2.5						
12	Above + steel flange ring (no screws)			complete	19675	9	12.5						
13	Above + Al flange ring 1 (no screws)			complete	19945		13						Flange ring 1 is interference fit in die
14	Above + Al flange ring 1 (1 screw)			complete			13						
15	Above + Al flange ring 1 (2 screws)			complete			12						
16	Above + Al flange ring 1 (4 screws)			complete			10						
17	Above + Al flange ring 1 (8 screws)			complete	19885		9						
18	Above + Al flange ring 2 (4 screws)			complete	20033	13	9						Flange ring 2 is clearance fit in die
19	Above + Al flange ring 2 (8 screws)			complete			10						
20	Above + Al flange ring 2 (2 screws)			complete	20223		1.5						
21	Above + Al flange ring 2 (1 screw)			complete			<0.1						

TABLE 6.12 - ADMITTANCE PLOTTER MEASUREMENTS - MOUNTING EVALUATION (1 OF 2)

Items 5 to 10 show measurements of the other test die with the first steel mounting fitted. These show two problems. Firstly there were three measurable resonances around 20 kHz - this means that the mass of the mounting is great enough for its own resonances to seriously influence the whole system (particularly because the die is aluminium and hence relatively light). Secondly the circle diameters are all very small (at best only half of the smallest circle for the aluminium mounting). The three measurements were made to estimate the effect of the fixing screws. There was no significant difference when using eight, three or no screws.

Items 12 to 21 take these experiments further with three rings (one steel and two aluminium) which fitted into the back of the die in the same way as the mounting. All measurements were made with the die on its edge for direct comparison with item 5. When the steel ring was fitted (without screws but using an interference fit) there were significant additional losses (circle diameter reduced from 19 to 12.5 mV). Similar results were obtained for the first aluminium ring, which was also an interference fit in the die. In this case the fixing screws were also used and the circle plotted for one, two, four and all eight screws inserted. With the screws inserted both the resonant frequency and the circle diameter decreased indicating that the screws were adding both extra mass and extra losses. The second aluminium ring was a clearance fit in the back of the die. When this was fixed by four or eight screws its results were identical to those of the first aluminium ring, but when it was held by only two screws (fitted on opposite sides) the circle diameter became very small (1.5 mV) and held by only one screw the resonance was effectively eliminated.

This series of trials demonstrated that the mounting flange screwed to the back of the die was generally undesirable. The simple interference fit was better but even this was not ideal. For later dies and mountings the fixing system was redesigned as shown in figure 6.19. The flange and fixing screws were eliminated in favour of a simple interference fit. Furthermore the end of the mounting tube was increased in thickness to increase its rigidity (and so improve the effectiveness of the interference fit) and at the same time maintain the 20 kHz resonance which had been lost when using the flange. After design optimization the interface was eliminated altogether by manufacturing the die outer and the mounting together in one piece.

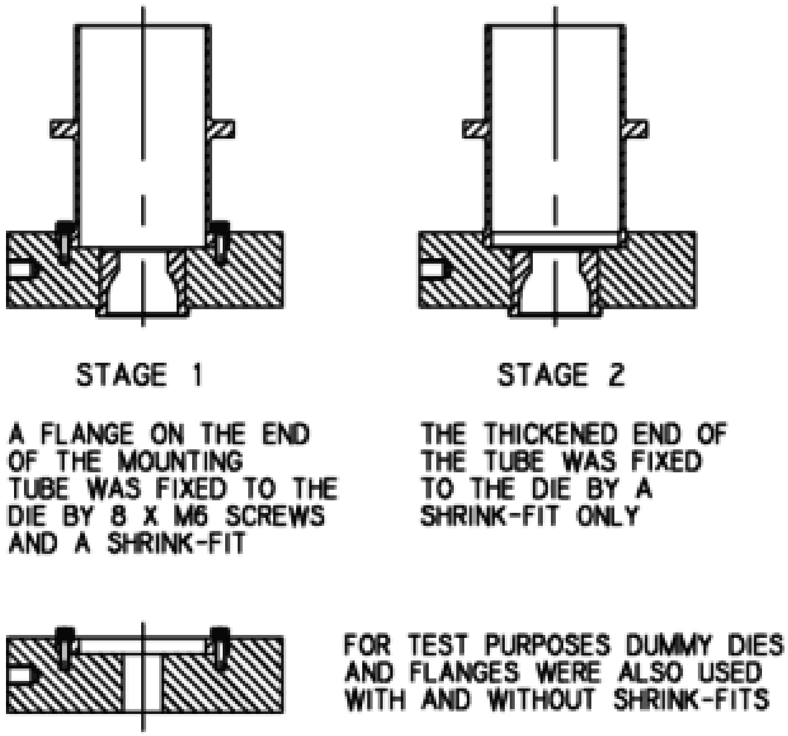


Figure 6.19 - Fixing of tubular mounting to the die

Table 6.13 shows some further admittance plotter measurements used for evaluation of tubular mountings. Items 1 and 2 are results of circle plots for a die with and without an aluminium mounting fixed by interference fit only. The results show that the effect of the mounting is minimal. Items 4 and 7 (for the same die and mounting, but using a different transducer and a booster) show that the mounting flange can be fixed with minimal effect on the die performance.

Subsequent mountings were made integral with the die, to eliminate potential losses at the interface. Some of these were described in sections 6.2.2.2 (die tuning) and 6.2.2.3 (miscellaneous dies and mountings). The good measured performance of these "diemountings" in comparison with the earlier dies is evidence for the success of the design.

6.4.3 Tubular mounting measurements - summary

These results show that in general the mounting has little effect on the resonant frequency of the system (presumably it is dominated by the greater momentum of the die) but adds some power losses to those of the remainder of the system. Additional losses for early designs running at 20 kHz, 10 μ amplitude were approx 300 W. Later versions under the same circumstances would use less power (of the order 100 W) but this was difficult to evaluate because in these later dies the mounting was made integral with the die outer (no shrink fit) so direct comparison with and without mounting was not practical.

This type of mounting (particularly in the later versions with optimised geometry) has therefore been shown to be a practical and efficient method of mounting the ultrasonic die.

	ULTRASONIC EQUIPMENT TESTED	DATE	DIE DIA (mm)	TUNING STATUS (mm)	VIBRATION MEASUREMENTS (FREQENCIES /Hz, BANDWIDTH /Hz, CIRCLE DIA /mV)								COMMENTS / OTHER MEASUREMENTS
					RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	RES FREQ	BAND-WIDTH	CIRCLE DIA	ANTIRES FREQ	
01	Kerry 757 + 45-33 Al/M2	10/86			19947	14	17	20072	21083	19	17	21377	
02	Above + Al mtg #2 (free)				19945	12	17	20075	21181	22	13	21433	
04	Kerry 786+1:1.25 Ti+45-33 Al/M2 +Al mtg #2 (free)				20008	20	29	20075					
07	Kerry 786+1:1.25 Ti+45-33 Al/M2 +Al mtg (fixed)				19906 20860	11	28 4		20670 20910		1 4		

TABLE 6.13 - ADMITTANCE PLOTTER MEASUREMENTS - MOUNTING EVALUATION (2 OF 2)

6.5 MEASURED PROCESS FORCES

The process of necking welded cans (ie reducing the diameter of one end) is discussed in detail in section 1.1, along with the various problems which can occur. In this application the prime reason for using ultrasonics is to prevent collapse of the can body. Without ultrasonics the forming force exceeds the strength of the body, which is then crushed as shown in figure 6.20 (as figure 1.09). With ultrasonics the forming force is reduced (for reasons discussed in section 1.2) to less than the collapse force of the can body. The collapse of the can is therefore a crude measure of the process force.

Clearly the crushing / not crushing of the can was not an adequate method of force measurement and a more accurate method was required. In fact two methods of measuring force were used, as follows.

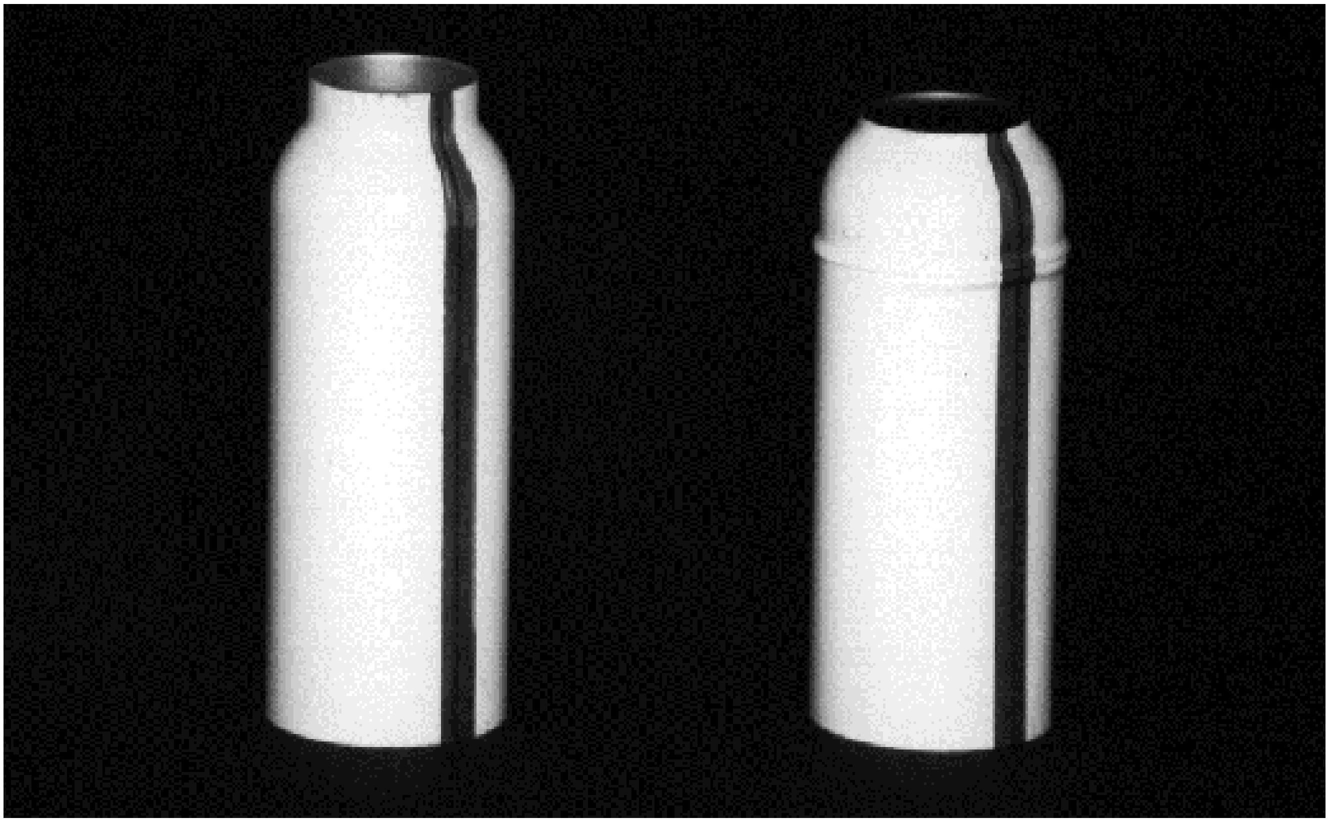


Figure 6.20 - Cans necked successfully and crushed during necking

6.5.1 Evaluation of forming force in early work

In the early part of the project a very simple experiment was conducted. The hydraulic pressure supply to the cylinder used to perform the necking process was reduced so that minimal force would be applied to the can. One can was necked at this pressure and the necking process stopped when the required forming force exceeded the available force (hydraulic pressure x piston area). The neck diameter of the partially necked can was then measured. After a small increase in the supply pressure the process was repeated, and this continued until the available force was sufficient to crush the cans (full forming was not possible at this stage). The result was a set of corresponding forming force and neck diameter data which could be plotted as a graph.

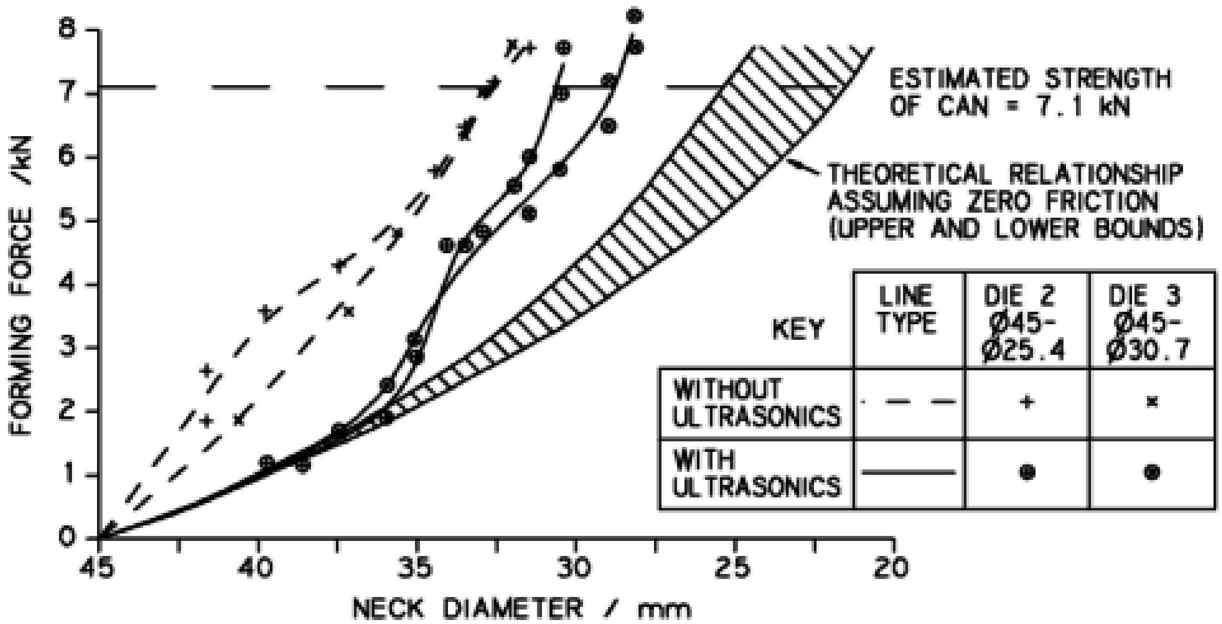


Figure 6.21 - Measured forming force vs diameter (early work)

Figure 6.21 shows the results for cans formed with and without ultrasonics, in dies designed for a final diameter of 31 mm and 25.4 mm. For comparison a graph of the theoretical forming force is also included (calculated using the analysis shown in appendix 1). The analysis takes account of work hardening of the metal (based on measured strength before and after necking) but assumes zero friction. It is remarkable how closely the measured forming force for the cans formed with ultrasonics follows the theoretical curve for the initial part of the forming process (arguably indicating that the process happens with almost zero friction in the early stages). Note that towards the end of the process the measured forces (with ultrasonics) diverge from the theoretical curve but remain significantly lower than the measured forces without ultrasonics. Note also that a smaller diameter was achieved using the 25.4 mm diameter die, almost certainly because extra work is required to bend the material up into the straight section, and because contact with the (non-vibrating) inner tool causes extra friction. This straight section is necessary to provide the material for forming the rolled end ("curl").

6.5.2 Evaluation of forming force in later work

One problem with the method described above is that the can is formed slowly (coming to a complete halt). It has been found that the can is less likely to be crushed if the necking tools move at high speed (there is presumably a limit to this but this was not found within the speed capability of the hydraulic rams - about 0.25 m/s). It was therefore desirable to measure the forming force while the operation proceeded at normal speed. A load cell would have been ideal but this would have been difficult to fit into the forming rig because of various other moving parts. A simpler option was therefore implemented as shown in figure 6.22. Pressure transducers were fitted in the supplies to the hydraulic cylinder which powered the die movement. Two transducers were required to measure pressure above and below the piston.

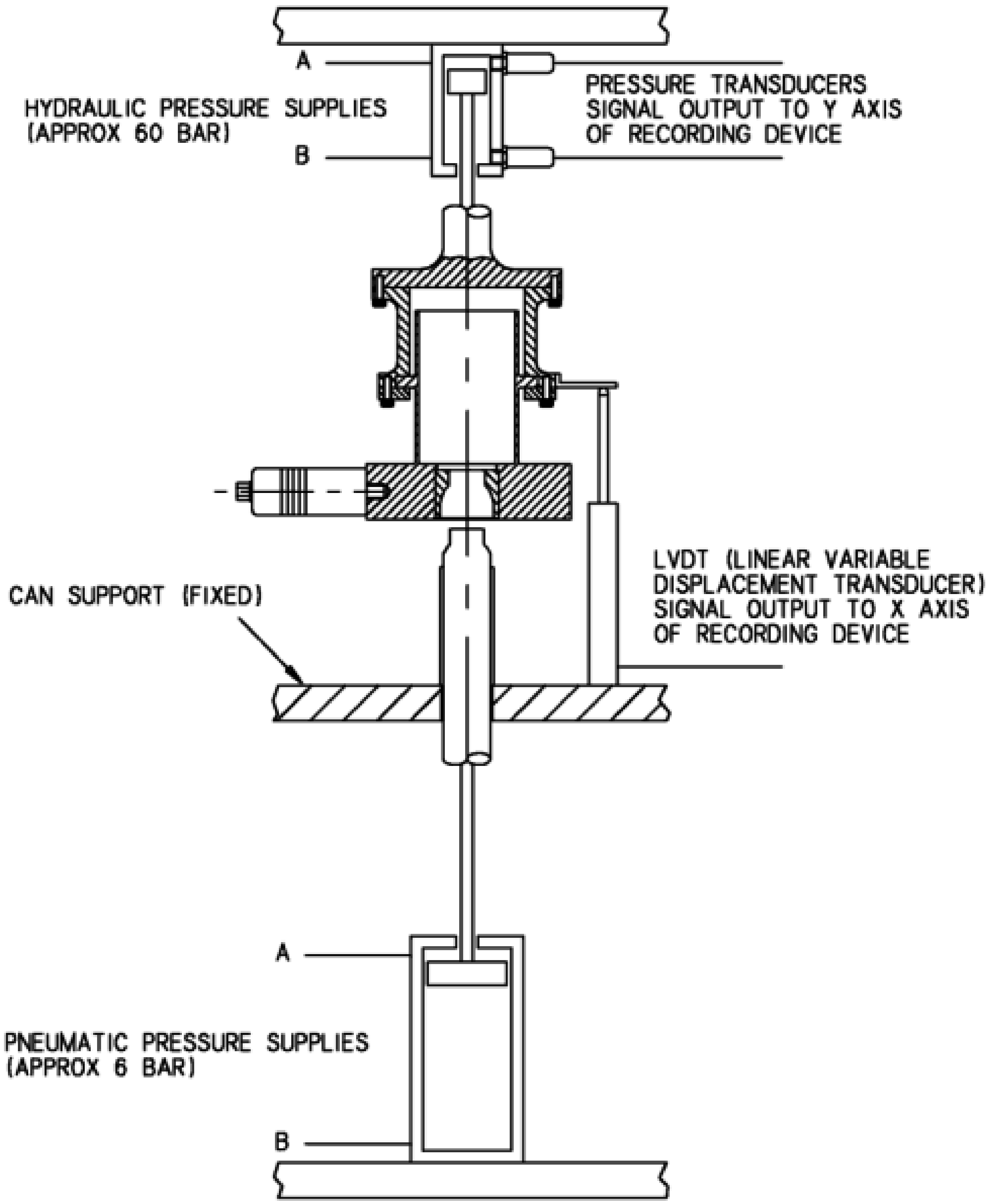
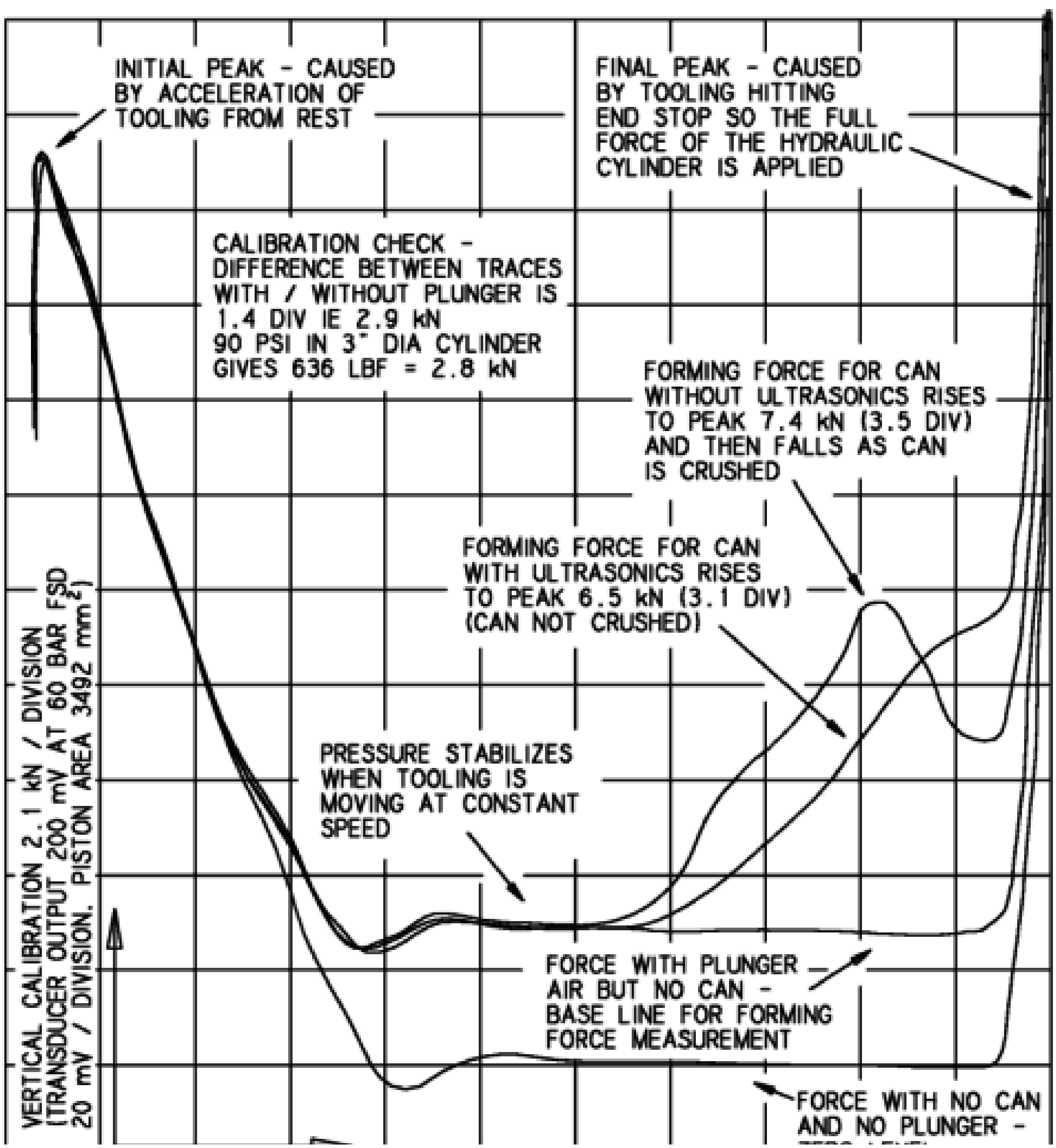


Figure 6.22 - Equipment to measure forming forces on test rig

Forming force was calculated by subtracting (pressure x area) below the piston from (pressure x area) above. An LVDT (linear variable displacement transducer) was also used to monitor the position of the moving die and so provide a reference to the progress of the forming process.

Results are shown in figure 6.23, for cans formed with and without ultrasonics. Note that the can formed without ultrasonics was crushed (causing a sudden drop in the applied force) while with ultrasonics the can was fully formed. The results are transferred to a graph of force vs neck diameter in figure 6.24 and here the graph of the theoretical forming force is also included (as on the earlier force - diameter graph). In this case the measured forming force (with ultrasonics) follows the theoretical curve much further, almost to the end of the forming process. Comparison with the measurements made in the early stages of the project shows that developments in the die technology have led to a further reduction in forming force but that the forming force has not been reduced below the theoretical zero friction force. This is strong circumstantial evidence in favour of the friction reduction theory of force reduction (see section 1.2).



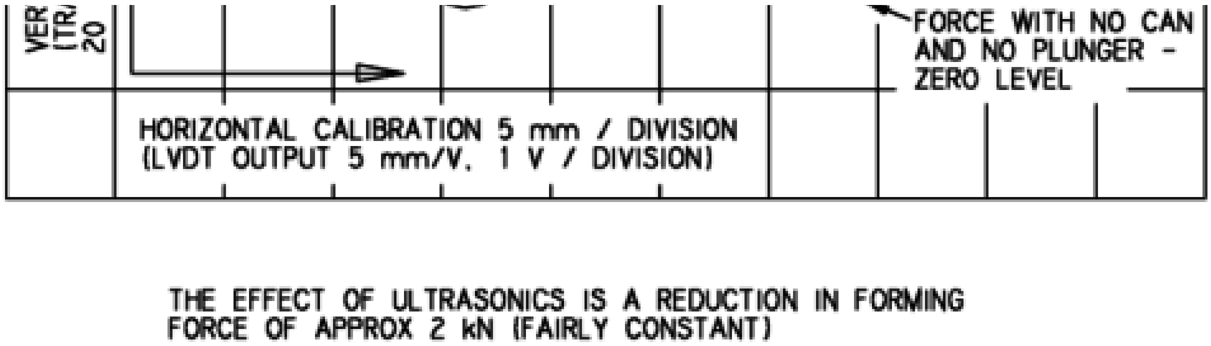


Figure 6.23 - Forming forces measured on test rig with and without ultrasonics

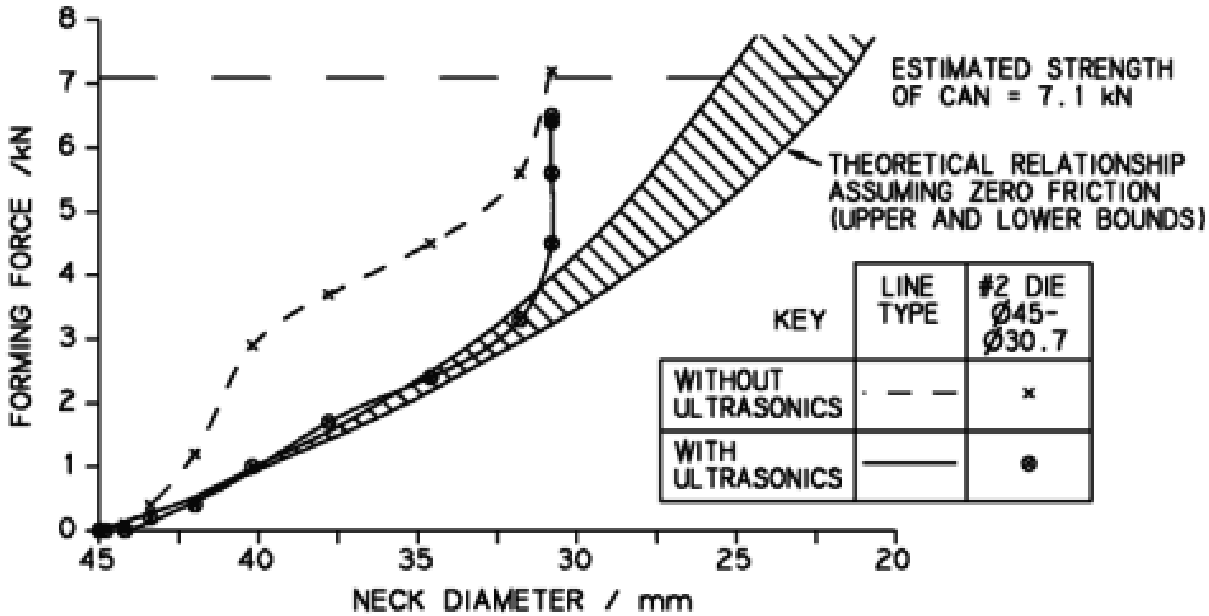


Figure 6.14 - Measured forming force vs diameter (later work)

6.6 CONCLUSIONS

Various methods have been used for evaluation of the die vibrations. ESPI (electronic speckle pattern interferometry) is potentially the most useful, offering full three-dimensional analysis of all visible surfaces of the die, even while forming a can. With further development the disadvantages of this system (cost, setting up and interpretation of results) could be reduced in the future. For evaluation of resonance modes and frequencies the admittance plotter (section 6.2.2) was used most. This gave convenient, accurate and revealing measurements of each die's performance.

Problems of "mode-switching" were found in dies with unwanted resonances close to the working frequency. The use of shaped dies was shown to overcome this problem.

Comparative measurements on dies with and without the tubular tuned mounting showed the improvements obtained by developing the method of attachment and the mounting geometry. The result of this development is a mounting system which accurately locates the die while allowing it to vibrate with minimal loss of energy.

Measurements of the force required to form a can showed that the effect of the ultrasonic vibrations was to reduce forming force by 40 to 60%. Where high reductions are required this may mean the difference between successfully necking the can and crushing it. The reduced forming force corresponded very closely to the theoretical zero-friction force, suggesting that the observed effect of ultrasonics may be caused by reduction or elimination of friction.

1. INTRODUCTION

This project concerns the development of a new technique for forming metal aerosol cans using ultrasonic vibrations to assist the forming process. The work described forms part of a collaborative research project between CarnaudMetalbox and Loughborough University sponsored by the Science and Engineering Research Council under the specially promoted programme for the development of high speed machinery. Research at Loughborough included the development of special optical and modal analysis techniques for vibration measurement and design optimisation, while at Wantage finite element analysis was used to develop the design of new ultrasonic tools. For a general overview of project aims and achievements see Chapman and Tyrer [1].

The project involves two main areas:

1) Aerosol can manufacturing methods

2) High power ultrasonics, particularly where applied to metal forming processes.

In this chapter the reasons for the use of ultrasonics are explained and possible reasons for their beneficial effects discussed. Safety considerations when working with high power ultrasonics are also included.

A short summary of the thesis follows to indicate the content of the remaining chapters.

1.1 BACKGROUND

The background to the project includes the manufacture of aerosol cans (which was the first application of the technique), and the use of high power ultrasonics.

1.1.1 Background - Aerosol Cans

Most aerosol cans available at present are manufactured from either steel or aluminium. The production method depends on the material. Aluminium cans are produced by extrusion of a cylinder with a closed end, followed by multiple die forming operations to reduce the diameter of the open end and create the rolled end on which the valve assembly is fitted. Figure 1.01 shows diagrammatically the whole process while figure 1.02 shows a series of cans at each stage of the neck reduction.

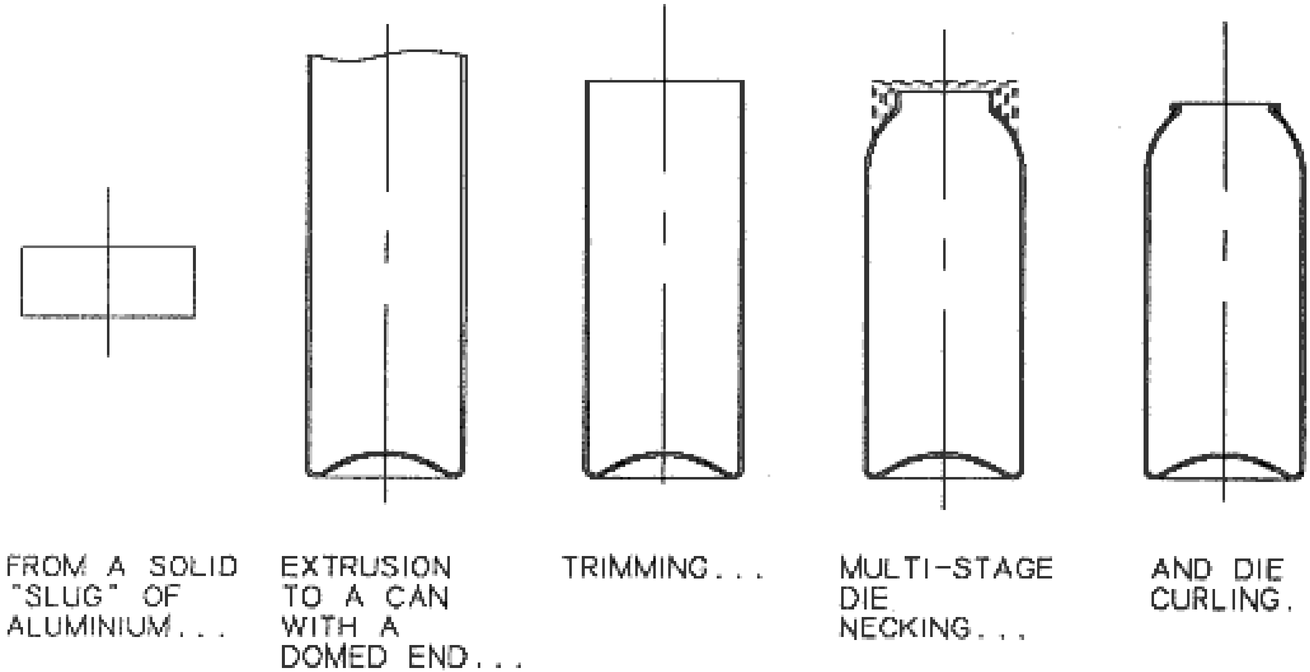


FIGURE 1.01 - MANUFACTURING PROCESS FOR ALUMINIUM AEROSOL CANS

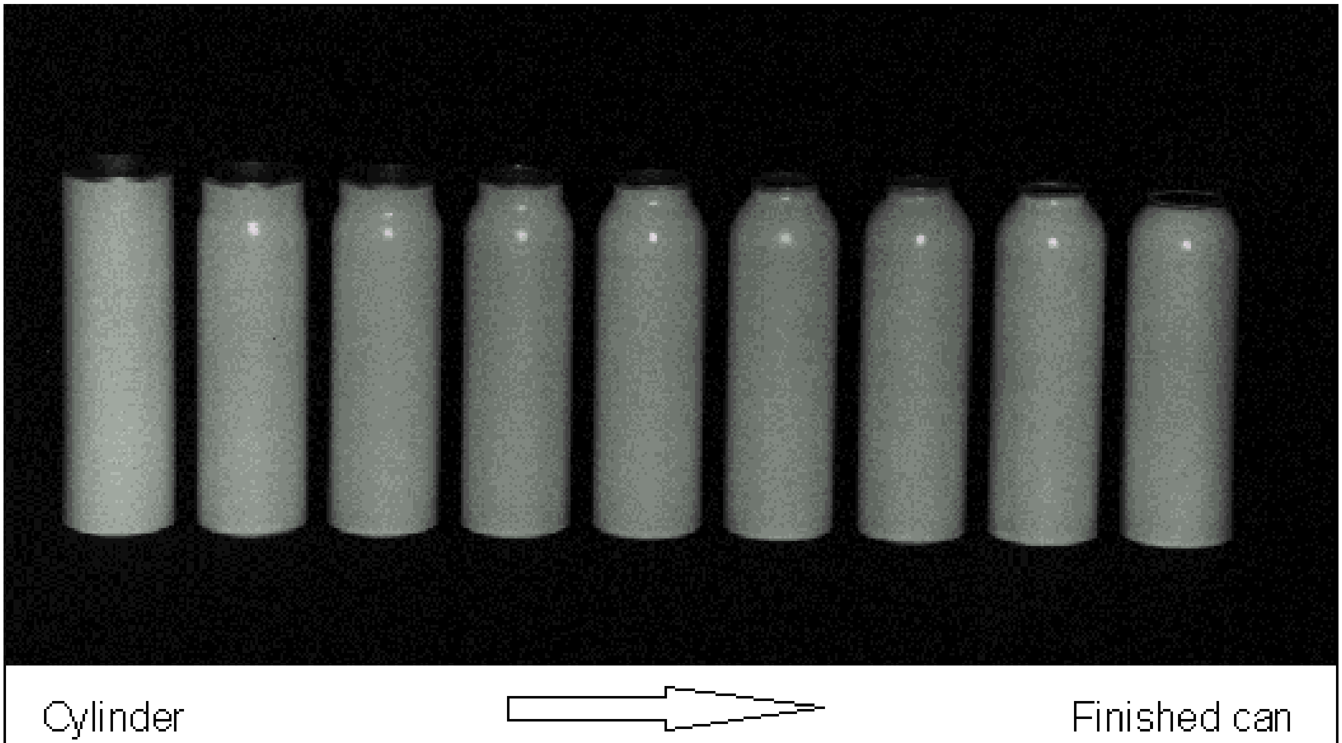


Figure 1.02 Series of aluminium aerosol cans at successive stages of the necking process

Steel (tinplate) cans are produced by a different process shown in figure 1.03. A rectangular shape is cut from sheet, rolled into a cylinder and welded along the seam. The round end pieces (pressed from another sheet of steel) are then fitted by a clinching process known as double seaming.

Both types of can are supplied to the filler (cosmetics / pharmaceutical companies) with the top open. Valve assemblies are supplied separately. The filler puts his product plus propellant into the can and then fits a valve assembly which is fixed by clinching (figure 1.04). To ensure that the filling operation goes smoothly and to avoid leakage after filling both the can and the valve assembly must be made to tightly controlled dimensions - typical tolerances are ± 0.1 mm.

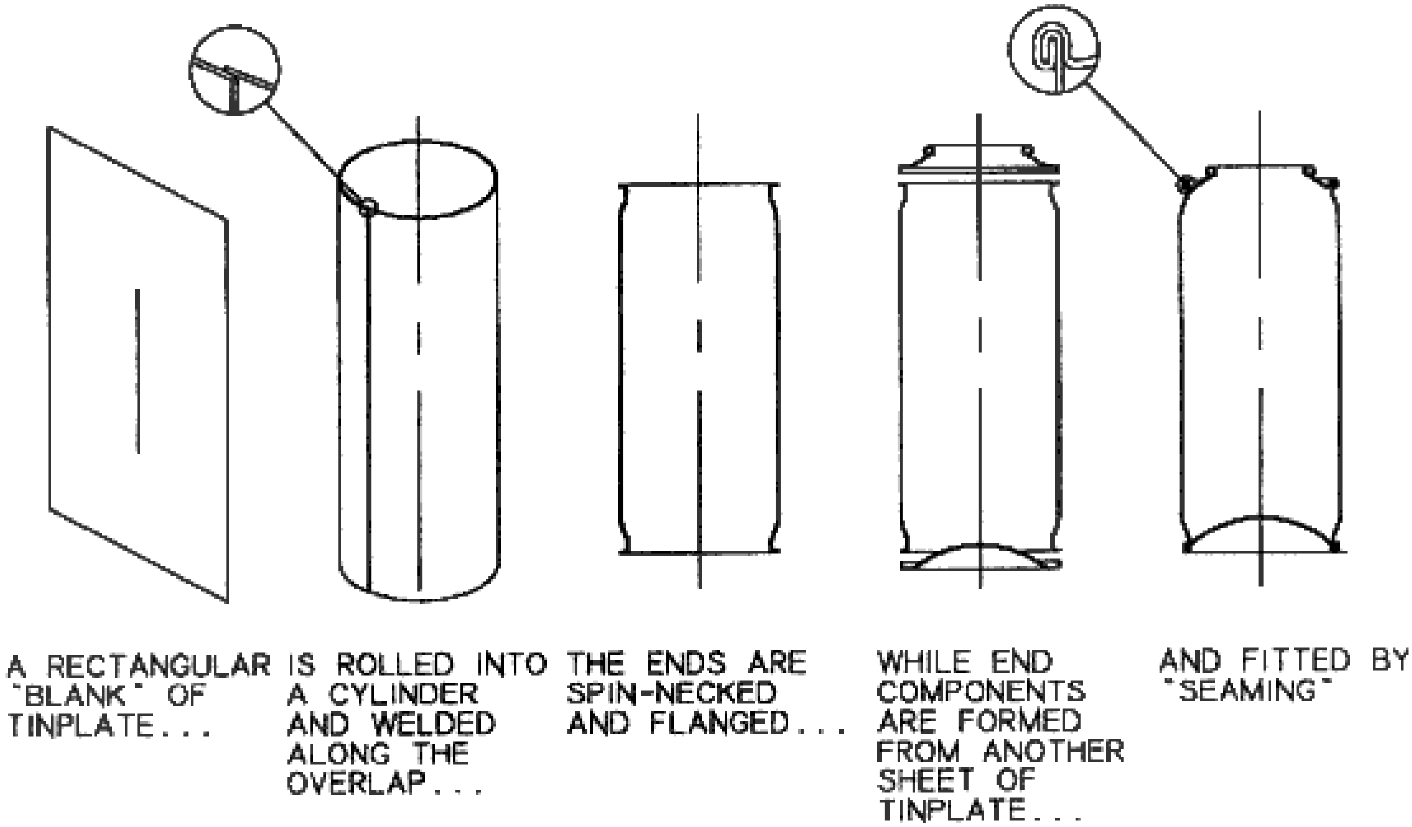


FIGURE 1.03 - MANUFACTURING PROCESS FOR TINPLATE AEROSOL CANS

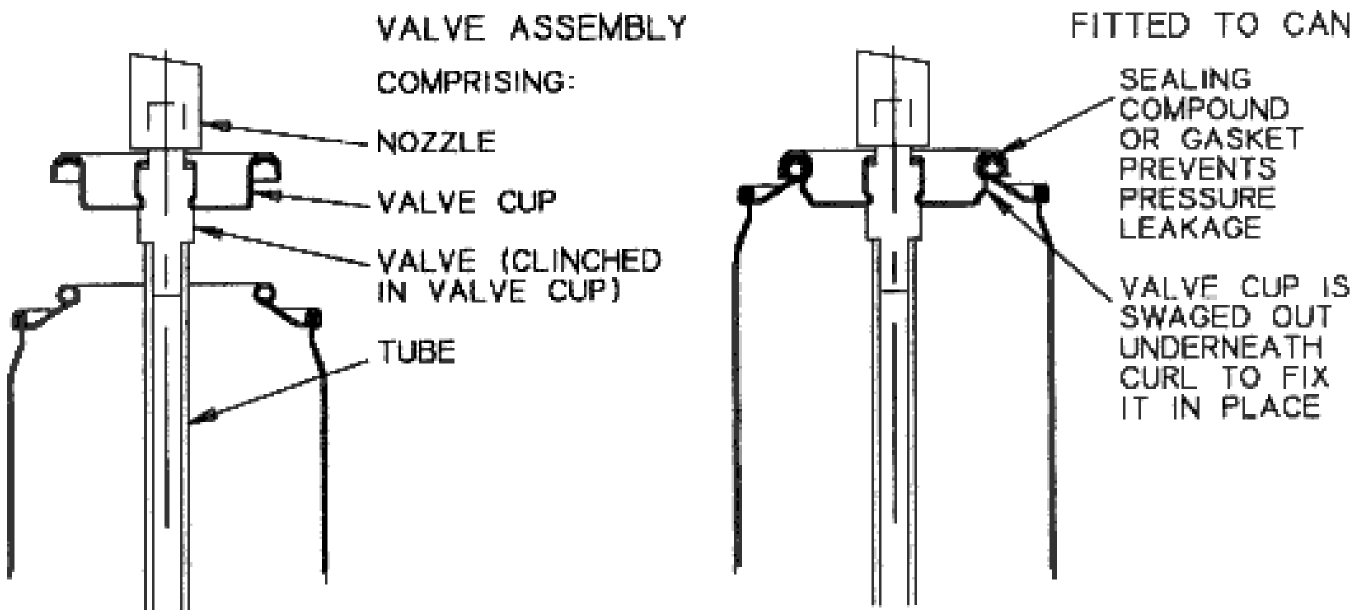


FIGURE 1.04 - FITTING OF AEROSOL VALVE ASSEMBLY

Each can material has advantages and disadvantages. The advantages of aluminium cans are their smooth, attractive appearance and the reduced risk of corrosion (many aerosol products are corrosive). The main advantage of steel is its lower cost - the raw material cost of aluminium is relatively high and aluminium can walls must be thicker to withstand the same internal pressure (the yield strength of the aluminium used is lower than that of steel). Also steel aerosol cans may be decorated with a higher quality design because printing is done on the flat sheet - this is easier than printing onto a cylindrical can surface. To counteract the risk of corrosion of steel cans various systems are used to apply a protective coating to the inside and outside surfaces.

Most aerosol cans on sale in the UK are made from steel, primarily because of their lower cost. Aluminium cans are used mainly in small sizes for cosmetic products where the appearance advantages outweigh the extra cost.

CarnaudMetalbox Aerosols UK manufactures only tinplate aerosol cans. To gain a competitive advantage, therefore, it was desirable to improve the design of the tinplate aerosol to make it more competitive with the aluminium can. This was the basis for the development of the "coneless" tinplate aerosol can, so called because the top component (the cone) has been eliminated. The rolled form on which the valve fits must be formed from the cylindrical body as in the aluminium can. This has the advantage of an attractive appearance similar to the aluminium can while maintaining the lower cost of the tinplate can (in fact the cost of a coneless tinplate can may even be less than that of the conventional can because the cost of producing the cone is eliminated). Figure 1.05 shows the manufacturing process for coneless tinplate aerosols. Figure 1.06 shows for comparison a conventional tinplate aerosol, the new coneless aerosol with and without a shrink-sleeve decoration (to disguise the unprinted weld area) and an aluminium aerosol.

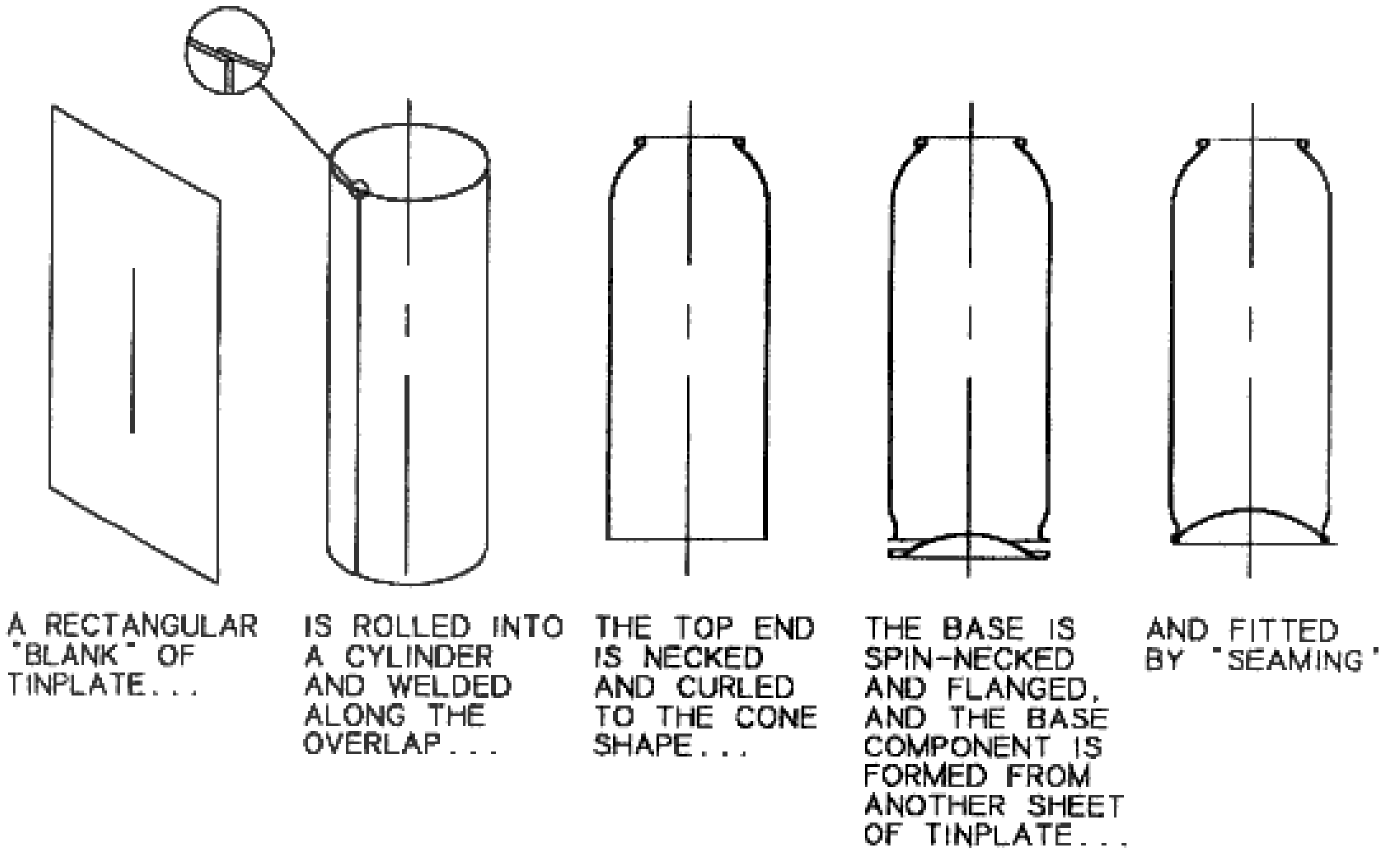


FIGURE 1.05 – MANUFACTURING PROCESS FOR "CONELESS" TINPLATE AEROSOLS

Figure 1.06 Comparison of different types of aerosol can

The process of forming the end shape from the cylinder is much more difficult in steel than in aluminium, because the steel is harder, thinner and more liable to work hardening than the aluminium material. This means that even more forming operations are required to achieve any given reduction in diameter. A similar process has been used on steel cans by Stoffel [2] but in this case the rolled end on which the valve fits was formed by rolling the material inwards. This makes the necking operation much easier and reduces work hardening of the can material but leaves the raw edge of the material inside the can. This part of the can is particularly prone to corrosion because it lacks the protection of the layers of tin and lacquer that cover the surfaces of the can walls. This means that a steel aerosol manufactured in this way would be limited to non-corrosive products, such as solvent-based hair sprays. Water-based products such as mousses and shaving foam (for which there is a large market) could not use such a container and it is probably for this reason that commercial exploitation has not followed.

The problem is essentially that the conventional die necking process is incapable of reducing the can diameter by more than a few millimetres in each operation. If a greater reduction is attempted then the material undergoes a hoop buckling failure known as "pleating" (figure 1.07). The basis of the new necking operation is to prevent this by using a shaped plug inside the die (figure 1.08). The profile of the die and plug match, so that the gap between them is about 1.5 times the material thickness. This is sufficient to permit the material to pass through, even if it thickens slightly, but not to permit the material to pleat.

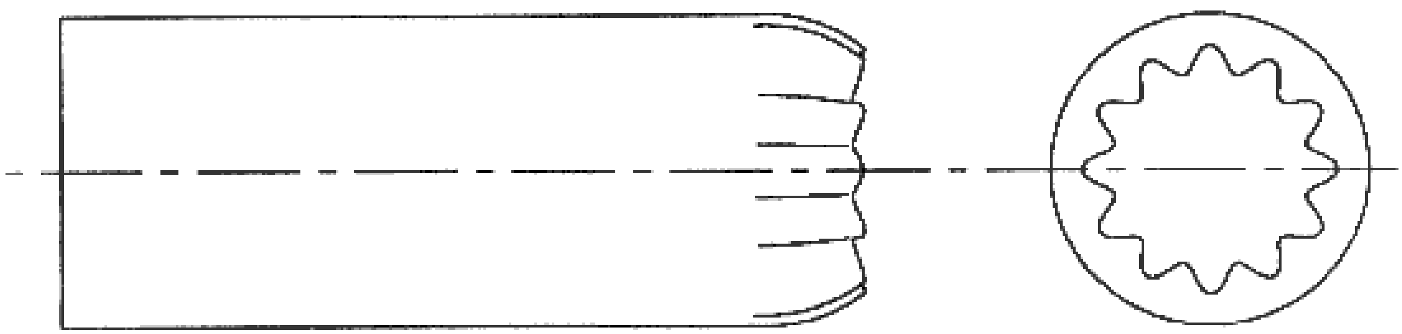


FIGURE 1.07 PLEATING (HOOP BUCKLING) DURING NECKING

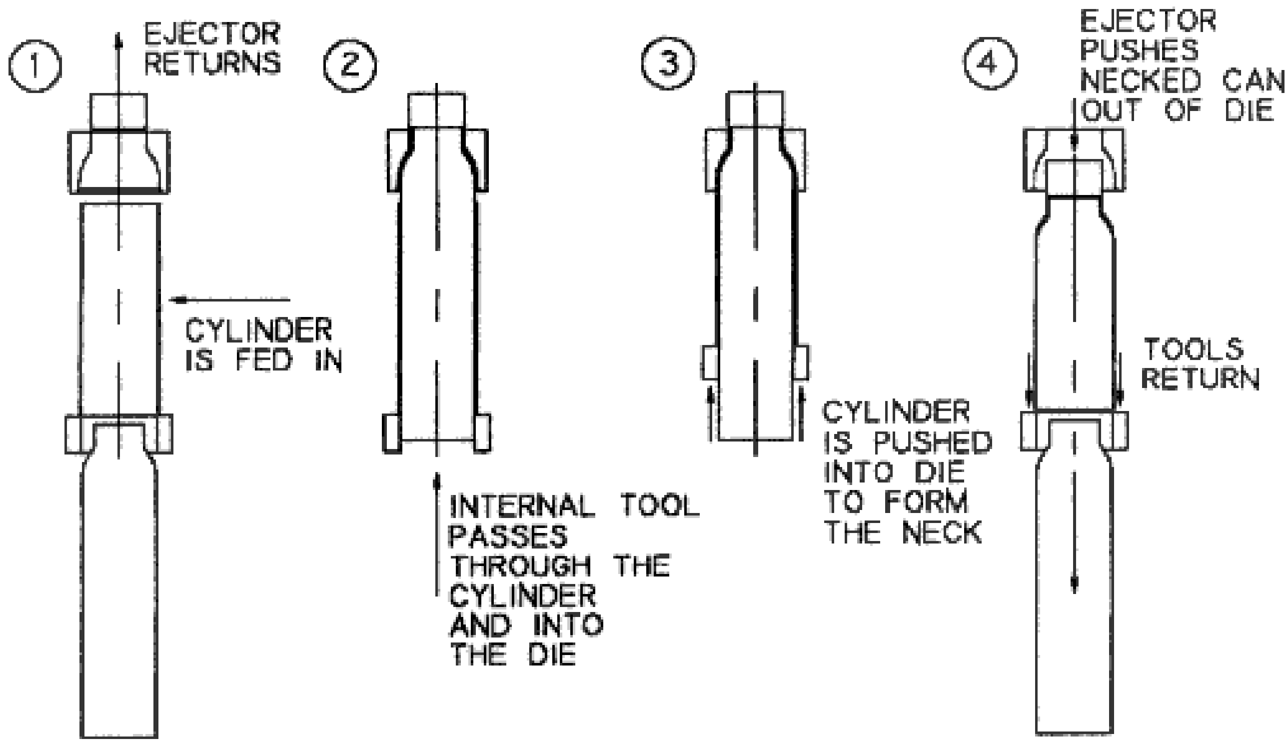


FIGURE 1.08 - SEQUENCE OF EVENTS - DIE NECKING WITH INTERNAL PLUG

Using this type of tooling the problem of pleating is eliminated, so far greater reductions are made possible (More than 30 % reduction of diameter has been achieved in a single operation, compared to about 5 % maximum in conventional necking processes). The achievable reduction is still limited, however, by the force that can be applied. The can must be pushed into the die and the force, applied to the base, must be transmitted through the body of the can to the neck area (see figure 1.08). Thus the maximum force that can be applied is limited by the strength of the can body. If the necking force exceeds the strength of the can body then the necking will stop and the can will be crushed. Figure 1.09 shows a can crushed by excessive forming force.

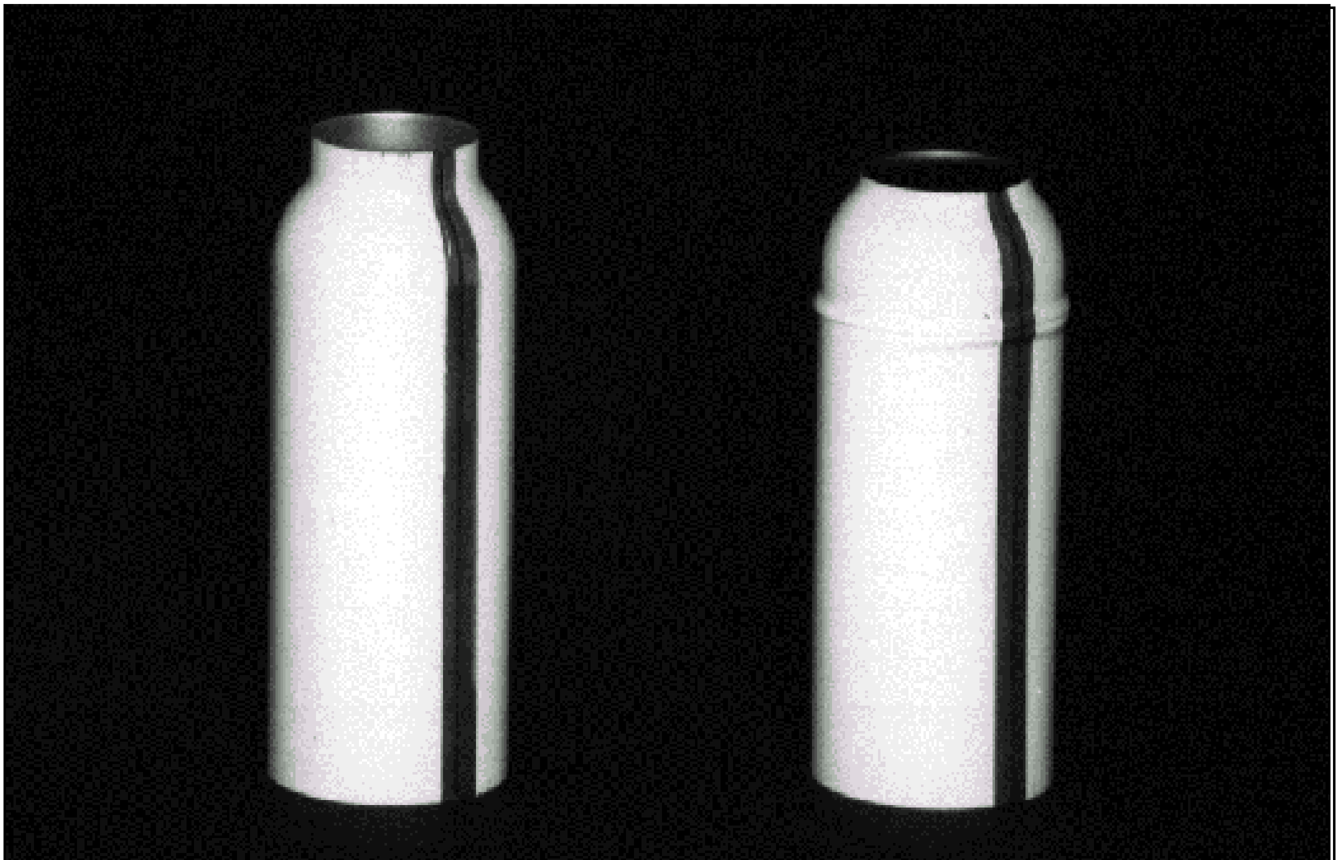


Figure 1.09 Cans necked successfully and crushed during necking

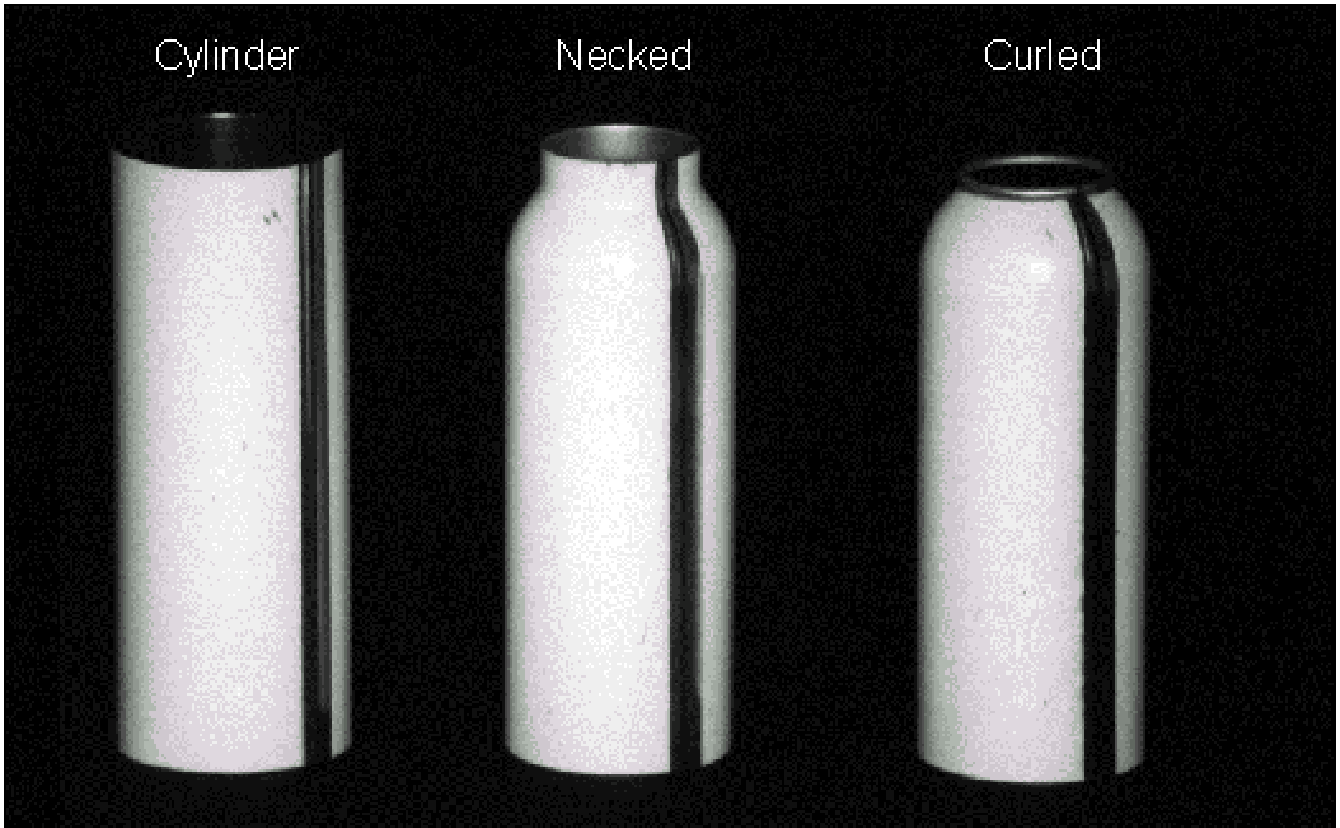


Figure 1.10 Manufacturing process for coneless tinplate aerosols

Figure 1.10 shows cans at three stages of the new process - before and after the new single die necking operation and after spin necking and curling to form the rolled end. A new spinning process to form the required "outward" curl (leaving the cut edge outside the can) has also been developed specifically for the new aerosol can, but a detailed description is outside the scope of this document.

1.1.2 Analysis of can body strength

The strength of the can body depends on a number of factors including the Young's modulus and yield stress of the material, the plate thickness and the can diameter. The mode of failure may be buckling or yield, whichever occurs at the lower level of applied force. The yield strength of the can is easily calculated:

$$F_y = 2.\pi.r.t.\sigma_y$$

where

F_y = yield force
r = can radius
t = can thickness
σ_y = yield stress

i.e. Yield force is yield stress times area.

The formula for buckling collapse is more complicated. Roark [3] page 689 gives the following for critical stress in a thin walled cylinder:

$$\sigma' = \frac{1}{\sqrt{3}} \cdot \frac{E}{\sqrt{(1-\nu^2)}} \cdot \frac{t}{r}$$

where
σ' = critical stress
E = Young's Modulus
ν = Poisson's ratio

but suggests that measured values are typically between 40 and 60% of this theoretical value. Taking 40% and multiplying by the cross sectional area gives the predicted collapse load in buckling:

$$F' = 0.4619 \frac{\pi t^2}{\sqrt{(1-\nu^2)}} \cdot E$$

where F' = buckling force

Into these formulae we can put the known values for the can geometry and the material properties of the steel as follows:

E = 210 GPa, σy = 240 MPa, r = 22.5 mm, t = 0.21 mm, ν = 0.3

The result is a calculated yield load of 7.1 kN, and a buckling load of 14.1 kN. This suggests that the mode of failure for this type of can will be yield. The measurements described in section 6.5 confirm this, and the measured collapse force matches this calculated value well.

The mode of failure and the formula describing the collapse load are important to determine what could be done to improve the process. Theoretical analysis of the neck forming (appendix 1) indicates that the forming force is proportional to yield stress, diameter and material thickness (and is also dependant on the amount of reduction, the work hardening characteristics of the material and friction). Since both the forming force and the strength of the can are proportional to the same three parameters, varying these parameters will not improve the forming process or permit a greater reduction. This can be achieved only by reducing friction or by reducing work hardening of the material.

In fact this is oversimplifying the situation slightly. The force required to form the neck depends on the yield stress in the hoop direction, while the can strength depends on the yield stress in the axial direction. The tinplate sheet is not isotropic - the rolling process imposes a "grain direction" that is visible to the naked eye. The nature of the anisotropy varies from one material to another but for the type of tinplate used for this product ("temper 2") the yield stress is about 5% less along the grain than across it. The 45 mm diameter aerosol cans are usually made with the grain direction along the can (called "H-grain") in order to maximise the efficiency of material usage within the sheet sizes available from tinplate suppliers. This is not ideal because the higher yield stress in the hoop direction increases the forming force while the lower axial yield stress reduces the strength of the can body. Making the cans with the grain direction around the can ("C-grain") improves the process. To manufacture 45 mm "coneless" aerosols C-grain material was specified. The small cost penalty associated with this is far outweighed by the improved neck forming.

Apart from the (marginal) issue of grain direction, there are three methods of maximising the achievable necking reduction:

1) Minimise work hardening

2) Minimise friction

3) Radically change the nature of the forming process.

It was thought that the use of ultrasonics might help to achieve some or all of these aims.

1.1.3 Background - Ultrasonics

Ultrasound can be defined as mechanical vibrations in a solid or fluid at a frequency higher than the range audible to humans. The lowest ultrasonic frequency is normally taken as 20 kHz. The top end of the frequency range is limited only by the ability to generate the signals - frequencies in the gigahertz range have been used.

Historically ultrasonic vibrations have been used for a huge variety of applications. These can mostly be divided into two broad categories: low power ultrasound (up to about ten watts) and high power ultrasound (ranging from hundreds of watts to tens of kilowatts). Low power applications include non-destructive material testing (particularly for welds), fluid level measurement, thickness measurement and medical imaging. These applications are not highly relevant to the subject of this research and so will not be discussed in detail. High power industrial applications of ultrasound include welding of metals and plastics, ultrasonic cleaning and sonochemistry (altering rates and / or products of chemical reactions). Some of these are relevant to this research because there are common problems in generating, transmitting and controlling the ultrasonic vibrations. For a general review of these and many other applications of high power ultrasonics the reader is referred to a very comprehensive review by Perkins [4]. For more detail Vigoureux [5] gives a detailed account of the physics of high-power ultrasound while Puskar [6] gives a comprehensive description of experimental work in this field, particularly in Eastern Europe where much of the research has been conducted.

A common feature of all high power applications is the use of frequencies at the lower end of the scale (i.e. in the range 20 to 60 kHz). This is because the power available is limited by mechanical stress in the vibrating parts (as described further in section 3.8). Conversely higher frequencies (and square waves or step functions that include high frequency harmonics) tend to be used in measuring applications because the shorter wavelength offers greater accuracy, and at low power mechanical stress is not a problem.

In the following sections the application of high power ultrasound to metal forming is discussed, along with methods of generating the ultrasonic vibrations and the benefits obtainable.

1.1.4 Application of high power ultrasound to metal forming.

The history of research into the use of ultrasound in metal forming is discussed in section 1.3.1. The technique has been assessed in diverse operations including wire drawing, tube drawing, deep drawing, wall ironing and necking, also called nosing or upsetting (i.e. reducing the diameter of one end of a cylinder). In general the use of ultrasound has led to some reduction in the forming force and / or increase in the maximum strain achievable. Note that a reduction in forming force is not, in itself, particularly useful, but an increase in maximum strain can have a dramatic effect because this may permit the use of fewer operations to manufacture a product or even make possible a product that otherwise could not be formed.

The application most similar to the work described in this thesis was reported by Skachko, Pashchenko et al [7], [8]. This group applied high-power ultrasonics to the forming of an aerosol neck, and found that it was possible to reduce the number of operations required from 9 to 3 using ultrasonic vibrations in the axial and / or the radial directions. It is likely that the number of operations could not be further reduced because of hoop buckling (pleating) as described in section 1.1.

This problem would have been much more severe had the can material been thinner and harder as a steel can is. In this case the use of a shaped plug is essential to prevent pleating. Note that once the problem of pleating is solved more importance is placed on the effectiveness of the ultrasonics, because this is the only factor that limits the achievable reduction. It is for this reason that the research into ultrasonic dies has been carried out at CarnaudMetalbox.

1.1.5 Methods of generating high power ultrasonic vibrations

To generate and maintain vibrations in an object a transducer is normally used to convert an electrical signal to mechanical motion. A simplified description of the two most common types of transducer (magneto-strictive and piezo-electric - see figure 1.11) will be given here. The published literature relating to ultrasonic transducers for power generation is discussed in section 1.3.3.

The first type of transducer works on the principle of magnetostriction, by which a magnetic field causes elongation of certain metals (nickel alloys are usually used). A coil of wire wrapped around a metal core creates a magnetic field proportional to the electric current and the core expands and contracts as the field changes. A biasing field is required to obtain a (relatively) linear response; this may be achieved using permanent magnets or a dc biasing current. The core is usually laminated to minimise eddy currents within it.

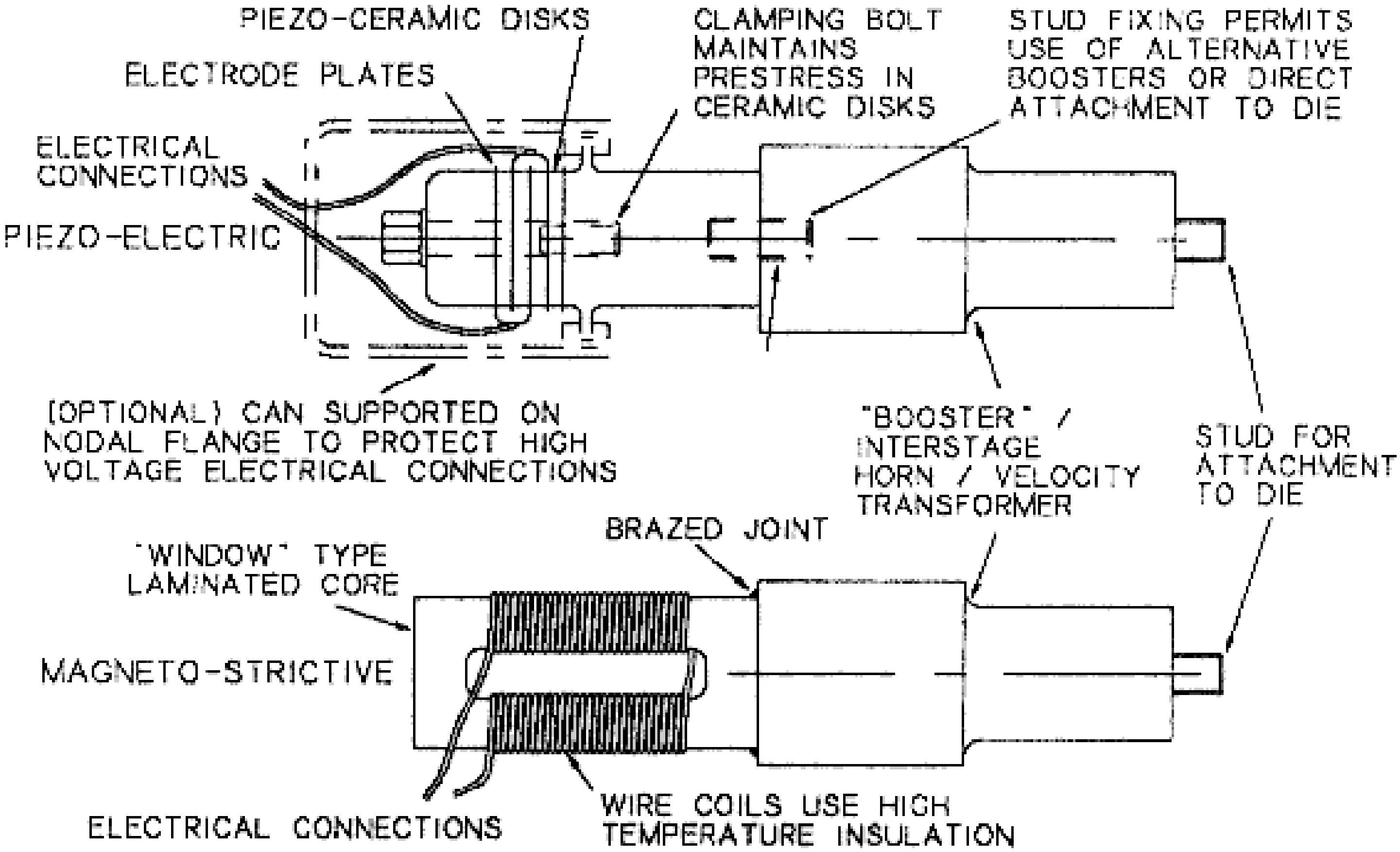


FIGURE 1.11 - TYPES OF HIGH POWER ULTRASONIC TRANSDUCER

The piezo-electric transducer consists of a number (normally 2 or 4) of piezo-ceramic disks clamped between metal blocks by a high tensile screw. Under the action of an applied alternating voltage the disks expand and contract, transmitting vibrations to the blocks. The disks are liable to fracture if subjected to tensile stress so they are preloaded by the blocks and screw to ensure that a compressive stress is maintained at all times.

Magneto-strictive transducers are extremely robust (almost unbreakable) and can work over a wide frequency band, so are tolerant of frequency mismatching; their disadvantages are largely associated with inefficiencies caused by non-linearity in the magneto-strictive effect, eddy currents in the core and resistance losses in the wire coils. These limit the vibration amplitude that can be generated and can cause overheating (the coils are often wound with PTFE-insulated wire to prevent melting). Also the laminated cores are not easily fitted to a vibrating tool - often the cores are brazed to a solid part on which the tool can be fitted using a stud. The addition of this part naturally increases the losses still further. The recent development of magnetostrictive transducers based on rare earth - iron alloys may lead to solutions to these problems (Lhermet & Claeyssen [9]).

The piezo-electric effect tends to be more linear, and because it converts the electrical signal directly to mechanical movement there are no other sources of inefficiency. For this reason they operate with much higher efficiency and (given that only a certain amount of power is available) they can maintain a higher operating amplitude. Some early transducers of this type had a poor reputation for reliability, with fracture of the bolt and / or the disks as the mode of failure. This was to some extent a by-product of their high efficiency. Given a fairly low level of power input with the transducer under no load a very high vibration amplitude could be generated - causing tensile stresses high enough to destroy the transducer. The solution to this problem was in developing intelligent electrical power supplies capable of varying the power input to maintain a constant (safe) amplitude in the transducer.

Most of the work that has been carried out in the field of metal forming has used magnetostrictive transducers, largely because most of the research was carried out in the 1960's and 1970's when the piezo-electric type was not fully developed. More recently in the plastic welding industry the piezo-electric transducer has become the accepted standard. Several manufacturers of equipment for this industry have now developed highly efficient transducers that are neat, self-contained and have a high power capacity. For this research the piezo-electric transducers were chosen in order to achieve maximum amplitude under load. They have proved extremely efficient and reliable in this application. A magneto-strictive system has also been used for some research work where its lack of efficiency is not important and its relatively wide frequency range is an advantage (for vibrating the die at non-resonant frequencies).

1.2 ULTRASONIC SYSTEM FOR FORMING AEROSOL CANS

The aim of this section is to discuss the requirements of an ultrasonic system for forming steel aerosol cans. First the possible mechanisms of reduced forming force are described, and the most likely ones described in detail. This effectively fixes the type of ultrasonic die. Other requirements of the vibrating system are then discussed.

1.2.1 Proposed mechanisms of force reduction from earlier work

The reasons proposed for the observed reductions in forming force generally fall into one of three categories: changes to the material properties of the metal being formed, changes to the stress state and changes to the frictional state. A brief discussion is included here while the published work is reviewed in detail in section 1.3.1.

Some researchers, notably Langenecker [13], [14] and Izumi et al. [21] have attributed an apparent softening of the material to preferential absorption of ultrasonic energy at the grain boundaries, leading to localised heating and facilitating flow.

Another mechanism, proposed by many researchers, eg. Nevill and Brotzen [11], Pohlman and Lehfeldt [16] and Winsper and Sansome [28], [29] is that the reductions in forming force can be attributed to changes in the stress state during the vibration cycle. The argument can be applied to axial or radial excitation of the die. For axial vibration the extra stress generated by a "push" each cycle is superimposed on the average stress level. Provided the total stress exceeds the yield strength of the material then yielding will take place once per cycle, while the average stress is less than the yield strength of the material. In many metal forming applications (including this study) the force which can be applied is limited by the strength of the component. Superposition of axial stress will not help this type of process because the vibration stress generated will be applied equally to the component, causing it to yield at an average stress level lower than its actual strength. The application of radial vibrations, however, is potentially more useful. Here the vibrations may cause an increase in the hoop stress in the forming region (assisting its yielding in this direction) without a corresponding increase in the axial stress that the component must withstand. The process of stress superposition by radial squeezing is known as swaging. This was demonstrated in a laboratory experiment by McQueen and Sansome [44].

One further complication here is that when the forming force is reduced (by whatever means) the material is, by definition, less stressed, so less work hardening would be expected. Reduced work hardening would also lead to an apparent softening of the material with ultrasonics, although the effect of this would be slight.

The final proposed reason for force reduction is a change to the frictional conditions. Friction changes have been measured in laboratory tests, notably by Pohlman and Lehfeldt [16] and by Polanski et al. [17]. The friction coefficient may be reduced by separation of the surfaces, reduction of the normal force or "pumping" of lubricant over the surface. Alternatively the direction of friction may be changed - it may work at an angle to the direction of motion or, ideally, may be reversed so that friction assists the process. There is a theoretical basis for all of these possible changes:

Vibrations normal to the surface will cause a variation in the normal force. During that part of the cycle when the normal force is reduced sliding can take place with reduced friction. At the opposite part of the cycle, when the normal force is increased, the sliding may stop. Thus sliding takes place only when the normal force is reduced, so the friction force is correspondingly reduced. If the variation in the normal force is such that zero force is obtained then the surfaces separate for a part of each cycle, and sliding can take place with zero friction during this period. The reduced normal force also contributes to the lubricant pumping effect.

Vibrations parallel to the surface can cause changes in the direction of friction. If the direction is parallel to the surface but perpendicular to the direction of motion then the angle of the friction vector will be altered. The magnitude does not change (using the Coulomb friction model) so the component of friction in the direction of motion is reduced. If the vibrations are induced parallel to the direction of motion, and the vibration velocity is greater than the sliding velocity, then there will be a part of the cycle during which the direction of sliding is reversed. This must result in reversal of friction during that period. Note that these changes are heavily dependent on the relative sliding velocity - at higher forming speed the effect of the vibrations is reduced.

1.2.2 'Most likely' mechanisms in this application

From the available information it was thought that vibrations normal to the die surface (i.e. radially) would give the most beneficial effect, and this was largely confirmed by some early trials comparing the effects of axial and radial excitation. Therefore the design and optimisation work has been focused on radial-mode dies. The "most likely" force reduction mechanisms for radial vibrations are swaging (gradual deformation by successive radial squeezes) and friction reduction (figure 1.12).

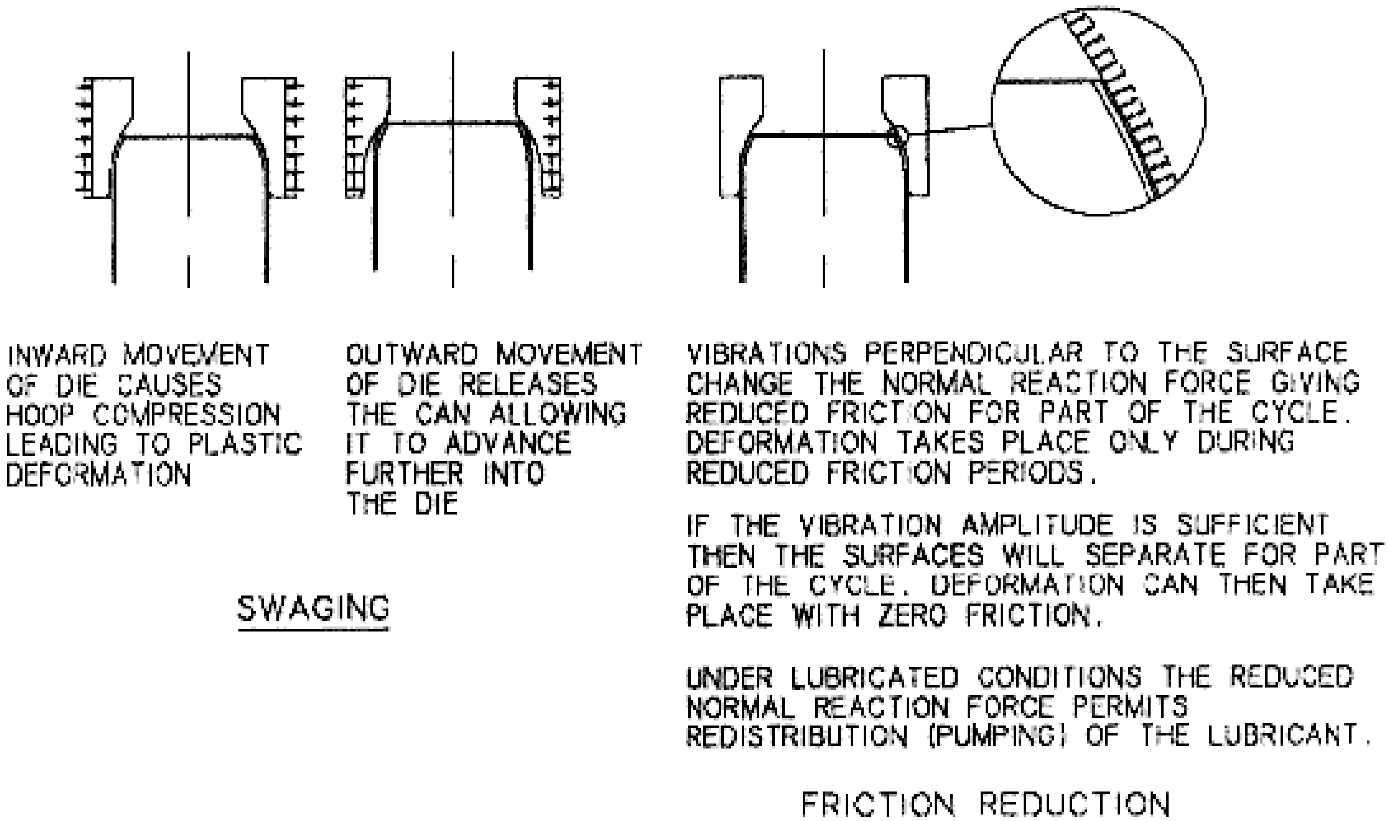


FIGURE 1.12 - EFFECTS OF RADIAL DIE VIBRATIONS

The swaging process has the potential (ideally) to reduce the forming force to zero, but this is dependent on many factors including particularly the forming speed. The faster the can is advanced into the die the more deformation will be required during each cycle, and so the higher the forming force will be.

In contrast friction reduction does not have the potential to reduce the forming force beyond a certain limit. When friction is eliminated a forming force will still be required because work must be done to deform the material of the can. The forming speed should not affect the forming force because the friction reduction depends only on the normal force, not on the sliding speed.

Thus the character of these two mechanisms is quite different, although their apparent effect on the process (a reduction in the forming force) may be similar. In fact it is very difficult to definitively state which mechanism describes the real situation, but the measurements presented in section 6.5 correspond closely to the friction reduction model in two ways. Firstly the forming force did not increase at higher speed (if anything it was found to be reduced), and secondly the forming force with ultrasonics corresponded very closely to the force calculated in an analysis that assumed zero friction (appendix 1).

1.2.3 Ultrasonic system for forming aerosol cans

It follows from the proposed mechanisms of force reduction that vibrations perpendicular to the can surface are required. This implies that the die must vibrate in a radial mode - in which it alternately expands and contracts with every point on the inside surface moving radially with the same amplitude and phase. Accordingly the aim of this work has been to develop such a die, building on past work (as discussed in the literature review) but improving the efficiency of the vibrating system to obtain maximum amplitude while minimising operating costs.

For this reason the piezoelectric type transducer was chosen, and proprietary units from two manufacturers of plastic welding equipment have been used. Only one of these transducers can normally be fitted to a die (in contrast to the magnetostrictive type) but provided that the resonance characteristics of the die are correct this is not a problem - a single transducer fitted at one point on the die can excite the required uniform radial mode. The first priority in the design of the ultrasonic system, therefore, is to ensure that the resonance characteristics are correct - this is discussed in detail in chapters 3 and 4.

The second problem for a radial-mode vibrating system is that no part of the die is stationary - there are no nodal points. A mounting system is required which permits the die to vibrate freely while providing a stationary point by which the whole system can be fixed to the machine. Again there is some prior art but a more efficient, simple and robust system has been designed specifically for this application (described in chapter 5).

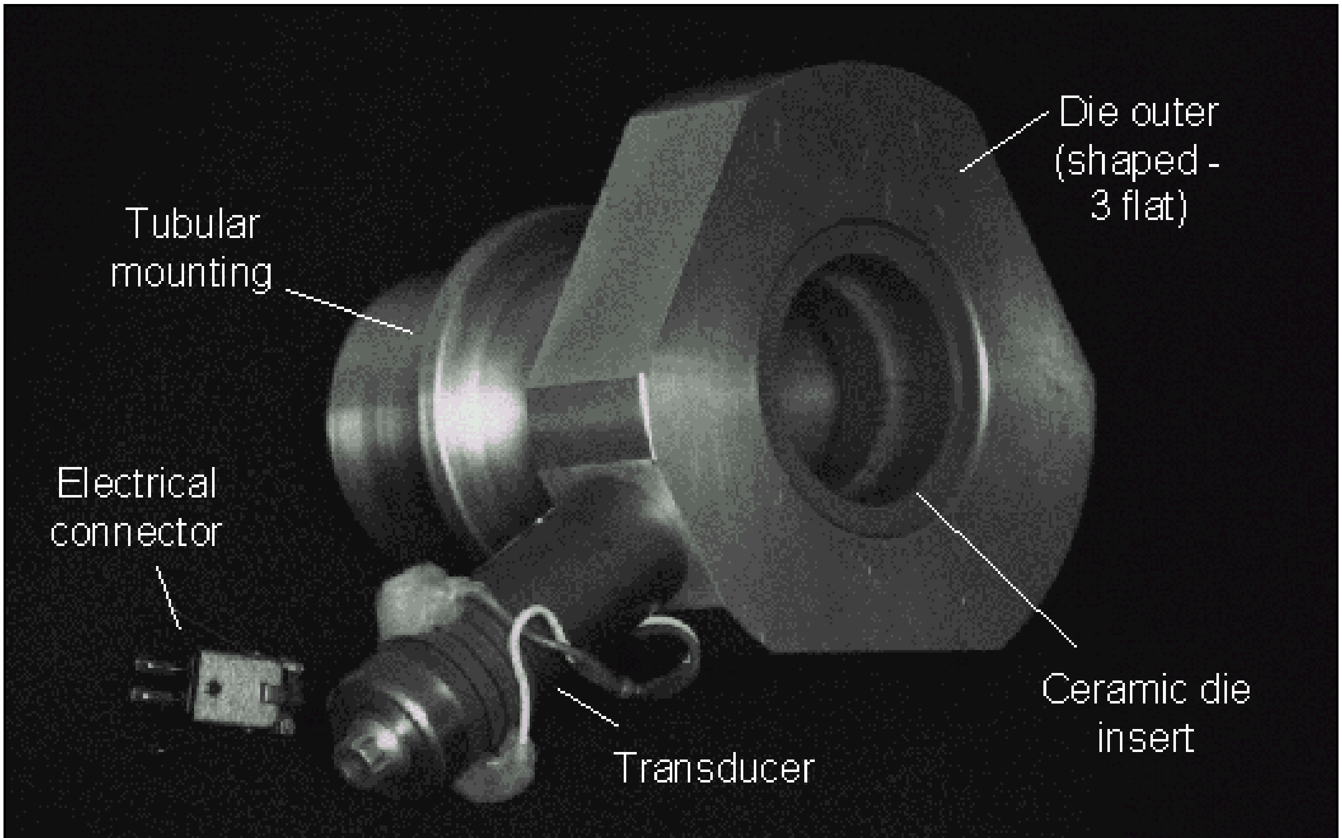


Figure 1.13 Ultrasonic equipment selected / developed for the project

A typical system used for ultrasonic necking of metal cans in this project, comprising piezoelectric transducer, radial-mode die and tubular mounting system is shown in figure 1.13.

1.3 LITERATURE REVIEW

The purpose of this section is to identify and review previous work that may be relevant to the present study. Published papers dealing with the use of high power ultrasound in metal forming processes are listed and discussed to indicate the history of this technique. Other industrial applications, methods of analysing die vibrations and materials for ultrasonic tools are also reviewed.

1.3.1 Application of high power ultrasound to metal forming.

Much of the early research work was largely theoretical and concentrated on apparent changes to the material properties under the action of the ultrasonics. Blaha and Langenecker [10] strain tested monocrystalline metal samples immersed in tetrachloromethane irradiated with ultrasound over a wide frequency range (up to 800 kHz). The ultrasound led to increased strain to fracture and increased ultimate tensile strength. Finding that ultrasonic energy was more effective than thermal energy at reducing the tensile stress, they suggested that ultrasound might be more readily absorbed at the dislocation sites that gave rise to plastic flow.

Other work (e.g. Nevill and Brotzen 11]) suggested that a reduction in flow stress could be attributed simply to superposition, because although the mean applied stress was reduced, the peak stress was equal to the static yield stress. Another alternative, proposed by Severdenko and Klubovich [12] was that ultrasound was simply analogous to increased temperature, causing a reduction in the rate of work hardening.

Langenecker [13], [14] showed that in tensile tests the results could not be explained by acoustic stress alone. He subsequently [15] discussed the various possible mechanisms and suggested that at low energy density the superposition mechanism operated, while at high energy overheating of the sample caused softening.

Besides these "volume effects" ultrasound has also been reported to affect frictional characteristics (the "surface effect"). For example Pohlman and Lehfeldt [16] investigated not only "internal friction" effects (stress superposition) but also "external friction". Applying vibrations in three orthogonal directions to a sliding contact they found that in all cases friction was reduced. This was attributed to the vibrations shearing of the welded asperity junctions, which would permit free sliding. Later Polanski et al [17] also measured changes in friction coefficient using a wedge test and found a 40% reduction in dry friction and a 20% reduction under lubricated conditions.

Given these promising results ultrasonic vibrations were soon applied to industrial metal-forming processes, particularly forging, extrusion and drawing. Ultrasonic vibrations were used in addition to the normal equipment for the processes concerned and the aim was to improve forming conditions.

In early work on forging aluminium with ultrasound, Severdenko and Klubovich [12] reported dramatic results, including reduction of forging force to zero, virtual elimination of "barrelling" and reversal of the residual stress distribution. It was suggested that these benefits were a result of reduced friction, elasto-plastic wave formation and thermal softening effects. In similar experiments Balamuth [18] and Kristoffy [19] in the USA and Izumi et al [20], [21] in Japan observed force reductions which at low vibration amplitude could be accounted for by superposition, but at higher amplitudes the effect was greater than would be expected for superposition alone. In these experiments, however, the temperature of the test piece rose by as much as 300 °C, and the force reduction was attributed to a combination of stress superposition and thermal softening. The altered residual stresses and reduction in "barrelling" reported by Severdenko were not observed by Izumi.

In the process of extrusion of metals with applied ultrasonics Tursunov [22] measured force reductions of 20 to 40%, and noted a reduction in microhardness of the product. He attributed the effect to a reduction in yield stress caused by the ultrasonics. In the USA Jones [23] (of Aeroprojects Inc.) extruded lead and aluminium with applied ultrasonics and found that by vibrating the die (the most effective option) the force could be reduced by 15%, or the rate of extrusion (at constant force) could be increased by 88%. In this case the improvement was attributed to friction reduction. Tarpley [24] reported even greater improvements: force reduction of between 15 and 30% or rate of extrusion increased 100 to 300%.

In wire drawing ultrasonic vibrations have generally been applied to the die along the wire axis. Early investigations by Severdenko and Klubovich [25], Robinson [26] and Boyd and Maropis [27] for a wide range of materials and draw speeds showed a significant reduction (up to 65%) in the draw load and a slight reduction in the microhardness of the drawn wire. However using ultrasonics also led to severe pick-up in the die and a poor surface finish. By contrast Jones [23], while noting a similar reduction in draw force, found that the material properties of the drawn wire were unaffected and the surface finish was improved. In this case the improvements were attributed to a reduction in friction. By measuring the instantaneous stress in the wire (as opposed to the mean stress), Pohlman and Lehfeldt [16] and Winsper and Sansome [28] determined that the peak stress was unchanged. This indicated that the drop in apparent (mean) stress was due to superposition of the acoustic stress.

In a forming process limited by the strength of the product this effect would not be useful because the apparent strength of the wire would be reduced in proportion to the apparent drop in forming force. Nevertheless Winsper and Sansome [29], [30], using three dies with the centre one vibrating achieved a "genuine reduction" of up to 50 lbf in the draw force (total force figures are not given so the percentage improvement is not known). Another way to avoid this problem would be to use radial vibrations of the die and take advantage of a swaging effect due to the workpiece being compressed laterally. There are few reports of work in this area probably because of the difficulty of producing small aperture radial-mode ultrasonic dies, but a similar effect can be obtained by using a split die and vibrating one half laterally, or by installing the die in the centre of an axial mode resonator. Using this technique Oelschlagel and Weiss [31] observed force reductions from 37% to 62%. Later work by Lehfeldt [32] also included investigation of this type of die.

In the drawing of tube, where the die aperture is often larger, there was more scope for using radial vibrations. In early work, however, the axial mode was used as for wire drawing. Mainwaring [33] and Jones [23] tested axial-mode dies in plug drawing and reduced the draw force by up to 80%. Surface finish and hardness of the product were found to be unaffected. In this process (which uses a fixed plug inside the tube) it is also possible to axially vibrate the plug to obtain similar results. This is the process that Aeroprojects put into production claiming many advantages including reduced draw force, improved surface finish on the bore and the ability to achieve greater reductions and produce more complex sections. Again Aeroprojects attributed these benefits to a reduction in friction. Boyd and Kartluke [34], also derived a formula for the effects of ultrasonics based on this theory.

A notable researcher in the UK at this time (1960's and 1970's) was Prof. D. H. Sansome along with his team at Aston University, Birmingham. Some of their research into wire drawing is described above. Their research into tube drawing began by using axial vibration of the plug (as

Aeroprojects) - Winsper and Sansome [35]. The beneficial effects (reduced draw load and improved surface finish) were attributed to a combination of stress superposition and friction reduction. In later work Kariyawasam, Young and Sansome [36] used radial die vibrations with a plug bar of tuned length (so that axial vibrations would be induced in the plug) to achieve a force reduction ranging from 10 to 30%.

This team also applied radial ultrasonic vibrations to deep drawing and wall ironing processes. Biddell and Sansome [37] used a variety of radial-mode dies to achieve improved depths of draw, especially at low speed, and concluded that the effect was a result of reversal of the friction vector. Later Biddell [38] reported further work again using radial dies which showed an increase of draw depth of about 12%, but this was not always achieved. The work also extended to wall ironing but it was found that for high reductions the ultrasonic system was unable to maintain the vibration amplitude. Tisza [39], [40] also reported work on ultrasonic deep drawing, in this case with a complex combined axial-radial mode die which converted axial vibrations at the transducer to radial at the die. This overcame the perceived need to use a large number of transducers arranged around the die to generate a uniform amplitude. Using a single magneto-strictive transducer an amplitude of 15 μ was achieved and the achievable deformation was increased by up to 15%. The effect was attributed to reduced "friction factor", friction vector reversal and a modified tensile strength under the action of the ultrasonics.

To avoid problems maintaining amplitude and to approach the research in a more fundamental way Sansome's team developed simpler test processes - the wedge draw test simulated deep drawing while deforming only a sector of a cylinder, while the strip ironing test simulated wall-ironing in a flat sample. Initial results for the wedge test were mixed. Smith, Young and Sansome [41], [42] reported that vibrating the punch alone produced an apparent reduction in the forming force (due to stress superposition) but no significant benefit in achievable depth of draw. However by radially vibrating the die an increase in draw depth of the order 5% was achieved. Best results were obtained by radially vibrating the blankholder [43] which gave an increase in depth of draw of the order 10%.

The wall-ironing process was simulated by drawing a strip of metal through a pair of flat dies. McQueen and Sansome [44] vibrated both dies in a perpendicular direction at approximately the same frequency (within 50 Hz). The maximum area reduction achievable was increased from 63 to 80% with ultrasonics. Note that this process simulates wall ironing with a radial-mode die and a radial-mode punch. Vibrating one die only would perhaps have been more realistic - simulating the wall-ironing process with a radial-mode die only.

The application most similar to the work described in this thesis is "tube sinking" (a term used in the tube drawing industry that is equivalent to "necking" in the can industry). In this process one end of a tube is forced into a die to reduce its diameter. Aeroprojects' work on tube drawing was also applied to tube sinking in the early stages [23]. Westinghouse also used an ultrasonic process for tube expansion [45].

More recently in eastern Europe highly relevant work was reported by Skachko, Pashchenko et al [7], [8]. This group applied high-power ultrasonics to the forming of an aerosol neck, using ultrasonic dies in the conventional process for necking aluminium aerosols, i.e. multi-stage necking with a simple parallel plug. He found that it was possible to reduce the number of operations required from 9 to 3 using ultrasonic vibrations in the axial and / or the radial directions. It is important to remember, however, that this work was applied to aluminium aerosols. Using harder, thinner material (steel) the limiting factor on reduction achievable in a conventional necking operation is buckling in the circumferential direction (pleating), and this is not significantly affected by vibrations.

In almost all applications a significant improvement in the forming process was reported when using ultrasonics, either a reduction in the forming force or an increase in the apparent formability of the workpiece. Various theories have been proposed for these observations, as further described in section 1.3.1. Despite this, widespread application in industry did not follow. Several review articles suggested that full production status was imminent [46], [47], [48], [49] and in another Biddell and Sansome suggested that industry was to blame for not applying the technology [50]. Industry would probably argue that the benefits were insufficient to justify the extra cost and complication of the ultrasonic equipment. High-power ultrasonics have been fully accepted in another section of industry (plastic welding) as described in section 1.3.2.

For a more detailed review of early work on vibratory forming (both low and high frequencies) see Dawson et al [51]. For a review of work at Aston University see Sansome [52]. Jones' review of work at Aeroprojects [23] is particularly comprehensive and includes a table of experimental results obtained from many industrial trials.

1.3.2 Other industrial applications of high power ultrasonics

Other applications of high-power ultrasonics in industry include cleaning, plastic welding, metal welding, cutting. These have largely developed in a different section of industry to the metal-forming applications, and the development of equipment to generate ultrasonic vibrations has taken a different route (this will be further discussed in section 1.3.3). Few reports of the developments in these areas have been published, possibly because most of the work has been undertaken by industry rather than academia. Nevertheless these applications will be discussed, with reference to sales literature where necessary.

Ultrasonic cleaning involves immersing the workpiece in a fluid irradiated by ultrasound, often from several sources (to obtain a relatively uniform field). The cleaning action is enhanced by agitation of the fluid, which helps it to penetrate any awkward cavities in the workpiece, and by cavitation. This is the catastrophic collapse of vapour bubbles that produce "micro-shocks" capable of dislodging dirt and even eroding the component surface - the standard test for intensity involves immersing a piece of metal foil for a set time and then counting the holes! Traditionally the fluid was agitated by multiple piezo-ceramic disks arranged around the walls of a tank (see, for example Perkins [4] but more recently the disks have been replaced by one or more tuned probes transmitting the vibrations into the fluid from above the surface. One such system is produced by Telsonic and described in OEM Design [53]. The probe systems are claimed to be more efficient because less energy is lost to the tank walls.

Another application using broadly similar equipment is sonochemistry - the use of ultrasound in liquids to affect the rate and / or products of a chemical reaction. For further details see the works of Lorimer and Mason, for example [54]. Ultrasound has also been applied to biological samples, offering improved mass transfer between cells or (at higher levels) disruption of cell walls - see Sinistra [55]. For a detailed description of the ultrasonic equipment and instrumentation necessary for this type of work (sonochemistry and biological effects) see Perkins [56].

A similar application is ultrasonic deburring [57]. Standard cleaning equipment is used with an acid slurry (chemically and mechanically aggressive) to remove unwanted material from a machined surface. The use of ultrasonics is claimed to provide better control over the rate of removal because the ultrasonic intensity can be conveniently adjusted.

Previous applications of ultrasonics for machining have been described by Neppiras [58] and Markov [59] (edited by Neppiras). The latter is particularly detailed, describing techniques for ultrasonic cutting, drilling and grinding. Typically these operations use an abrasive slurry containing hard, sharp particles, along with a relatively soft tool, into which the hard particles become embedded. The machining is accomplished by breaking microscopic particles from the workpiece.

Welding of plastics using ultrasonics has become a standard technique in many industries including packaging (e.g. joining card / plastic laminates for carton manufacture), automotive (e.g. light clusters, bumpers, fuel tanks) and many others. The process involves vibrating one component against the other while clamping them tightly together, and is described in great detail in booklets produced by the German Electrical Manufacturers Association (ZVEI) [60] and the equipment manufacturer Herfurth (edited by Rische and Abel [61]). As one component slides against the other the sliding generates frictional heat that softens both surfaces, allowing them to merge under the action of the clamping force. Typically the direction of vibrations is perpendicular to the joining faces, although this may also generate sliding motion parallel to the surface. It is important to maintain the clamping force for a short time after the ultrasonics have been turned off to allow the weld to cool and harden. The advantages of this process are efficiency (because the heating is localised at the weld area) and convenience, indeed the weld may be some distance away from the ultrasonic tool, although resonance of the components themselves may limit the weld integrity (Jagota and Dawson [62]).

Metals can also be welded using vibration energy, see Devine [63]. Ultrasonic equipment differs from that used for plastic welding in that the vibrations are applied parallel to the surfaces to be welded. The advantages claimed for this technique are its ability to weld dissimilar metals and to weld through oxide layers without the use of corrosive flux. It has been used for welding of small components, e.g. connectors to car battery leads, but is generally limited to relatively thin sections. An exception is the work described by Tsujino et al. [64] which showed that aluminium plates up to 10 mm thick could be successfully butt-welded.

More recently Tsujino et al [65] have also reported an ultrasonic sintering process that improves the density and uniformity of the material. This used three independent ultrasonic systems (a radial-mode die with axial-mode plugs at each end).

A very different application, operating currently at much lower power, is in ultrasonic motors. For example in robotics, Schoenwald et al. [66] describe an ultrasonic gripper system. This is an example of a simple rotor system - driving a contact at an oblique angle to the surface so that a small incremental movement is generated on each vibration cycle. More complex (but potentially more efficient) systems produce drive by generating an elliptical motion at the surface. This can be achieved by generating a travelling wave in one component, which may be generated by superposition of two (resonant) standing waves at a fixed phase angle. An example of this type of work is LeLetty et al. [67], who described rotary ultrasonic motors using resonant rings operating in high harmonic modes similar to the unwanted modes observed in this project. Furthermore the motor design was achieved using finite element analysis (ATILA) to include the piezo-electric effect in three dimensions. The generation of elliptical surface motion, if it could be achieved at higher power and for the more complex geometry of a metal-forming die, could offer a major improvement to the forming process. This is discussed further in section 7.2.3.

Another totally different application is sonar - the use of reflected sound waves in liquid or air to detect distant objects. Note that this is in principle quite similar to non-destructive testing, but on a much larger scale. Because of the large scale the power used in sonar detection is high, and generation techniques are broadly similar to those used for other high-power applications. The most important parameter in this case, however, is generally the coupling to the transmission medium. See, for example, Gough and Knight [68] for a discussion of the requirements of this application. This paper is notable also for the use of admittance circle plots to indicate the performance of the ultrasonic system - see section 6.2.2.

Another use of high-power ultrasonics is in material testing, where the relatively high stresses combined with the high frequency operation significantly shorten the time required to characterise the material. For example Soderberg et al. [69] investigated fretting wear while Puskar [70] and Chapman [126] among many others, studied fatigue testing under the action of ultrasonics. Note the danger this highlights - all ultrasonic tooling is prone to fatigue failure, and careful design and control of operating conditions is necessary to prevent this. This is discussed in section 3.7.

1.3.3 Methods of generating high power ultrasonic vibrations

Transducer materials to convert electrical signals to mechanical motion (or vice versa) have been developed since the 1920's. Neppiras' review [71] describes the history and characteristics of many transducer materials, including nickel / cobalt alloys (used for most high-power magnetostrictive transducers) and lead-zirconate-titanates (used for high power piezoelectric transducers). For a more recent review of the piezoelectric / electrostrictive materials see Uchino [72], who has studied actuator applications (deformable mirrors, dot-matrix printers) and ultrasonic motors.

Whymark [73] gives a detailed description of the design and evaluation of magnetostrictive transducers, including consideration of performance under load. At this time - 1956 - the optimum efficiency of this type of transducer was particularly low (42%).

Perkins [4], while reviewing all aspects of high-power ultrasonics, compares the two types of transducer. He quotes potential efficiencies of 55% for magnetostrictive and 90 to 95% for piezoelectric.

Shelley [74], reviewing the work of Sansome's team at Aston, suggested that piezo-electric transducers had been found to be too delicate for industrial applications. Rees and Rippon [75] also found piezo-electric transducers unreliable but noted in contrast the low efficiency (65%) of magneto-strictive systems. Much of the unreliability observed was probably the fault of the control systems. Wearden [76] describes a control system for tube drawing (with magneto-strictive transducers) which automatically adjusts the drive frequency to maintain resonance within 0.3%, or 60 Hz at 20 kHz. For plastic-welding systems using piezo-electric transducers a much more precise frequency control is required (for example the Telsonic system [77] maintains resonance within less than 10 Hz). Furthermore Wearden does not mention amplitude control at all, but control of the transducer amplitude is vital to the correct operation of a piezo-electric system because under no-load very little power is required to develop high amplitude (and hence high stress) in the transducer and tooling. Sonkin [78] also discusses the design of ultrasonic generators.

For further information the German Electrical Manufacturers Association (ZVEI) has produced a useful manual of the application of ultrasonics to plastic welding [60] which includes details of the transducers and control systems used. The equipment manufacturer Herfurth has also produced a booklet of similar content based on their own work [61]. This is one of several manufacturers of equipment for this industry who have now developed highly efficient transducers that are neat, self-contained and have a high power capacity. Sophisticated instrumentation and control systems have also been developed to operate them (see also [53]).

1.3.4 Analysis of vibration characteristics

The design of axial-mode ultrasonic tools is relatively straightforward provided the diameter of the tool is less than about a quarter wavelength. Selecting a length which is an integer number of half-wavelengths ensures that the tool (sonotrode) will be tuned to approximately the required frequency, and fine tuning can be achieved by further machining of the length. Young, Winsper and Sansome [79] even suggested that a tool could be attached to the end of an axial-mode resonator by simply removing an equal mass of material from the free end. This practice is not generally recommended because the joint will not be at a stress node and the fixing is likely to be destroyed by any significant vibration amplitude. The design of radial resonators is much more difficult, firstly because the relationship between dimensions and resonant frequency is more complex and secondly because the harmonic natural frequencies do not appear in a regular series (see section 3.2).

Analysis of the vibrations of rings specifically for the ultrasonic die application was carried out by Biddell and Sansome [37], [38] and by Young, Winsper & Sansome [80], [81]. These analyses are limited to specific die shapes (flat, tapered, exponential, etc.) and to the radial axisymmetric mode only. The analysis of appendix 2 is similar but anticipates analysing the die as a series of thin rings. This permits analysis of any die shape and a number of different material properties (e.g. for dies with a hard insert of a different material). Like the earlier work however this is limited to the axisymmetric radial mode of vibration, and other modes (as described in section 3.1) can be very important. Analysis of non-axisymmetric modes of rings is discussed by Den Hartog [82] and in more detail by Timoshenko [83] but this work only covers rings of thin cross-section that do not accurately model typical ultrasonic dies. Blevins [84] gives empirical formulae for natural frequencies of rings, plates and tubes, including the harmonic modes, but the first harmonic is listed as a rigid body mode. The analysis of non-axisymmetric modes of thick rings was carried out using finite elements by Gladwell and Vijay [85] and as a full (classical) analysis by Hutchinson & El-Azhari [86], [87], although their equations required matrix arithmetic with large matrices and iterative solution. Both of these analyses still involved some simplification - the shape of the ring was limited to a hollow cylinder of uniform thickness, so this work has been used only to verify the finite element results (section 2.8).

Finite element analysis has been used for assisting in the design of ultrasonic tools notably by Derks [88] who was concerned with the design of plastic welding sonotrodes. This involved finite element analysis similar to that described here but with the aim of promoting axial modes of vibration in complex cylindrical and rectangular resonators. These are resonators for which the dimension perpendicular to the vibrations is greater than a quarter wavelength, so the simple approach to sonotrode design does not work. His work would be extremely valuable in the plastic welding industry but is not directly relevant to the design of radial-mode ultrasonic dies.

The finite element method is now a well-established tool for all kinds of engineering analysis. With the ever increasing availability of computing power and the continuing development of user-friendly interfaces this trend is certain to continue.

1.3.5 Materials for ultrasonic tools

The materials that are believed to be most suitable for the ultrasonic tooling in this application are described in detail in section 3.7. Two types have been selected corresponding to the different requirements of the inner and outer components of the die. For the hard, wear resistant inner die suitable materials include tool steels, steel matrix cermets and ceramics, while for the fatigue-resistant die outer high strength alloys of aluminium and titanium have been chosen. For clarification of the die construction see figure 1.13.

For general information on tool steels see the Metals Reference Book [89] or the Properties of the En steels [90]. To obtain a hard, wear-resistant surface finish various heat treatments are possible. In particular for the nitriding steel used in this work a plasma-nitriding treatment has been used to produce a thin layer of hard material on the surface with minimal distortion of the part. The harder surface also gives a lower coefficient of friction that assists the forming process. Both the surface hardness and the friction coefficient can be further improved by the addition of a titanium nitride coating (applied on top of the plasma-nitrided surface to prevent cracking of the coating due to collapse of the substrate). These surface treatments are described by Staines [91]. The steel-based cermet used in this work is Ferro-titanit Nikro 292, manufactured by Thyssen [92] (note that this particular grade has now been discontinued by the manufacturers - the similar Nikro 128 may be used in its place). The ceramic material that has been used is sialon, a modified silicon nitride described in general by Wilson [93], specifically Syalon 101 [94].

For further information on high strength aluminium alloys (and particularly the L168 aircraft grade used in this work) see the Aluminium Reference Book [95]. The general-purpose titanium alloy Ti-6Al-4V (i.e. 6% aluminium, 4% vanadium), which has also been used, is described in detail in [96]. For a more general discussion of the engineering applications of titanium alloys (although curiously ultrasonic tools are not mentioned) see Hanson [97].

One common requirement of both components of the ultrasonic die is a low rate of acoustic loss (i.e. energy loss caused by material damping). This is particularly important for the die outer since it is generally the larger component, and the total power loss from the system will depend on the amount of each material as well as their individual damping coefficients. Unfortunately information on the damping characteristics of materials is rarely available. Even when data is available, test results must be treated with caution because the damping value obtained is dependent on the frequency and amplitude of vibration and on the nature of the test. This is described in the Metals Reference book [89] which includes a warning regarding the accuracy of the information because it is collected from various sources. A collection of results for different materials tested under the same conditions is more useful, for example Adams [98] gives good comparative data for several grades of steel, brasses, bronzes and aluminium alloys at 11.6 kHz (unfortunately titanium alloys are not included). This work suggested that the best materials for ultrasonic applications (i.e. those with the lowest damping) are aluminium alloys, followed by brasses and bronzes.

The selection of material for the die inner and outer components depends to a large extent on the requirements of the process (e.g. wear resistance and hardness of the inner according to the abraisiveness of the material to be formed), but further constraints are put on the material selection by the essential resonance characteristics of the assembly. These are discussed in detail in section 3.4. One further group of materials has been considered because of the potential to provide more flexibility in this area: aluminium matrix composites. These materials (comprising ceramic particles in an aluminium matrix) offer a significant increase in Young's modulus with minimal change in density. This increases the sound velocity in the material so that for a given resonant frequency a larger component will be required. In producing ultrasonic dies for larger diameter forming operations this change could be crucial to producing a working ultrasonic die. Furthermore the change in modulus depends on the proportion of ceramic in the composite - so by selecting the appropriate mix the material properties could be customised to suit a particular application. The damping properties of these materials have been investigated by Bhagat et al [99], [100] who found slightly higher damping in the composites than in the base aluminium alloy, but the difference was small enough at high frequency not to cause problems for ultrasonic equipment, although it was suggested that at higher strains the composite should have higher damping. At present these materials are new to the market and very expensive, but as production levels increase the cost should fall and in future these materials may become common in the ultrasonics industry.

For any combination of materials used to construct an ultrasonic die the maximum safe amplitude at which the die can operate will generally be limited by fatigue of the die outer. One very effective method of improving the fatigue resistance is shot peening. This generates a compressive stress in the surface layer to resist the growth of microcracks that are always present there. The technique is described and analysed by, for example, Fuchs [101].

1.4 SAFETY OF HIGH POWER ULTRASONICS

With the introduction of any new technology to the industrial workplace any possible health risks must be carefully considered. In the case of high power ultrasonics, as discussed in section 1.1, other industrial applications exist, and it is possible to learn from this experience. In particular, ultrasonic equipment has become almost universal in the plastic welding industry, and ultrasonic cleaning is also a commonly used process.

The health risks of high power ultrasonics fall into two categories: risks from direct contact with the vibrating parts and risks from airborne noise (including audible noise and ultrasound). Besides these there may be other risks normally associated with moving machinery (e.g. trapping points).

Normal machinery risks can be avoided by suitable guarding, as described in BS5304:1988 [102]. In the case of the aerosol forming process the forces are high enough to present some risk of amputation of a finger or even a hand. Access to the machine is also required (for setting or clearing jams) so an interlocked guard system is required.

If a user comes into direct contact with a vibrating part there a risk of disruption of the tissues and / or rapid energy transfer, causing a burn (see, for example Hill [103] for a discussion of physical effects). Despite this, it is common (though not recommended) practice in the plastic welding industry to evaluate the performance of a sonotrode (ultrasonic tool) by the "feel" of the vibrations. This practice does not normally cause injury because the fingers are only lightly touched on the vibrating parts, so energy transfer is minimal. To prevent deliberate or accidental contact with a vibrating part the ultrasonics should be electrically interlocked to the guard system.

In addition to studying physiological effects of direct contact, other researchers, e.g. Acton [104] and Wiernicki & Karoli [105] have proposed standards for safe exposure to airborne ultrasound. These indicate that while the effects of airborne ultrasound are not fully researched, there appears to be less risk from ultrasound at any given sound level than from audible noise at the same level. Applying normal legal standards for noise level / exposure time should therefore ensure that there is no risk of hearing damage. Airborne high-frequency sound is easily deflected by lightweight barriers so these standards are easily achievable.

1.5 SUMMARY

The following is a short description of the contents of the remaining chapters.

The analysis and design of ultrasonic dies rely heavily on finite element analysis. Chapter 2 describes the theoretical basis of this, plus practical considerations using the Ansys [106] finite element program. Some methods of simplifying the analysis are discussed, along with their advantages and drawbacks. Alternative analytical approaches are also considered in chapter 2, and several are used to verify the accuracy of the finite element results.

In chapter 3 the background information on finite element analysis is applied to the design of ultrasonic dies. To describe the various natural modes of the dies a new system of nomenclature was developed. Detailed information on the process of design and manufacture is given, and the major design considerations (materials, allowable stresses, geometric constraints, etc.) are also discussed.

Chapter 4 describes a simplified system that was developed to assist the initial design of new ultrasonic dies. Design information in the form of two dimensional contour plots is given for a range of materials in appendix 5. The use of the new system is demonstrated by means of examples.

In chapter 5 the problem of attaching a vibrating die to a fixed machine is addressed. There are no stationary (nodal) points on the die so a mounting system is required which will permit the die to move with the vibrations while at the same time locating it accurately. The shortcomings of existing systems are discussed and a new mounting system is introduced.

Chapter 6 describes methods of measuring the performance of the ultrasonic system (i.e. the die and its mounting, along with the transducer required to drive it). The measurements are aimed at both characterising the vibrations in use and evaluating the effect on the forming process. The results reproduced include summary tables of information for a number of different ultrasonic dies and graphs of the force variation during the forming stroke. The accuracy of the finite element results is also indicated by comparison with the measured data.

In chapter 7 suggestions are made for areas of further work in this field. In particular, industrial pressures have required that producing an effective ultrasonic system has taken priority over understanding the reasons for its effectiveness. Alternative methods are discussed for studying the interaction between the vibrations and the forming process.

Finally chapter 8 lists conclusions drawn from the work described here, along with a discussion of their implications.

POWER Ultrasonics

Calculate sound velocity, resonant frequency and dimensions of tuned parts for a range of power ultrasonics components and sonotrodes. Sonotrode analysis example (or click File -> Examples -> Length Ti Sonotrode)

File Analysis Materials Shapes Calculate Animation Help

Analysis: Axial Mode : Calculate Length
Material: Titanium : Ti-64
Shape: Stepped Sonotrode

Inputs:

Amplitude input	20	µm(p-p)
Frequency	20	kHz
Input Diameter	50	mm
Output Diameter	35.355	mm

Results:

Sound velocity (axial)	5073	m/s
Wavelength	253.6	mm
Amplitude output	40	µm(p-p)
Max stress	56.48	MPa
Material Spec	Ti-6Al-4V	
Young's Modulus	114	GPa
Density	4430	kg/m3
Poisson's Ratio	0.33	
Length	126.8	mm

Unit conversion:

1 Pa	1 Pa
1 Hz	1 Hz
1 m	1 m
1 m/s	1 m/s

1 m	1 m
1 kg/m^3	1 kg/m3

This first version analyses axial-mode vibrations of straight rods and stepped sonotrodes. Radial and torsional mode analyses are planned for future releases. Please let me know if you have a particular interest or need for one of the options not yet set up.

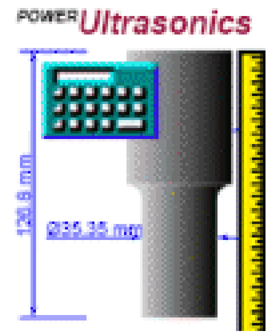
Note: The calculator uses SVG (Scalable Vector Graphics). When you first load this page you should see a simple text animation above; this will be replaced during calculations with a scale drawing of the sonotrode and graphs of stress and amplitude. If you don't see the animation your browser doesn't fully support the SVG code used.

Recent versions of Firefox and Mozilla browsers include a built-in SVG engine that doesn't support animation - to view animated images in these browsers you need to disable the built-in SVG and use the Adobe plug-in as before - more info.

Users of Microsoft Internet Explorer should download and install the latest plugin from Adobe. See the help page for more information.

New 14 October: If you find the graphics too small you can also view the same sonotrode calculator alone on the page (at least 800 x 600 resolution recommended).

PowerUltrasonics Ultrasound Calculator Help



This is the help / documentation for the Power ultrasonics Sonotrode Calculator, version 0.1 (October 2004)

Contents:

Problems:

Introduction / aims

Top of page

This online calculator automates some simple calculations relating to the design of ultrasonic components - notably sonotrodes (horns) and boosters (interstage horns). The intention is not to provide a comprehensive solution to the design of ultrasonics components (I don't believe that would be a practical proposition anyway) but rather to offer a starting point for new designs and an educational tool for newcomers to ultrasonics.

A complete, successful sonotrode design will still require expert advice, perhaps finite element analysis (FEA) and most likely a series of prototypes - see the disclaimer.

While accepting these limitations I plan to develop the calculator to be as useful as possible, with more shapes and not-so-simple calculations to come (more details). If you'd like to request development in any particular direction please contact me.

During development the calculator is available to all free of charge, but at some stage I may apply restrictions to advanced analysis options, requiring registration and / or payment of a subscription charge.

Analyses

Top of page

This version of the calculator provides 3 analysis options:

Show properties
: This displays the material properties used for the calculations (Young's Modulus, Density and Poisson's Ratio), plus some derived properties (sound velocity for axial and radial-mode vibrations and acoustic impedance).

Axial mode -> Calculate length
: Given a frequency at which the sonotrode is to be resonant, calculates the length of the tuned section (a half wavelength).

Axial mode -> Calculate frequency
: Given a sonotrode of known length, calculates it's resonant frequency.

Plans are afoot to add many more analyses to the calculator - see Proposed developments.

Menus

Top of page

File

New
: Clears inputs and erases all options - start again from scratch

Open
: Allows you to select a setup file, restoring the calculator to the state it was in when you saved the file

Save As File
: Allows you to save a setup file containing all information you have entered (analysis, shape, materials and inputs)

View Parameters
: View / save a list of all information you have entered. Format is identical to that produced by "Save as File" above but the server delivers it as a text document. Use this option (then File -> Save As on your browser menu) if you are behind a corporate firewall and it blocks the file produced by "Save as File".

Examples
: Offers some examples to run on the calculator and adapt to your needs.

Print

Opens your browser's standard print dialogue, allowing you to print the page (subject to your computer setup).

Analysis

Show Properties

Displays material properties and some derived properties such as sound velocity.

Axial mode

Calculations for axial-mode ultrasonic systems.

Radial mode

Calculations for axisymmetric vibrations of radial-mode ultrasonic systems.

Torsional mode

Calculations for torsional-mode ultrasonic systems.

Materials

Steel / Aluminium / Titanium etc.

Click on any material option, then narrow down your choice by selecting a sub-category and so on until you specify a unique material.

User defined

Choose this option if the material you want to use is not listed in the standard menus. You will need to provide it's elastic properties. See the links section for online resources giving material properties.

Shapes

Rod / Stepped Sonotrode / Exponential Sonotrode etc.

Click on the shape that you wish to analyse (this section can be ignored if you choose "Show Properties" as your analysis).

Calculate

Go

After you have entered or changed inputs (eg. sonotrode diameter), click here to recalculate with the new value.

Animation

Off

Turns off animation for the diagram (mode shape, amplitude and stress graphs).

Speed

Select slow, medium or fast animation cycle rate.

Help

About

Brings up an information box (javascript alert) containing the calculator name, version number and release date.

Help Page

Brings up this page in a new window.

Formulae

Shows formulae used in the calculations and assumptions on which they are based.

Entering and reading data, units conversion

Top of page

Inputs:

Depending on the analysis you select you will usually need to enter some numerical data about your analysis eg. to calculate the axial-mode tuned length of a rod sonotrode you will need to enter the working frequency and rod diameter. You enter data in the white text fields that appear on the left side of the calculator once the analysis, material and shapes have been selected.

Note that the calculator is designed to operate in several different units. A list of available units is shown just to the right of the input field. The units listed will be only those appropriate to the particular input (and if the input happens to be dimensionless there is no choice of units).

The calculator converts between different units automatically, so for example if you have a length specified as 125 mm and you change the unit selector to inches the value will change to 4.92125 in.

Note that this has implications when you first define an input value - you need to set your chosen units **first** and then enter the numerical value, which is a little counter-intuitive!

For your convenience, once you have chosen units for each input the calculator will remember your choices for the rest of the session.

Results:

After setting up your input data select Calculate -> Go from the menu to recalculate (perform the calculation). Your results will then be shown below the input data. The text fields used have a pale blue background and cannot be changed directly.

As for the inputs, you can choose units for the numerical results and the values will change accordingly. The values and units shown on the graph image will also be updated the next time you recalculate.

Unit conversion:

Finally towards the bottom left of the calculator a list of unit conversion factors is shown. These select menus are for information only - really just a compact way of displaying lists of data - and changing the value selected will make no difference to the calculator.

Proposed developments

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More Analyses:

In the initial release options are limited to axial-mode analysis (fixed length, unknown resonant frequency and fixed resonant frequency, unknown length). Radial-mode and torsional-mode analyses will be added once I can sort out the relevant formulae!

More Shapes:

In addition to straight and stepped sonotrodes I plan to add more shape options (notably the useful exponential sonotrode) for axial and torsional-mode analyses. Radial mode analysis will require a completely different set of shapes.

More Materials:

Additional materials will be added on request, or users can choose the "User defined material" and input their material properties directly. The links section lists online material property databases.

Stacks:

The mechanical parts of a complete ultrasonic system are commonly arranged in a "stack" - typically transducer, booster and sonotrode (aka converter, interstage and horn). The calculator can be developed to combine an arbitrary number of components with the output amplitude of one giving the input amplitude of the next.

Formulae

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To view the formulae used in these calculations first select your analysis options and then click Help -> Formulae. This gives the formulas used and the assumptions behind them. I sadly decided to display these using images - I don't think there is yet enough MathML support out there!

Disclaimer

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The formulae used here include some simplifying assumptions (eg. plane stress) that may not accurately represent a real-world sonotrode. Furthermore ultrasonic components in the real world are subject to many sources of variation that cannot be included here, eg. differences between nominal and actual material properties and the presence of other (unwanted) modes of vibration. Experts with specialist knowledge will be able to predict some of these problems and allow for others, possibly leading to a quite different design than the one that this program would suggest.

Therefore NO RESPONSIBILITY IS ACCEPTED FOR THE ACCURACY OF RESULTS PRODUCED BY THIS CALCULATOR, OR THEIR SUITABILITY FOR ANY PURPOSE. All users are strongly advised to verify both the input information and results, and to take expert advice on other issues that may affect the functioning of ultrasonic components.

Linking to the Calculator

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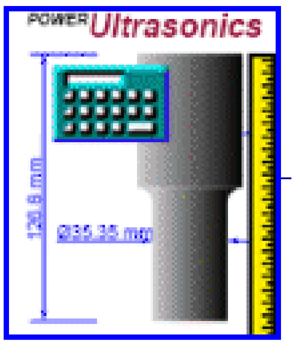
You're welcome to place a link to the calculator on your web site, subject only to the condition that you must not claim it as your own, place it inside a frame on your site or in any way claim or imply that you produced it. Some example links are shown below - to use any of these just cut and paste the code from the box on the right into your page. Alternatively feel free to adapt these or create your own link if you prefer.

Sonotrode Calculator from PowerUltrasonics

```
<a
href="http://www.powerultrasonics.com/ultrasonic_calculator.html" title="Calculator for sonotrode length,
resonant frequency, sound velocity">
  Sonotrode Calculator from PowerUltrasonics
```




```
<a
href="http://www.powerultrasonics.com/ultrasonic_calculator.html" title="Calculator for sonotrode length,
resonant frequency, sound velocity">
  <img
```

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Licensing the Calculator

The calculator as seen here comprises two parts, available and licensed separately:

The calculator engine

The calculator engine is designed to be flexible - it can be applied to any mathematical calculation and is particularly useful where results can be displayed graphically. It uses the excellent "Template Toolkit 2" module by Andy Wardley (see the perl links section for more information). A perl program written as a TT2 plugin provides the special functions while various template files control the appearance of the calculator. The calculator engine is one part of a larger web site design / content management system that I plan to release as open source. When released, conditions of use will be as follows:

- You may use the software without purchasing a licence provided certain copyright notices and links are left intact.
- You may remove these copyright notices and links from the software after purchasing a licence for each web site on which it is to be used.

- You may redistribute the software only as a complete package along with this licensing information.

If there's enough interest I may release an earlier draft version of the calculator engine alone - please contact me if you'd be interested.

The sonotrode calculation files

Because the calculator engine is generic (suitable for almost any calculations) it relies on separate files to define the specific menu options, inputs, outputs and calculations, as well as the graphics that will be drawn. This information is held as a set of data files that are read and executed as required by the calculator engine. These calculation files contain specialized knowledge of the application concerned and are therefore proprietary. You can purchase a licence to use these sonotrode calculations on your own site, with either the free or the licensed calculator engine.

Using the calculator for other applications

If you want a calculator to perform other calculations you can use the calculator engine either with or without my standard copyright notices (licensing fee applies to use without copyright notices). Then you can create the calculation files yourself using the sonotrode calculations as a model, or I will prepare them for you to your specifications (this work to be on a consultancy basis). In either case you would own the resulting proprietary calculation data files.

The following prices apply to licensing the calculator. These may change without notice - please contact me for a current quote:

Using the calculator engine complete with copyright notices and links (you may change colours, graphics etc. provided you don't obscure the copyright notices)	Free
Using the calculator engine with copyright notices and links removed	US$250 per web site
Using your own calculation files (non-ultrasonics applications)	Free
Using my calculation files for sonotrode analysis, including one year's free upgrades	US$250 per web site
Preparation of calculation files for a new application (consultancy)	Quote on request

Installation of calculator with any of the above options on your web server (subject to server specifications)	US$50

If you have any questions about licensing or other requests please ask.

Aside - a note about server-side programs

The calculator in its present form is a server-side application - all the important processing is done on the web server. This makes it ideal for cases where you want to offer a calculation service to your clients and web-site visitors without giving them full access to the program (unlike for example spreadsheets or Java applets). However this also means that it can't be installed on your desktop computer and run like other applications (at least not unless you're prepared to install a web server and perl first). I may develop a standalone version but it's not presently on the list of proposed developments. If you want to convince me there's a demand for this then please contact me!

Links

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SVG (Scalable Vector Graphics):

Adobe SVG Viewer Download Area

Download SVG plugin for Microsoft Internet Explorer

Mozilla SVG project FAQ - How to use a plugin instead of Mozilla's native support

For Mozilla / Firefox browsers (in short: about:config, svg.enabled = false)

Instructions for installing Adobe SVG plugin

For Mozilla / Firefox browsers (in short: Install v6 plugin, copy NPSVG6.dll and NPSVG6.zip to browser plugins folder)

Mozilla SVG Project

"The goal we're working towards with Mozilla's SVG implementation is SVG 1.1 Full. What exists now in the tree should be treated as a technology preview"

SVG Wiki home page

Huge repository of information on SVG provided by users and developers (a wiki is a community website built by its own readers)

Material property databases:

Matweb

"The heart of MatWeb is a searchable database of material data sheets"
Composition and property specifications for a huge database of materials.

Globalspec - The Engineering Search Engine

Searches other online databases to find the information you require (for material properties will often send you to Matweb).

AZOM

Advanced materials site, includes many articles and datasheets relating to engineering materials

Conversion Factors, Material Properties and Constants

Page with many unit conversions and material properties for common materials by Walter A. Siegmund

Mechanical Material Properties

Page of material properties for many common materials by Hugh Jack

Perl:

Perl home page

Perl is a scripting language widely used for programming on the World Wide Web. Arguably its greatest strength is the enormous number of modules and extensions for any conceivable application that users have written and generously shared with the rest of the Perl community.

Comprehensive Perl Archive Network

Searchable library of Perl modules and extensions.

ActivePerl Home Page

ActivePerl is a port of core Perl to Windows. It's the easiest way to use Perl on a Windows computer.

Template Toolkit module from Andy Wardley

The Template Toolkit is a set of Perl modules which collectively implement a template processing system.

SVG.pm

Perl extension by Ronan Oger for generating Scalable Vector Graphics (SVG) documents.

Alternative browsers:

Official home page of Mozilla Firefox

"The new Firefox Preview Release empowers you to browse faster, more safely, and more efficiently than with any other browser. Join more than 3 million others and make the switch today."

Hot tip in Microsoft mag: drop the lost Explorer

SMH article by Graeme Philipson - July 27, 2004: *"I have had enough of Internet Explorer. Microsoft's web browser is underfunctioned and has not been improved for years. It is shot full of security problems. It is slow and it is ugly. There is an alternative. It is called Firefox. I have been using it for a month and I can't envisage ever returning to Internet Explorer."*

Why you should switch to Firefox now

ZDNet article by Robert Vamosi - 27 September 2004: *"Recent flaws in the way Microsoft processes common Internet image files and a decision to offer IE updates only to Windows XP users lead to just one logical conclusion: bail on Microsoft*

Internet Explorer."

Problems / frequently asked questions:

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I click on the menus and nothing happens

The calculator requires that you have javascript turned on to operate the menus. If you are working on a company computer please ask your tech support staff how to enable javascript for this site. If this option isn't available to you, and you're using Microsoft Internet Explorer, you will need to "Enable Active Scripting" - an option to be found under Tools -> Internet Options -> Security -> Custom Level. And if that gets you concerned about the security of your computer (which it should!) then you could add powerultrasonics.com to your "Trusted sites" zone, while leaving more restrictive security settings in place for the "Internet Zone". Or perhaps you should consider upgrading to a better browser, like Mozilla Firefox

I can't see the image

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The image uses the relatively new SVG (scalable vector graphics) format. If you don't see the image on the right side of the calculator (or the animation above) you will need to download a "Plugin" program to allow your browser to display this format. The SVG links section offers links to suitable plugins from Adobe and more information about the format.

No image using Mozilla / Firefox

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If in your browser the image above shows blue jumbled text and no animated circular "Powerultrasonics.com" you're probably using the built-in SVG support that comes standard with recent versions of Mozilla and Firefox. Unfortunately this lacks many useful functions including special fonts and animation, so is unable to show the images correctly, but the result may be usable. For full support including animation of the sonotrode's distorted shape the only solution I have found is to disable the built-in SVG engine and use the Adobe version 6.0 preview 1 plugin from July 2003. This is not a solution I find acceptable (Adobe describe this version as "pre-alpha") but it's the only one I've found that works - any other suggestions welcome. At the time of writing the current release version of the Adobe SVG plugin is 3.03 which works with MSIE but not with Firefox. If you wish to follow this solution (at your own risk) please see the SVG links section for instructions.

Why does the image disappear when I click on a menu?

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For most HTML elements the z-index property (or in its absence the order in which they are defined) dictates which one overlays the other. However for most browsers this doesn't work with embedded objects such as Flash animations and SVG graphics - they always appear on top of any positioned HTML elements. This makes it practically impossible to get menus to appear on top of such graphics (and menus hidden below the image are of very little use!) so until any other solution emerges I'm hiding the graphics whenever the menus are activated. If anyone can suggest a better solution I'd be happy to implement it.

Version history:

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Sonotrode calculations:

0.1b Improved separation of engine and application, created Sonotrode plugin
0.1c Added animation
0.1d Added version history

Calculator engine:

0.1a First release version
0.1b Improved separation of engine and application, improved css, fixed Mozilla menu problem
0.1c Added animation
0.1d Added version history, separated js, css files

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File Analysis Materials Shapes Calculate Animation

Help

Analysis: Not defined

Material: Not defined

Shape: Not defined

Inputs:

Results:

Please select analysis / material / shape

Unit conversion:

POWER Ultrasonics

Home
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Welcome, Guest. Please Login or Register.

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Username: Password: Logged in for: Keeps

Login | Forgot password?

Powerultrasonics Forum » YaBB 2 powered!

Welcome, Guest. Please Login or Register.

Register Required Information

* **Choose username:**
Used only for identification by YaBB. You can use special characters after logging in by changing your displayed name in your profile.

* **Email:**
This must be a valid e-mail address.

Hide Email from public?

User Agreement

You agree, through your use of this YaBB forum, that you will not post any material which is false, defamatory, inaccurate, abusive, vulgar, hateful, harassing, obscene, profane, sexually-oriented, threatening, invasive of a person's privacy, or otherwise in violation of ANY law. You also agree not to post any copyrighted material unless the copyright is owned by you or you have consent from the owner of the copyrighted material. Spam, flooding, advertisements, chain letters, pyramid schemes, and solicitations are also inappropriate to this YaBB forum.

Note that it is impossible for us to confirm the validity of posts on this YaBB forum. Please remember that we do not actively monitor the posted messages and are not responsible for their content. We do not warrant the accuracy, completeness, or usefulness of any information presented. The messages express the views of the author, not necessarily the views of this YaBB forum. Anyone who feels that a posted message is objectionable is encouraged to notify an administrator of this forum immediately. We have the right to remove objectionable content, within a reasonable time frame, if we determine that removal is necessary. This is a manual process, however, so please realize that we may not be able to remove or edit particular messages immediately. This policy applies to member profile information as well.

You remain solely responsible for the content of your messages, and you agree to indemnify and hold harmless this forum, and any related websites to this forum. We at this YaBB forum also reserve the right to reveal your identity (or any information we have about you) in the event of a complaint or legal action arising from any information posted by you. You have the ability, as you register, to choose your username. We advise that you keep the name appropriate. With this user account you are about to register, you agree to never give your password to another member, for your protection and for validity reasons. You also agree to NEVER use another member's account to post messages or browse this forum.After you register and log into this YaBB forum, you can fill out a detailed profile. It is your responsibility to present clean and accurate information. Any information we deem inaccurate or vulgar will be removed.

Please note that with each post, your IP address is recorded, in the event that you need to be banned from this YaBB forum or your ISP contacted. This will only happen in the event of a major violation of this agreement.

I Agree I Do Not Agree

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Powerultrasonics Forum

Forum name	Last post	Topics	Posts
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News Read about the latest changes on the powerultrasonics site! *Moderator: Chris*	28.02.2006 at 13:19:53 **In:** Forum upgrade **By:** Chris	3	3
Questions Any questions about ultrasonics technology and equipment? *Moderator: Chris*	07.08.2006 at 20:31:40 **In:** Re: Far Field weld **By:** Myles	23	63
New applications Suggestions for new applications of power ultrasonics. How can I apply ultrasonics to.... *Moderator: Chris*	09.06.2006 at 10:21:35 **In:** (spam deleted) **By:** gill - *Ex Member*	7	29

	Sonotrode calculator Questions about the sonotrode calculator, and suggestions for improvements *Moderator: Chris*	11.12.2004 at 18:35:55 **In:** Diameter ratio too large **By:** Chris	4	12
	Board rules Rules for registered users and guests *Moderator: Chris*	12.10.2004 at 22:06:07 **In:** Starting up **By:** Chris	1	1

New Posts

No New Posts

Info Center

Forum Statistics

Our users have made **108 Posts** within **38 Topics**.
The most recent post is **Re: Far Field weld** (07.08.2006 at 20:31:40).
View the 10 most recent posts of this forum.

We have **223** registered members.
The newest member is **suven**.

	Most Users ever online was **7** on 10.07.2006 at 22:52:13 Most Members ever online was **2** on 24.07.2006 at 14:52:11 Most Guests ever online was **7** on 10.07.2006 at 22:52:13

Users online

	Members: **0** Guests: **2**

IIIII YaBB Administrator
IIIII Global Moderator

Login

Username: Password: Logged in for: Keeps

Login Forgot password?

Contents

YaBB Help Center

Welcome to the YaBB Family

YaBB is one of the world's leading providers of free, Perl-based message board systems for webmasters. Our innovative system allows people to get and stay connected it an easy to use, easy to understand format. Come

Getting started

Register an Account

Since this forum is powered by YaBB, registering an account is so simple, you'll be chatting in no time!

Step 1: In the menu above, you will see items titled "Home", "Help", "Login", "Register", etc. Click on "Register".

Step 2: On this new page, you will

Your Profile

Profile Overview

YaBB allows you to fill out a profile which tells people about you. You can have your name, age, instant messenger information, personal avatar (picture), and more!

Step 1: To

change your profile, click the "Profile" option in the forum menu above. This will bring you to the View Profile page.

Step 2: On your View Profile page, you will see a special link titled "Modify". Click this link.

Step 3: For security reasons, you will then be asked to enter your password. Do so, then click "Confirm Password".

You now have access to all of your account settings and options for this YaBB, divided into four sections: Edit Profile, Contact Information, Options and PM Preferences. For details on each of this, please read on below.

see a form where you can choose your username and password (if the administrator allows) and enter you email address. Fill in the boxes with your information.

Step 3: Check the box to agree to the User Agreement.

Step 4: Click on the "Register" button at the bottom of the page.

That's it! The administrator may require you to validate your account before you can post. If this is the case, an email will be sent to you containing your password. Now you"re ready to log in and post!

^

Log Into Your Account

see what hundreds of thousands of webmasters and millions of registered users already know!

For a more complete manual, please visit **The YaBB Codex**.
For support and troubleshooting, please visit **YaBB's Support Community**

This help section will get you up to speed on the functions of this YaBB forum. Inside, you will learn how to register an account, login, edit your profile, post a message, and much more. If you would like to skip ahead to a section, please use the menu to the left.

^

^

Edit Profile

The Edit Profile section gives you quick access to your basic profile settings for you account on this YaBB forum.

Password
If you wish to change your password, you may do so by filling in this box. It is highly recommended that your password be at *least* 6 characters and use a combination of letters and numbers.

Verify Password
In order to change your password, YaBB needs to know that you'll remember it. You can do this by entering your new password again in this box.

Name
This is your

Now that you've registered an account, it's time to sign in.

Step 1: In the menu above, you will see items titled "Home, "Help", "Login", "Register", etc. Click on "Login".

Step 2: On this new page, you will see several options.

- Username - Enter in the name you registered with.
- Password - Type in your password.
- Logged in For - Choose how long you would like to stay logged in for.
- Forgot Password - If you can't remember your password, click this button to have it resent. (Full directions below.)

Step 3 Once you have everything

Display Name. This is the name everyone will see throughout this YaBB forum. Most forum systems display the username you login with, but this is not the case with YaBB!

Gender
Optional. If you want others to know your gender, you may pick "male" or "female" from this drop-down box. Keep in mind that this forum may have boards with access only allowed to certain genders.

Birthday
Optional. If you would like others to see how old you are and have a special icon in your profile on your birthday, please enter it in DD (day), MM (month),

filled out, click the button in the form titled "Login".

Congratulations! You are now ready to participate in this community! Note, if you do not see the "Login" button in the menu, you may already be logged in. This can happen on some boards set up for instant registration.

^

Log Out of Your Account

When you are done posting, it is a good idea to log out of your account so others using your computer will not have access to your information. To do this, find the menu item titled "Logout". Once you click this button, YaBB will log you out of the forum. You must log in again if you wish to post or access member-only functions.

^

Forgotten Password

YYYY (year) format.

Location
Optional. Filling in this box will display where you live, where your from or anything else you choose.

^

Contact Information

If you would like other members of this YaBB community to be able to contact you, this section will allow you to provide this information in your profile.

Email
This must be a valid email address. It is used for system notifications such as a forgotten password, topic notifications, and forum emails.

Hide Email from Public
Check this

If you have forgotten your password, YaBB can resend it to the email account your registered your account with.

Step 1 In the menu above, you will see items titled "Home", "Login", "Register", etc. Click on "Login".

Step 2 On this new page, you will see a button titled "Forgot Password". Click this button.

Step 3 A new page will load with a single box. Enter your username or the email address you registered with.

Step 4 Click the button titled "Send".

^

box if you do not want other YaBB community members to view your email address. Note: this does not hide it from Admins.

ICQ
If you have an ICQ account, you may enter your UIN here.

AIM
If you have AOL Instant Messenger (AIM), you may enter your user name here.

YIM
If you have Yahoo! Instant Messenger, you may enter your screen name here.

MSN
If you have an MSN Messenger address, you may enter it here.

Google Talk
If you have Google Talk,

you may enter your address here.

Website Title
If you have a website, you can enter the title here. This will be the text the URL (below) will attached to.

Website URL
Here you can enter the URL to your website. Note, this must be a full URL. (i.e. include http://)

^

Options

The third section of your YaBB profile allows you to edit forum settings that relate to your account.

Personalized Picture
YaBB allows you to define a small picture (called an avatar) that will display under your name

next to your posts. This forum has a number of avatars already installed, and you may pick one from the list. If you have your own avatar, please see the option below.

I have my own pic
If you have your own avatar and would like to use it on this YaBB, you may enter the URL here.

Personal Text
This is a small line of text that will display under your avatar.

Signature
Your signature is displayed at the bottom of every post you make and in your profile.

Preset Time Format
This option allows you to change how the dates and time are

presented to you throughout this YaBB community.

Custom Time Format
You may also create a custom time format using the special codes here.

Time Offset
Since your time may be different from the server, you can enter your correct time zone to adjust it correctly.

Template
If the webmaster of this YaBB forum has other templates installed, you may choose one from this box.

Language
Here you can select your native language to view this community in if it is available.

^

PM Preferences

The final section of the profile gives you the ability to customize how you view and receive personal messages from other community members.

Ignorelist
This function allows you to ignore other members and prevents you from viewing any personal messages they send. Additionally, you may disable all PMs by entering a *

Notify by e-mail:
If you would like an email when a members sends you a personal message, this options allows you to enable that feature.

PM Popup shows PMs in new Window?
If you have

PM Popups enabled, checking this box will open your PMs in a new window. Otherwise, it will load in the current one.

Enable Personal Message Popup?
Checking this box will display a small popup window to notify you of any new personal messages.

Personal Messages

Personal Messaging

YaBB is about community and communication. And there are plenty of ways to communicate: Posting on the boards, Personal Messaging, E-mail, ICQ, AIM, YIM, MSN, and Gtalk. Of course, all methods of communication are only available to members. An exception is when the

Posting

Starting a Topic

^

After you have registered an account, you will have the ability to start new topics. To do so, navigate to a category you would like to begin a conversation in. Make sure that this is the correct category for the subject of your post. Once you're inside this category, search for a link or button titled "Start New Topic" and click it. The exact location of this button will vary depending on which template is being used, but it is often near the top of the list of topics.

This will present you with a new page where you can begin to type your post. Below you will find a description of the items on this page.

Subject: This is the title of your topic and is what will be shown on the category page.

Message Icon: If you would like to add a special icon to your post, you may choose one from this list.

Add YaBBC tags: YaBBC tags give you the ability to format the text in your post. To add, simply click on the button of your choice. See below for a complete

Forum Staff decides to allow guests to post on the boards: in this case all unregistered users are NOT allowed to do is viewing the Member List and sending Personal Messages to members.

While e-mail is a good way to correspond privately with members, it has several drawbacks: You must open your e-mail application to write and send the message; the recipient must open his/her e-mail application; check his/her mail and your message will mixed in with all the other mail and it can take sometimes several minutes to an hour for mail to reach the recipient.

As an alternative to e-mail, YaBB offers a faster, more private method. Personal

reference.

Add Smileys: Personalize your post by adding an emoticon, or smiley. Just click on the one you want and YaBB will automatically put it in your post.

Attach: If the Administrator allows, you may be able to add a file to your post by clicking on the "Browse" button to find the file on your hard drive to upload. Pay attention to the allowed file types and maximum file size.

Post / Preview / Reset: These three buttons do exactly what you would expect. Press the "Post" button if you're ready for the community to view your message, press "Preview" if you would like to see what your post will look like first or press "Reset" to clear all of the boxes and start again.

^

Replying to a Post

In addition to posting new topics, you can also reply to existing posts or topics quickly and easily. When you find a topic you would like to comment on, look for the button or link titled "Reply" or "Quote". Using "Reply" will take you to a post page much like the one described above. Quote does exactly he same thing, however, it will add what another user has said to your post in a special box like you see below.

Quote:

> This is a quote

^

Posting a Poll

Messaging on the forum provides instantaneous delivery to the recipient's private mailbox. The mail is sent and received entirely through YaBB, so neither you nor the recipient have to open another program or leave YaBB. Personal Messaging also gives both the sender and recipient greater privacy: no one's real e-mail address is revealed. Personal Messages show only the username and name of both parties.

If a recipient isn't online, Personal Messages wait in the member's PM box until the next time he/she logs in and manually reads and/or deletes them. YaBB Personal Messages is basically a self-contained,

If you have a question you would like to ask this community, YaBB gives you the ability to create a poll along with your topic. This is a fantastic way to get a good idea of what this community feels about your question. To post a poll, find the button titled "Start New Poll" from the category view and click it. The exact location of this button will vary depending on which template is being used, but it is often near the top of the list of topics. On this special post page, type in your question and options in the respectively labeled box, then fill out your message as described above.

^

YaBBC Reference

For security reasons standard HTML code cannot be used in posts. Instead YaBB allows the use of YaBBC (YaBB Code) for formatting. YaBBC is similar to HTML, but safe and standardized for bulletin board use. To use, you can either click on the YaBBC button of your choice on all post pages or manually type them in. Below is a listing of each tag and it's function.

What is YaBBC?

YaBBC is a set of tags based on the HTML language. It allow you to add formatting to your messages in the same way as HTML does, but have a simpler syntax and will never break the layout of the pages you are viewing. Most YaBBC tags can be wrapped around text, by first **highlighting** the text, and then clicking on the YaBBC button with the desired formatting.

Insert URL, Link

Syntax: [url]http://www.yabbforum.com[/url]
Result: http://www.yabbforum.com
Syntax: [url=http://www.yabbforum.com]YaBB Forum[/url]
Result: YaBB Forum

highly private e-mail system.

^

- Type URL and text: www.yabbforum.com YaBB Forum
- Highlight all of it: **www.yabbforum.com YaBB Forum**
- Click the button: YaBB Forum

The [link] YaBBC tags work in the same manner as the [url] tags, with the exception that the [link] tag (there is no insertion button for this tag) will open the clicked link in the present window, whereas the [url] tag opens the clicked link in a new window.

Insert FTP

Syntax: [ftp]ftp://ftpdom[/ftp]
Result: ftp://ftpdom

Insert Image

Syntax: [img]http://www.powerultrasonics.com/yabb/Templates/Forum/default/on.gif[/img]
Result:

Insert Email

Syntax: [email]myname@domain.com[/email]
Result: myname@domain.com
Syntax: [email=myname@domain.com]Click to email me[/email]
Result: Click to email me

- Type mail-addr. and text: myname@domain.com Click to email me
- Highlight all of it: **myname@domain.com Click to email me**
- Click the button: Click to email me

Insert Flash

Syntax: [flash=width,height]url to flash file[/flash]
Example: [flash=150,30]http://www.your-domain.com/yabbchelp.swf[/flash]
Result: **(150 x 30):** >http://www.powerultrasonics.com/yabb/Templates/Forum/default/yabbchelp.swf

---

Insert Table - Column - Row

Syntax: [table][tr][td]text example[/td][/tr][/table]

Insert Horizontal Rule

Syntax: [hr]
Result:

Insert Teletype

Syntax: [tt]text example[/tt]
Result: `text example`

Insert Code

Syntax: [code]<script language="Javascript">
<!--
alert("Hello YaBB 2!");
//-->
</script> [/code]
Result:

Code:

```
<script language="Javascript">
<!--
alert("Hello YaBB 2!");
//-->
</script>
```

Insert Quote

Syntax: [quote]Hello YaBB 2[/quote]
Result: **Quote:**

Hello YaBB 2

Insert Edit

Syntax: [edit]This was edited in YaBB 2[/edit]
Result: **Edited:**

This was edited in YaBB 2

Insert Superscript

Syntax: text [sup]example[/sup]

Result: text $^{\text{example}}$

Insert Subscript

Syntax: text [sub]example[/sub]

Result: text $_{\text{example}}$

Insert Marquee

Syntax: [move]text example[/move]
Result: text example

Insert Timestamp

Syntax: [timestamp=1121602762]
Result: 17.07.2005 at 13:19:22

Insert Bold Text

Syntax: [b]text example[/b]
Result: **text example**

Insert Italic Text

Syntax: [i]text example[/i]
Result: *text example*

Insert Underline Text

Syntax: [u]text example[/u]
Result: text example

Insert Strikethrough Text

Syntax: [s]text example[/s]
Result: ~~text example~~

Insert Highlighted Text

Syntax: [highlight]text example[/highlight]
Result: **text example**

Font Face

Change Font Face

Syntax: [font=Courier New]Courier New font [/font]
Result: Courier New font

2

Change Font Size

Syntax: [size=14]14 point font[/size]
Result: 14 point font

Insert Preformatted Text

Syntax: [pre] this is preformatted text [/pre]

Result:

```
 this  is
preformatted text
```

Insert Left Aligned Text

Syntax: [left]text example[/left]

Result: text
example

Insert Center Aligned Text

Syntax: [center]text example[/center]

Result:

text
example

Insert Right Aligned Text

Syntax: [right]text example[/right]

Result:

text
example

Insert List - List Item

Syntax: [list][*]item 1
[*]item 2
[*]item 3[/list]

Result:

- item 1
- item 2
- item 3

You can create 2 or 3 level lists by including a list inside another list.

Example: [list][*]item 1
[*]item 2
[list][*]subitem 1
[*]subitem 2[/list]
[*]item 3[/list]

Result:

- item 1
- item 2
    - subitem 1
    - subitem 2
- item 3

/me

Syntax: /me loves YaBB 2

Result: ** loves YaBB 2*

^

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Search for:	Match all words
By User:	Search -All- Members only
Choose the board(s) to search in: (Hold down the 'control' or 'apple' key to select more than one)	News Questions New applications Sonotrode calculator Board rules ☑ Check all
Fields to Search:	☑ Subject ☑ Message
This post was made in the last...	week
Display how many results?	15
Display only one result per thread?	☐

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Forum name	Last post	Topics	Posts
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News Read about the latest changes on the powerultrasonics site! *Moderator: Chris*	28.02.2006 at 13:19:53 **In:** Forum upgrade **By:** Chris	3	3
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New applications Suggestions for new applications of power ultrasonics. How can I apply ultrasonics to.... *Moderator: Chris*	09.06.2006 at 10:21:35 **In:** (spam deleted) **By:** gill - *Ex Member*	7	29

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Most Guests ever online was **7** on 10.07.2006 at 22:52:13

Users online

Members: **0** Guests: **2**

YaBB Administrator

Global Moderator

Login

Username: Password: Logged in for: Keeps

Login Forgot password?

Powerultrasonics Forum » General » News

(Moderator: Chris)

Read about the latest changes on the powerultrasonics site!

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		Subject	Started by	Replies	Views	Last post
		Forum upgrade	Chris	0	267	28.02.2006 at 13:19:53 **By:** Chris
		YaBB discussion forum (bulletin board)	Chris	0	396	12.10.2004 at 22:33:52 **By:** Chris
		Sonotrode calculator	Chris	0	385	12.10.2004 at 22:18:55 **By:** Chris

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Powerultrasonics Forum » General » News

(Moderator: Chris)

=> News Go

Normal Topic
Sticky Topic
Locked Topic
Sticky Locked Topic

Global Announcement
Hot Topic (More than 10 Replies)
Very Hot Topic (More than 25 Replies)

You **can** view topics in this board.
You **can not** post replies to topics in this board.
You **can not** start new topics in this board.
You **can not** start polls in this board.

An Error Has Occurred!

Sorry, you must register before using this feature!

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(Moderator: Chris)

‹ No topic | Next topic ›

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Send to a friend

Print

Forum upgrade (Read 268 times)

Chris
YaBB Administrator

Posts: 51

Forum upgrade
28.02.2006 at 13:19:53

The forum has been upgraded to YaBB version 2. If you find any problems please let me know.

Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

Email WWW

IP Logged

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Send to a friend

Print

Powerultrasonics Forum › General › News

(Moderator: Chris)

‹ No topic | Next topic ›

=> News Go

Powerultrasonics Forum » YaBB 2 powered!

Powerultrasonics Forum » General » Questions

(Moderator: Chris)

Any questions about ultrasonics technology and equipment?

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		Subject	Started by	Replies	Views	Last post
Important Topics						
		Adjusting ultrasonic horn frequencies	ros	3	655	22.10.2004 at 11:23:49 **By:** Chris
Board Topics						
		Far Field weld	Myles	2	121	07.08.2006 at 20:31:40 **By:** Myles

		sonochemical pollutant abatement	Isabel	1	76	24.07.2006 at 14:39:28 **By:** Chris
		Long time no posts	tester	0	64	14.07.2006 at 13:27:39 **By:** tester
		Power calculation of ultrasonic generator	saikiran	5	442	03.06.2006 at 12:21:20 **By:** saikiran
		Good News!! ultrasonic assised drilling	bahman	1	277	14.04.2006 at 14:16:43 **By:** Chris
		how to start	kadora	2	357	02.03.2006 at 08:10:08 **By:** kadora
		ultrasonic cleaning	ewoud	1	232	24.02.2006 at 14:26:42 **By:** Chris
		Generators	Shon	1	251	24.02.2006 at 14:12:20 **By:** Chris
		Aphalina Ltd - Russian manufacturer	kant	3	439	23.01.2006 at 13:52:48 **By:** Chris
		Ultrasonic cutting	Sergi	1	236	12.01.2006 at 21:00:57 **By:** Chris
		Sheffield Cavitron-Anyone Heard Of It?	Amplitude	2	295	23.12.2005 at 20:09:23 **By:** Amplitude

		hello sir wanted to know what is the life of a hor	VAIBHAV_INDUSTRIES	1	257	18.11.2005 at 19:12:12 **By:** Chris
		Ultrasonic drilling	bahman	1	262	02.11.2005 at 22:46:08 **By:** Chris
		Develop Ultrasonic Plastic Welder	j_shirazi	1	345	22.08.2005 at 02:12:46 **By:** Chris
		Boss cracking after insert welding	alban	3	343	12.08.2005 at 02:52:08 **By:** Chris
		U/S power cable length	sohkl66	2	322	30.06.2005 at 08:52:50 **By:** sohkl
		Square sonotrode	sohkl	2	379	30.06.2005 at 08:33:25 **By:** sohkl
		How to make 1 mm ultrasonic amplitude !?	bane	1	463	02.03.2005 at 17:26:03 **By:** Chris
		Question about horn design	spudbone	1	507	15.02.2005 at 23:59:18 **By:** Chris

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Powerultrasonics Forum » General » Questions

(Moderator: Chris)

=> Questions Go

Normal Topic
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Global Announcement
Hot Topic (More than 10 Replies)
Very Hot Topic (More than 25 Replies)

You **can** view topics in this board.
You **can not** post replies to topics in this board.
You **can not** start new topics in this board.
You **can not** start polls in this board.

Powerultrasonics Forum » YaBB 2 powered!

Far Field weld (Read 122 times)

Myles
YaBB Newbies

Ultra-sound!

Posts: 2

Far Field weld
30.07.2006 at 02:54:25

I am just started work with a small plastic company. we are having difficulty welding a small part. The part 38mm long 19mm diamenter . Hollow section wall thickness

2mm. Around the diameter is a 4mm hole. Due to weld length we seem to be unable to achieve a satisfactory weld .Both parts are acetal.

Any ideas

Myles

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Chris
YaBB Administrator

Posts: 51

Re: Far Field weld
Reply #1 - 05.08.2006 at 06:52:09

Hi Myles,

Far-field welding can be very difficult (I suspect it's more black art than science) but I'll try to suggest a few things to look at.

1. Presumably you can't change the design of the part, otherwise making it more rigid would probably help.
2. You may be able to

improve things by changing the design of the weld concentrator, as for any welding process.
3. Finally, if you're hitting a resonance of the part then a change of frequency (up or down) might help.

Sorry I can't give you any real answers. Perhaps other readers would be willing to offer other suggestions.

Regards
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Myles
YaBB Newbies

Ultra-sound!

Posts: 2

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Re: Far Field weld
Reply #2 - 07.08.2006 at 20:31:40

Thanks Chris

I give will your ideas a try

Cheers
Myles

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(Moderator: Chris)

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Powerultrasonics Forum » General » New applications

(Moderator: Chris)

Suggestions for new applications of power ultrasonics. How can I apply ultrasonics to....

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		Subject	Started by	Replies	Views	Last post
		(spam deleted)	gill (*Ex Member*)	0	119	09.06.2006 at 10:21:35 **By:** gill - *Ex Member*
		Ultrasonic Chocolate	Matt_Schweizer	3	464	11.03.2006 at 01:43:22 **By:** Chris
		Material compatabilities	cenmac	1	286	07.12.2005 at 19:33:30 **By:** Chris
		Magnetostrictive transducer to build	valerio	7	826	28.02.2005 at 16:59:30 **By:** Chris

		How can I build horns with a lathe, drill press..?	morrisR	8	838	11.12.2004 at 02:19:41 **By:** Raj
		Ultrasonic Peening of Parts and Welded Elements	Yuri	1	519	02.11.2004 at 02:05:24 **By:** Chris
		Ultrasonic drilling	eric	2	487	29.09.2004 at 05:21:59 **By:** eric - *Ex Member*

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(Moderator: Chris)

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(Moderator: Chris)

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gill
Ex Member

(spam deleted)
09.06.2006 at 10:21:35

(spam deleted)

« Last Edit: 09.06.2006 at 12:37:41 by Chris »

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Powerultrasonics Forum » General » Sonotrode calculator

(Moderator: Chris)

Questions about the sonotrode calculator, and suggestions for improvements

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		Subject	Started by	Replies	Views	Last post
		Conical horns???	kane	1	453	03.05.2005 at 01:37:52 **By:** Chris
		Diameter ratio too large	Raj	1	563	11.12.2004 at 18:35:55 **By:** Chris
		Sonotrode axial mode formulae	Chris	0	460	19.10.2004 at 23:20:29 **By:** Chris

		Sonotrode calculator & Mozilla	valerio	6	660	15.10.2004 at 01:41:22 **By:** Chris

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(Moderator: Chris)

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Powerultrasonics Forum › General › Sonotrode calculator
(Moderator: Chris)

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Diameter ratio too large (Read 564 times)

Raj
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 3

Diameter ratio too large
11.12.2004 at 18:01:38

Hi there,

I used your sonotrode calculator, it is very useful. I have an application whereby my 50W transducer have to have a horn of about 12mm radiator diameter. The calc says the diameter ratio is too large, could I make two steps like 45mm to 24mm and the next step is from 25 to 12mm? It finally would look like a full wave. Or should I have to go for exponential horn?

Thanks

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Chris
YaBB Administrator

Posts: 51

Re: Diameter ratio too large
Reply #1 - 11.12.2004 at 18:35:55

Hi Raj,

I moved your post here - this is the only appropriate board for questions about the calculator. I've set a rather arbitrary limit on step-up / down ratio, because at very high ratios the calculations on stepped sonotrodes become increasingly unrealistic. In any case a very high amplification in a stepped sonotrode is generally undesirable - likely to cause excessive stress in the smaller section.

You could certainly use 2 stepped boosters / sonotrodes to reduce from 45mm to 12 mm with a net 14:1 amplification, but do you really want that?

You can always change diameter at the interface between boosters, eg. if your booster is 45mm diameter you could fit it to a 24 / 12mm diameter stepped sonotrode for a 4:1 ratio. ie. the change from 45mm at the booster output to 24mm at the sonotrode input would not affect the output amplitude.

Alternatively as you say an exponential profile would be another option - this gives a much lower amplification for a given ratio of input to output diameter. I don't have an ETA for adding exponential sonotrodes to the calculator yet, sorry!

Regards
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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(Moderator: Chris)

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Powerultrasonics Forum » General » Board rules

(Moderator: Chris)

Rules for registered users and guests

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		Subject	Started by	Replies	Views	Last post
		Starting up	Chris	0	353	12.10.2004 at 22:06:07 **By:** Chris

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(Moderator: Chris)

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(Moderator: Chris)
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Starting up (Read 354 times)

Chris
YaBB Administrator

Posts: 51

Starting up
12.10.2004 at 22:06:07

While I'm setting up this board I thought it would be a good idea to get a few rules written down. These may change in time - feel free to reply with suggested changes:

1. On registration you will be required to

accept the standard user agreement provided by YaBB. Here's a very brief summary:
1a. No lies, defamation, abuse, vulgar, profane, threatening, etc. etc. language - I will remove such post as soon as I see them.
1b. I can't guarantee the accuracy, completeness or usefulness of any information posted. But if you think something's wrong then please bring it to my attention - I will check and / or remove it.
1c. You remain solely responsible for the content of your messages and your profile.

2. Unregistered users (guests) are currently allowed to post messages, but these are still subject to the rules above.

3. I ask all users to register since

this will provide you with many extra services (eg. details of other users, notification when your post is answered) and help build the community. Your e-mail address will not be published unless you want it to be.

4. Any representatives of businesses selling ultrasonic equipment **MUST REGISTER** and show their affiliation in their profile - Plugging your equipment is ok provided we know who you are! (I will be checking up...)

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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1	General / Questions / Re: Far Field weld on: 07.08.2006 at 20:31:40

Started by Myles | Post by Myles

Thanks Chris
I give will your ideas a try

Cheers
Myles

Reply Quote Notification

2	General / Questions / Re: Far Field weld on: 05.08.2006 at 06:52:09

Started by Myles | Post by Chris

Hi Myles,

Far-field welding can be very difficult (I suspect it's more black art than science) but I'll try to suggest a few things to look at.

1. Presumably you can't change the design of the part, otherwise making it more rigid would probably help.
2. You may be able to improve things by changing the design of the weld concentrator, as for any welding process.
3. Finally, if you're hitting a resonance of the part then a change of frequency (up or down) might help.

Sorry I can't give you any real answers. Perhaps other readers would be willing to offer other suggestions.

Regards
Chris

Reply Quote Notification

3 **General / Questions / Far Field weld**
on: 30.07.2006 at 02:54:25

Started by Myles | Post by Myles

I am just started work with a small plastic company.we are having difficulty welding a small part. The part 38mm long 19mm diamenter .Hollow section wall thickness 2mm. Around the diameter is a 4mm hole. Due to weld length we seem to be unable to achieve a satisfactory weld .Both parts are acetal.

Any ideas

Myles

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4 **General / Questions / Re: sonochemical pollutant abatement**
on: 24.07.2006 at 14:39:28

Started by Isabel | Post by Chris

Hi Isabel,

I'm not a specialist in sonochemistry (or any other kind of chemistry) but isn't calorimetric measurement used quite commonly for measuring the heat generated by a chemical reaction? Essentially just an insulated container and a thermometer measuring the temperature change.

Presumably by comparing the expected heat gain / loss in a reaction without ultrasonics to the actual measurement you would know how much energy was supplied by the ultrasonics. Alternatively, provided the density and viscosity of the reagents don't change too much you could perhaps sonicate them separately to see how much energy is supplied in the absence of any chemical reaction.

On a more practical level, most ultrasonic equipment does come with a power indicator which should be good at least for an indication of the supplied power. For better accuracy you could calibrate it with calorimetric measurements on water or a non-reactive fluid of similar density and viscosity to your reagents.

Hope that helps. If you have any other questions please don't hesitate to ask.

Chris

Reply Quote Notification

5 **General / Questions / sonochemical pollutant abatement**
on: 24.07.2006 at 14:15:05

Started by Isabel | Post by Isabel

Hello all, I am a Biochemist (from Chile, South America) .
Recently, I started reading about ultrasonic applications for pollutant abatement,
and I am most intereseted in this technology.
As I am starting to learn, I have some doubts, the main one is the following :
I have no idea how the "Power Input" can be calculated, it always says :“by calorimetric measurement” and I see the reference: Mason Practical
Sonochemistry 1991 Users guide to applications in chemistry and chemical engineering . Regretably, I have no chance of buying or borrowing this book,
it is not available here in Chile, could you please help?
If any of you has worked in the field ,could you give some advice?
or perhaps if you have the book. Could you possibly
scan those pages and send them to me??
I would be most grateful for any help you could provide..

Reply Quote Notification

6 **General / Questions / Long time no posts**
on: 14.07.2006 at 13:27:39

Started by tester | Post by tester

So, is this board still alive or what?

Reply Quote Notification

7	**General / New applications / (spam deleted)** on: 09.06.2006 at 10:21:35

Started by gill - *Ex Member* | Post by gill - *Ex Member*

(spam deleted)

Reply Quote Notification

8	**General / Questions / Re: Power calculation of ultrasonic generator** on: 03.06.2006 at 12:21:20

Started by saikiran | Post by saikiran

Thank you Chris. The thread I was referring to is by Jurag. Your reply is as given below. Of course, it seems you have given that power value out of your experience.

I'd suggest the best equipment to start with would be a probe-type ultrasonic system with a high gain and a small tip. This will give you high amplitude on a small area and so a high energy density - ie. lots of energy concentrated into a very small volume of water. Typical "sonicator" type systems working at 20-30kHz, 500-1000W would be suitable.

Another thread where you could roughly predict the power suitability is :

Hi Shon,

Sorry but as a mere mechanical engineer my knowledge of the electronics is very limited. 600V for cleaning equipment sounds about right though (considerably higher for welding systems).

......

This question is just for clarification. However, I understood that there is no direct relation for power in terms of freq. and amplitude.

Thank you once again.

Regards
Kiran

Reply Quote Notification

9	**General / Questions / Re: Power calculation of ultrasonic generator** on: 31.05.2006 at 14:47:50

Started by saikiran | Post by Chris

Quote from saikiran on 31.05.2006 at 14:01:54:

> But In piezo.com site in FAQs section they just gave how much mechanical and electrical power we can extract from a given sheet. It must be experimentally obtained value.

Thanks for the info. To me that looks more like a theoretical value but in any case it's not the answer to the question I thought you were asking... Power ultrasonic transducers are capable of delivering typically between 1 and 3 kW at 20kHz, but even if, for example, a 3kW transducer is driven by a 3kW generator you still cannot know how much power will be delivered without defining the working conditions. The power required to drive the transducer and booster / sonotrode is quite low, perhaps 50W or less, and under no load that is how much power the generator will deliver. As the load increases, generator power increases to match.

Quote from saikiran on 31.05.2006 at 14:01:54:

> One more doubt I've is: How the transverse movement of the piezo crystal is arrested or minimized in ultrasonic head. Any consequences?

The piezo-ceramic disks are designed to expand and contract in the direction of the transducer axis. Sure there is also transverse movement, as with all elastic materials, but provided the diameter is small enough to avoid resonances in the radial direction it's not an issue (this is really the limiting factor on the maximum diameter of a transducer).

Quote from saikiran on 31.05.2006 at 14:01:54:

> I shall contact Bahman. But can you pls tell how to raise an alert or attract attention of Bahman (for that matter any other member in the forum) by just replying to this mail?

As a general rule to contact another member of a forum you can send a private message and he should find it on his next visit. In this case I will also be putting up some images he sent so the credit on that page may also give you an idea of where to find him!

Quote from saikiran on 31.05.2006 at 14:01:54:

> I noticed that in one of the threads in this forum, you've replied to a person designing a ultrasonic cleaning equipment that instead of his chosen 12V 70W generator, it would be better to start with 600 or 700 W. Can you tell how you arrived at such rough value? Is it due to experience or some calculation?

Are you referring to this thread? If so I think you misunderstood it - the existing system featured 12 transducers of 50W each (600 W total) and the aim was to replace all of them with a single transducer of 600W. If you meant a different thread please give me a link so I can remember what I was talking about!

Chris

Reply Quote Notification

10	General / Questions / Re: Power calculation of ultrasonic generator on: 31.05.2006 at 14:01:54

Started by saikiran | Post by saikiran

Hi Chris,

I noticed that in one of the threads in this forum, you've replied to a person designing a ultrasonic cleaning equipment that instead of his chosen 12V 70W generator, it would be better to start with 600 or 700 W. Can you tell how you arrived at such rough value? Is it due to experience or some calculation?

Regards
Kiran

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Web:	sonochemistry.com
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Phone:	5152966030
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Sonic Systems United Kingdom

Products:	OEM ultrasonic equipment
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Address:	Bakers Farm Barns, Puckington, Ilminster, Somerset, TA19 9JA, United Kingdom
Phone:	+44 (0) 1460 52123
Fax:	+44 (0) 1460 55234
Web:	www.sonicsystems.co.uk
Email:	Info@sonicsystems.co.uk
Contact:	Mr Rob Perkins
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Stapla Ultrasonics Corp. United States

Subsidiary of:	Stapla Ultraschall-Technik GmbH
Products:	Metal welding equipment
Services:	Consultancy, Proving trials
Address:	375 Ballardvale Street, Wilmington, MA 01887, United States
Phone:	978 658 9400
Fax:	978 658 6550
Web:	www.staplaultrasonics.com
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Stapla Ultraschall-Technik GmbH

Stapla Ultraschall-Technik GmbH Germany

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Phone:	49 6107 71080
Fax:	49 6107 61139
Web:	www.staplaultrasonics.com
Email:	staplahq@aol.com
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Nevik electronics India

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References page for Chris Cheers' thesis: Design and optimisation of an ultrasonic die system for forming metal cans - see www.powerultrasonics.com

Home

- Home

Welcome to the YaBB User/Visitor Help and Administration Guide

YaBB is one of the world's leading providers of FREE Perl-based Message Board systems for webmasters, with currently over 50,000 web communities using YaBB worldwide, and over 1 Million registered users througout these forums! Join the messaging revolution; keep visitors coming back or help your favorite website grow by chatting on their forum....

YaBB is the solution! BBS sytems were meant to be: Free, Beautiful, Fast, Secure, Easy to Install, Able to give you full Administrative Control, and Easy to Use with International Languages...

Use this manual to learn how to use a YaBB forum (such as registering and posting) and administrate a YaBB forum!

Users:: Posting

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Posting

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Creating a new thread

In order to start a discussion on a subject, you must create a thread, you can do this by clicking the start new thread button on the board index page.

Posting a reply

To reply to a post, you can click the post a reply button at the top or at the button of the table. If you want to insert a quote to which you are replying, you can click the quote button of the post.

YaBBC

For obvious reasons standard HTML code cannot be used in posts. Instead YaBB allows the use of YaBB Bulletin Board Code (YaBBC) in posts. YaBBC is similar to HTML, but safe and standardized for bulletin board use.

Type This	For This
[hr]	
[url=http://site.com]SITE**[/url]**	[SITE](http://site.com)
[url]http://site.com**[/url]**	http://site.com
[img]http://site.com/image.gif**[/img]**	
[img width=80 height=40]http://site.com/image.gif**[/img]**	
[b]Bold[/b]	**Bold**
[i]*Italic***[/i]**	*Italic*
[u]Underlined[/u]	Underlined
[s]strikethrough**[/s]**	~~strikethrough~~
[color=Red]Red text**[/color]**	Red text
[move]stuff**[/move]**	stuff :)
[shadow=color,glow width, #characters wide]TEXT**[/shadow]**	Shadowed Text
[glow=color,glow width, #characters wide]TEXT**[/glow]**	Glowing Text
[flash]http:/site.com/flash.swf**[/flash]**	Flash Movie
[quote]Quoted text**[/quote]**	Quoted text

Emoticons

Emoticons are a fun way to express your emotion in your posting. They can help you indicate whether you are joking, happy, sad, or a variety of other things. Each YaBB emoticon uses standard chat-style key-strokes, so it requires no thinking on your part.

Emoticon	Type this...
	:)
	:D
	;D
	;)
	:(
	:-*
	>:(
	:P
	:'(
	:-[
	8)
	:o
	::)
	:-/
	:-X
	??? or ?!?

Thanks for visiting. Sorry but due to incessant spam I've had to disable further entries in the guestbook.

Guestbook entries from 14th November 2003 to 6th June 2005. Page 1 of 6. Next>

2005-06-06 10:37:09
Mrs Jennifer Houin G.M. Enterprises
I am looking for a horn for our Sonics and Materials Ultra Sonic Welder. Is this something you carry?

2005-05-21 06:42:44
Mr gaurav kakran student
sir, i need contacts of whirlpool of india (faridabad),larsen and turba switchgears(faridabad),carrier aircon,(gurgaon),goetze auto ancillaries(rohtak)

2005-02-15 20:31:50
Ms Loes sauren -

2005-01-25 05:44:44
Mr wally kowalec -

2004-11-01 21:46:02
Mr Ravikanth Bendarapu IKV RWTH (Germany)
Very informative

2004-10-26 18:34:15
Mr pius DICK chaier limited
THIS IS A GREAT SITE , PLEASE KEEP IT UP

2004-10-01 17:59:47
Mr Pitty Mahesh P M GROUP INC
I glad to see this ,and using the chan ce to advert my company and imploy more workers and customers

2004-09-28 06:47:02
Mr Jeffrey Fredenburgh self employed

2004-07-20 17:35:00
Mr Thomas Hielscher Hielscher Systems GmbH
-

2004-07-20 17:32:00
Mr Gerhard Hielscher Dr. Hielscher GmbH
-

2004-07-20 17:28:00
Mr Gary Keil Hielscher USA, Inc.
-

2004-07-03 08:02:00
Mr bustillos raymond bba envionmental
-

2004-06-30 18:19:37
Mr Morris Rush -
Dear Sir, Young people think they know it all until opportunity knocks & then you get a reality check. This happens to describe how I felt when my boss decided to give me a bench model Cavitron 20k Hertz Ultra sonic welder. Well, how does one learn to make custom horns and such? The old manual shows a device that checks horn design but of course this magic box is missing. How can I build horns with a lathe, drill press and mill equipment?

Editor's note: Not strictly one for the guestbook but I've included it here as an example of a common theme. I emailed back and forth with Morris for a while, and those messages will be up on the new discussion board shortly...

2004-06-28 18:44:58

Mr Adrian Mordecai Ultrasonics Ltd

-

2004-06-09 14:08:14

Mr Michael Kardosh Neurosonix

-

2004-06-05 08:38:47

Mr Bhupesh Chavan D SONICS TOOLINGS PVT LTD

Very good site. Any detail for Finite element analysis?

Editor's note: Coming soon...

2004-05-15 12:15:41

Mr Wilson Hatanaka WWHATA Consulting

-

2004-04-23 06:18:51

Mr Richard Zachary Ergosonics

-

2004-04-14 16:02:13

Mr Rick Elwood -

-

2004-03-31 16:01:11

Mr Lucio Gutierrez Embalajes ALLCRAFT S.A.

Very good graphics. Thanks

2004-03-26 09:20:46

Mr Dennis Wells Branson Ultrasonics (UK)

-

2004-03-25 17:23:50

Mr Richard Zachary Ergosonics

-

2004-03-25 15:58:05

Mr Dennis Wells Branson Ultrasonics (UK)

-

2004-03-25 11:53:50

Mr kishor sonawane oscar ultrasonics pvt.ltd.

-

2004-03-16 08:48:25

Mr Martin Choleva Eye departement

-

2004-02-18 15:20:38

Mr Hever Burga SIENA GROUP SAC

-

2004-01-30 19:41:45

Ms Andrea Horan Delphi Corporation

-

2004-01-30 15:34:04

Mr Robert Garford Warwick University

-

2004-01-28 11:53:08

b.v.avhad Vibronics Pvt. Ltd.

-

2004-01-28 04:48:02

Dr Bharat Kale C-MET, Pune

-

2004-01-17 05:47:55

Ms sailaja mohapatra Whirlpool of India Ltd

-

2004-01-09 15:52:52

Mr Luis Lopez Martinez -

-

2004-01-07 07:42:43

Mr Richard F Gorton	Far West Micro Inc.
	-

2003-12-15 19:08:04

Mr German Noriega	Cidete Ingenieros SL
-	

2003-12-14 07:26:54

Mr Bhavesh patel	Sheetal Ent
-	

2003-12-13 19:17:15

Mr Jim Keltos	American Technology Inc
-	

2003-12-11 10:13:40

Mr mostapha sahebkar	toosounic
-	

2003-12-04 14:08:01

Mr somchai Matta	M.I.T Knitting Co. Ltd.
-	

2003-11-25 05:51:02

Mr tocaiu calin	Med Plast
-	

2003-11-14 20:00:28

Mr Lee Johnson	-
-	

Page 1 of 6. Next>

On this page I am collecting a series of links to technical articles that will interest users and suppliers of ultrasonic equipment, as well as researchers. Practical industrial applications are just as welcome as cutting-edge high-tech research.

If you know of a relevant article or technical paper that is available from the web I would be happy to provide a review and a link on this page. Suitable subjects would be equipment and applications of high-power ultrasonics, either new research or technology reviews, that would be of interest to power-ultrasonics users.

As of August 2004 I now have hundreds of good links awaiting reviews... If you'd like to see them on this page please give me some encouragement and direction by selecting your field of interest from this list!

I am interested in articles about:

Select your area of intere Vote

Note - this system is designed to accept up to 3 different votes in one session from any individual (identified by their IP address). Results are updated in real time. Please select the subject(s) that interest you most and click 'Vote'.

Votes cast on "Request for articles on powerultrasonics web site".

Cleaning	13% (50 votes)
Ultrasonics for beginners	13% (49 votes)
Plastic welding	10% (37 votes)
Very high power ultrasonics	10% (37 votes)
New applications	8% (30 votes)
Machining	7% (27 votes)

Date range: 18th August to 4th August

Alternatively, if you have written a relevant article that's not yet published on the web I will consider it for publication on this site, if necessary scanning paper documents and / or converting files from other formats for you free of charge. (Of course, in this case it must be highly relevant!).

To suggest a link to an existing on-line article please use the discussion forum, but if you have an article to send to me please see the contact page.

Ultrasonic cleaning in supercritical liquid CO_2

	Miodrag Prokic et al M. P. Interconsulting	(View)
23 June 2001	Using liquid carbon dioxide as a cleaning solvent offers some great environmental advantages. Compared to conventional chlorinated solvents and detergents it is very clean, with no harmful emissions. Separating the liquid from the dissolved contaminants is easy - just reduce the pressure and allow the CO_2 to boil off (after which it can be trapped and recycled). However the pressure required to maintain CO_2 in liquid form (>60 bar) does present some challenges for ultrasonic tank design... Using a novel multifrequency actuator made it possible to generate ultrasonic vibrations in an autoclave with very thick walls. This paper, written for the 2001 UIA conference by Miodrag and fellow researchers from ECO_2 SA, a Swiss company specialising in supercritical fluid technology, describes the equipment they developed and results obtained.	

Design and optimisation of an ultrasonic die system for forming metal cans. Chapter 6 - Results.

	Chris Cheers Power Ultrasonics (Australia)	(View)
23 June 2001	At long last, another chapter from my PhD thesis converted to HTML. All measured results are shown, including modes and frequencies (comparing finite element predictions with actual results), ESPI (electronic speckle pattern interferometry) evaluation and force measurements with and without ultrasonics.	

Ultrasonic Motor Development

(View)

12 Aug 2004 (Now updated with a new link to NASA Telerobotics Program Plan, since the old page has been removed.)

An interesting page about research at MIT to develop a high torque-density solid-state actuator for use in the NASA/JPL Mars Micro Lander manipulator arm. It includes a general explanation of the principles of ultrasonic motors, and some cool animations! Note the use of dynamic and time-averaged ESPI (electronic speckle pattern interferometry) to evaluate the vibration modes.

Canon Ultrasonic Motors (USMs)

(View)

12 Aug 2004 (Link updated August 2004)

Canon's brief description of their development of ultrasonic motors for use in camera auto-focus lenses. Their explanation of the arrangement of piezoelectric elements is particularly good. There are two sets of elements, offset by a quarter-wavelength, each generating a standing wave. Superimposing the offset standing waves creates a travelling wave that drives the rotor.

Sonocrystallizer (TM)

AEA Technology (View)

12 Aug 2004 (Link updated August 2004)

The AEA Technology Sonocrystallizer (TM) is a new reactor which produces better crystals for the pharmaceutical and bio-tech industries. For more details see the July 2000 newsletter.

Ultrasonic Washing of Textiles

Fraunhofer Technology Center / Institute of Acoustic, Madrid. (View)

12 Aug 2004 (Link updated August 2004)

Ultrasonic cleaning, normally used in industrial applications, may now be applied to fabric cleaning in both domestic and commercial washing systems, according to FTech. This brief article discusses the process and potential advantages: significant savings of energy and water usage.

Magneto-strictive transducers are back!

Chris Cheers

19 Apr 2000 Not an article as such, but hopefully of interest to readers...

Since the early 1980's, piezo-electric transducers have dominated the power ultrasonics industry. After some early reliability problems (cured largely by improvements to the electronic control systems used to drive them) they have now almost completely replaced the old inefficient laminated nickel alloy transducers wrapped in coils of PTFE insulated wire (the heat generated would melt conventional plastic insulation!).

ETREMA plans to change all that, with their new ultrasonic transducers based on Terfenol D®.

This is a special magneto-strictive iron alloy which tolerates high strains. It has been available for many years but only from laboratory-scale production. Now full production brings larger sizes and much better pricing, plus laminated blocks to reduce eddy-current losses in high frequency systems. Their new 20 kHz, 6kW transducer handles more power than any other ultrasonic transducer I know, and they are promising something much bigger in the near future...

Watch this space!

Update August 2004 (still watching)

Four years later both pages I originally linked to have disappeared. Instead Etrema now offer a system called MaXonics, delivering 3kW in continuous operation. I have to say it's a bit disappointing...

Piezoceramic Tutorial

	PIEZO SYSTEMS, INC.	(View)
19 Apr 2000	And in order to maintain a strict sense of balance... this is an excellent tutorial on the piezo-electric effect, provided by Piezo Systems, Inc..	

Theory of ultrasonic metal welding

	American Technology (AmTech) Inc.	(View)
12 Aug 2004	(Link updated August 2004) The subject of metal welding seems to attract high-quality articles from equipment suppliers. While not as comprehensive as Stapla's book, this article from AmTech gives a good introduction to the theory and practice of welding metals, aimed particularly at wire-joining applications.	

Creating Sonoluminescence

	Hiroshi	(View)
12 Aug 2004	(Link updated August 2004) Ultrasound in liquids creates cavitation bubbles, which as they collapse can generate immense temperatures and pressures, and brief faint flashes of light - called sonoluminescence. It's a strange phenomenon, not yet fully understood but very reproducible. This article gives a clear account of the equipment required to generate and study sonoluminescence - a surprisingly simple set up suitable for a high-school laboratory.	

Power ultrasonics improve food quality - Reducing the degree of processing of heat-preserved foods using power ultrasound.

	Campden & Chorleywood Food Research Association	(View)

10 Jan 2000	The CCFRA is a food-industry funded research organisation in the UK. This is the March 1999 newsletter (I found it rather late but I still think it's worth a look!) in which they describe results of early trials using ultrasonics to speed up food processing. Most of their results are available only to subscribers.

Power ultrasonic equipment for sonochemistry research.

John Perkins (View)
Sonic Systems (UK)

12 August 2004 (Link updated August 2004)

John has vast experience in power ultrasonics. Here he starts with the basics, covering the design and construction of piezo sandwich transducers and sonotrodes, before giving a detailed description of sonochemistry principles - cavitation, energy-density, monitoring power and amplitude. The article concludes with a discussion of safety precautions and scaling-up the equipment to full production. It is aimed primarily at the chemist who wants to evaluate the use of sonochemistry techniques, but is also excellent reference material for anyone with an interest in power ultrasonics.

Ultrasonic Metal Welding - Principles and applications of high-grade bonding technology.

Stapla Ultrasonics (USA) (View /
Stapla Ultraschall-Technik (Germany) download)

22 Sept 1999 Stapla's comprehensive textbook of ultrasonic metal welding technology, available on-line or as a free download. Includes an overview of ultrasonic technology, equipment setup, quality-control techniques, materials and component sizes suitable for welding by this method. Essential reading!

Design and optimisation of an ultrasonic die system for forming metal cans. Part 1 - Introduction.

Chris Cheers (View)
Power Ultrasonics (Australia)

29 Sept 1999	My PhD research was all about making steel aerosol cans the same shape as the existing aluminium ones. This is surprisingly difficult, since the steel cans are much less formable, a consequence of their higher yield strength and thinner walls. Using ultrasonic dies solved the problem, reducing forming forces to make the process possible.

Contents

Topic Functions

Deleting a Topic

If you feel a topic is inappropriate, in violation of the member agreement of this forum, causing a problem, or is simply out of place, you have ability to remove the topic or offending posts.

- **Method 1:** Viewing the Topic
  - Scroll down to the bottom of the topic and locate your "Moderator Menu".
  - Click on the option titled "Delete".

YaBB Moderator Help Center

Your Moderator Status

Congratulations on your promotion to moderator status. You are now able to directly help this YaBB forum by managing one more boards and the posts inside of them. While most of the new functions available to you

Post Actions

Modifying a Post

You now have the ability to edit any post on the board (s) you moderate. This function will help you fight spam, remove unwanted language, censor users, add additions and much more. In order to do so, follow the directions below:

- **Modifying a Post**
  - Identify the post you wish to edit.
  - In that post, you will see a small menu with "Quote", "Modify" and "Delete". Click on the one titled "Modifty".
  - You will then be given access to the edit page where you may make your changes. When you're done, press the button titled "Save".

Please note that a small line of text will show on the post stating that you have made an edit. As such, it is advised you also attach a reason to why you made the edit. This lets the admin, other moderators,

  - A small popup will then ask you to confirm that you wish to remove this entire topic. Click "OK" to remove or "Cancel" to keep it.
- **Method 2:** Viewing the Message Index
  - At the end of the row for each post, you will have a small checkbox. Check it by clicking on it. Repeat for each topic you wish to remove.
  - Once all the topics you want to remove are checked, locate a set of radio buttons titled "Lock/Unlock", "Sticky", "Remove" and "Move To:". Click on the radio for "Remove".
  - Click the button titled "Go", next to the move drop-down box.

^

Locking or Unlocking a Topic

will be familiar, there are a few new ones that will be covered in this help section.

For a more complete manual, please visit **The YaBB Codex**.

For support and troubleshooting, please visit **YaBB's Support Community**

You may use the menu on the left to quickly jump to any topic below.

^

the poster and the rest of the community know there was an issue. You can use the [edit][/edit] YaBBC tags to add a message about your edit.

This will appear as follows:

Edited:

I modified this post and this is why!

^

Deleting a Post

If you believe a post is inappropriate, a violation of the User Agreement or does not belong, you have the option of removing it from the topic, without deleting the entire topic.

- **Deleting a Single Post**
  - Identify the post you wish to delete.
  - In that post, you will see a small menu with "Quote", "Modify" and "Delete". Click on the one titled "Delete".

This will *instantly* remove the offending post.

If there are multiple posts to be removed inside of a single topic, follow these directions to remove them all at once:

- **Deleting Multiple**

When you feel a topic can no longer serve a good purpose or you would like to prevent others from adding new posts, the lock/unlock function will provide you with this ability.

- **Method 1:** Viewing the Topic
  - Scroll down to the bottom of the topic and locate your "Moderator Menu".
  - Click on the option titled "Lock/Unlock"
- **Method 2:** Viewing Message Index
  - At the end of the row for each post, you will have a small check box. Check it by clicking on it. Repeat for each thread you wish to lock or unlock.
  - Locate a set of radio buttons titled "Lock/ Unlock", "Sticky", "Remove" and "Move To:" at the bottom of the message list. Click on the radio for "Lock/Unlock".
  - Click the button titled "Go", next to the move drop-down box.

Posts

- Identify the posts you wish to delete.
- In each post, *next* to the "Delete" button, you will find a small check box. Check this box by clicking on it.
- Near the bottom of the page, past all the posts in that topic, you will find your Moderator Menu. Find and click the button titled "Delete Selected".

This will also instantly remove all posts that you have checked.

^

Splitting a Topic

In the event that a conversation begins to drift away from the subject, you can maintain order on your board(s) by using the "Split" function. This enables you to move a post and all the posts under it, to a brand new topic where the conversation can continue.

- **Splitting a Post**
  - Identify the post you wish to split into to a new topic.

^

Sticky a Topic

If you feel a topic is very important for everyone who visits the board you moderate, you may turn it into a "Sticky" topic. These topics will then be displayed on top of all other topics. A useful example would be for forum rules.

- **Method 1:** Viewing the Topic
  - Scroll down to the bottom of the topic and locate your "Moderator Menu".
  - Click on the option titled "Sticky"
- **Method 2:** Viewing the Message Index
  - At the end of the row for each topic, you will have a small check box. Check it by clicking on it. Repeat for each topic you wish to lock or unlock.
  - Locate a set of radio buttons titled "Lock/ Unlock", "Sticky", "Remove" and "Move To:" at the bottom of the message list. Click on the radio for "Sticky".
  - Click the button titled "Go", next to

- In that post, you will see a small menu with "Quote, "Modify", "Split" and "Delete". Click on the one titled "Split". Note, this will *not* show on the first post of a topic.

This function will instantly move the post and all the posts under it to a brand new topic. The subject of the post you split is the new topic's subject.

^

the move drop-down box.

^

Adding a Poll

As a moderator, you can now add polls to any topic if you feel one is needed. To do so, fine the "Add Poll" button that's located next to the "Reply" button. Clicking it will bring you to the edit page where you can fill out the form to add a poll.

^

Contents

Topic Functions

Deleting a Topic

If you feel a topic is inappropriate, in violation of the member agreement of this forum, causing a problem, or is simply out of place, you have ability to remove the topic or offending posts.

- **Method 1:** Viewing the Topic
  - Scroll down to the bottom of the topic and locate your "Moderator Menu".
  - Click on the option titled "Delete".

Global Moderater Help Center

Your Global Moderator Status

A Global Moderator is an admin-like position. You have the ability to run moderator functions across all boards, and if the Administrator allows, you may be able edit some core settings of this YaBB

Post Actions

Modifying a Post

You now have the ability to edit any post on the board (s) you moderate. This function will help you fight spam, remove unwanted language, censor users, add additions and much more. In order to do so, follow the directions below:

- **Modifying a Post**
  - Identify the post you wish to edit.
  - In that post, you will see a small menu with "Quote", "Modify" and "Delete". Click on the one titled "Modifty".
  - You will then be given access to the edit page where you may make your changes. When you're done, press the button titled "Save".

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Locking or Unlocking a Topic

community. You have been entrusted with the care and governance to ensure this growing community thrives.

For a more complete manual, please visit **The YaBB Codex**.

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Using the menu to your left, you may jump to any topic below to get a better overview of how to access your new abilities.

^

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^

Contents

Manage Categories

Accessing the Category Functions

This YaBB version comes equiped with powerful tools to manage and control the conversational flow of your community. The cornerstone of which is the ability to group boards into an unlimited* number of categories. In order to access these functions, you must, of course, be logged in as an Administrator (or Global Moderator with proper access rights). Once you are, look at the main menu. You will notice a link titled "Admin Center". Clicking this will bring you to a large control panel. On the left hand menu, search for the section titled "Forum Controls"

Administrative Help Center

Introduction

As you are well aware, YaBB is a fantastic community platform. Easily installed; easily managed. It's the perfect solution for growing and maintaining a solid, proactive relationship with your user base. This help section will help you understand some of the many new and

Manage Boards

Accessing the Board Functions

Now that you have created your categories, you can use YaBB's amazing board-creation utilities to manage the postable sections of your community. YaBB allows you to create an unlimited* number of boards in every category. In order to access these functions, you must be logged in as an Administrator or Global Moderator with proper access rights. Once you are, look at the main menu. You will notice a link titled "Admin Center". Clicking this will bring you to a large control panel. On the left hand menu, search for the section titled "Forum Controls" and click on the second link titled "Boards".

** YaBB is only limited by the space allocated to you on your web hosting server.*

^

Adding New Boards

and click on the first link titled "Categories".

** YaBB is only limited by the space allocated to you on your web hosting server.*

^

Editing a Category

Editing a cateogry with YaBB is fast and easy thanks to the hard work our fantastic team of developers. While inside of the Categories function of your Admin Center (see above for details), you will see a list of existing categories, each with a corresponding check box. Clicking on this check box will flag this category for editing.

Once you have checked all the categories you wish to edit, scroll to the bottom of the list and search for the set of radio buttons titled " With selected:". Click on the radio button for "Edit", then press the button to the right titled "Go". Inside you will find the following items for *each* category:

- **ID**
  - This is for internal use only. It lets YaBB keep track of things, and it will be used in the URL to view that category.
- **Name**
  - This is the title of your category. It's the name your users will see. You may edit this however

powerful features you now have at your fingertips. If you would like to skip ahead to a specific subsection of this help, please use the navigation menu to the left.

For a more complete manual, please visit **The YaBB Codex**.

For support and troubleshooting, please visit **YaBB's Support Community**

^

YaBB now gives admins the ability to add multiple boards from a single screen. To do this, access the forum's board management functions as explained above. Once there, scroll to the bottom of the list of existing boards (if any) and find the function titled "Add Boards". Enter the number of new boards you would like to create in the text box then press the button titled "Add".

On this new page, you will be given a large set of options for each of the new boards you are trying to add:

- **Board ID**
  - This is only used for internal YaBB functions, and it is used in the URL used to view a board. You may enter any alphanumeric name you wish.
- **Name**
  - This is what your users will see. You may enter anything you wish here.
- **Description**
  - Describe this board so your users will know what the subject/ topic will be.
- **Moderators**
  - Enter the username of the members you wish to give Moderator access (seperate with commas).
- **Category**
  - Choose which category you wish.
- **Allowed to View / See Category**
  - If you wish to make this board private, you may choose which Member Groups will be allowed to see this category. Leave this blank to allow everyone access.
- **Allow Collapse**
  - Check this box to allow your users to expand and collapse this category on the front page.

When you've finished making your edits, search for and click the button titled "Save" at the bottom of the list of categories.

^

Deleting a Category

If you would like to remove a category, follow the directions above to access your category management page. In the list of categories, you will notice a check box that corresponds to each title. Check this box for each and every category you wish to remove. Once selected, scroll to the bottom of the category listings and locate the set of radio buttons titled "With Selected:". Click on the radio labeled "Remove" then press the button to the right titled "Go".

A small popup will ask you to confirm that you want to remove these categories. Click "OK" to remove them or would like this board to be a part of.

- **Board Picture**
  - Here you can assign a small picture to represent this board.
- **Zero Post Count Board?**
  - Check this box if you would like to prevent posts made in this board from increasing users' post counts.
- **Show to All?**
  - Checking this option will ensure the board is shown to all able to view the Board Index even if they are not allowed access to the board.
- **Allow Attachments**
  - Checking this option will enable users to attach files to their posts.
- **Global Announcements**
  - Checking this option will ensure the messages in this board are shown as important on top of every board. No matter how the permissions are set, only Administrators and Global Moderators can start new topics or reply. Note: YaBB only allows a single board to have this label.
- **Recycle Bin**

"Cancel" to keep them.

^

Adding new Categories

YaBB now allows you to add many new categories all at once. To do this, access the forum's category management functions as shown above. Once there, scroll to the bottom of the list and find the function titled "Add Categories:". Enter the number of new categories you wish to create in the box and press the button titled "Add".

On this new page, you will be given a set of options for each of the new categories you want to create:

- **ID**
  - This is for internal use only. It lets YaBB keep track of things, and it will be used in the URL to view the category. Entry must be alphanumeric (No symbols)
- **Name**
  - This is the title of your category. It's the name your users will see. You may edit this however you wish.
- **Allowed to View / See Category**
  - If you wish to make this board private, you may choose which Member Groups

    - Checking this option make this board a recycle bin for messages deleted by moderators. Note: YaBB only allows a single board to have this label.
- **Mininum Age to Access**
    - Restrict access by mininum age.
- **Maxium Age to Access**
    - Restrict access by maximum age.
- **Gender Allowed Access**
    - Restrict access by gender.
- **Allowed to Start Topics**
    - Limit which Member Groups can start a new topic.
- **Allowed to Reply to Topics**
    - Limit which Member Groups are allowed to reply to topics.
- **Allowed to View Topics**
    - Limit which Member Groups are allowed to view topics.
- **Allowed to Create Polls**
    - Limit which Member Groups are allowed to create polls.

Once you have filled out all the information for your new boards, scroll down to the bottom of the list and click on the button titled "Save". Your new boards will be created and opened for posting!

will be allowed to see this category. Leave this blank to allow everyone access.

- **Allow Collapse**
    - Check this box to allow your users to expand and collapse this category on the front page.

^

^

Deleting a Board

If you would like to remove a board, follow the directions above to access your board management page. In the list of boards, you will notice a check box that corresponds to each title. Check this box for each and every board you wish to remove. Once selected, scroll to the bottom of the board listings and locate the set of radio buttons titled "With Selected:". Click on the radio labeled "Remove" then press the button to the right titled "Go".

A small popup will ask you to confirm that you want to remove these boards. Click "OK" to remove them or "Cancel" to keep them.

^

Editing a Board

If you need to make changes to any of the boards you have created, simply follow the directions above to access your board management section. In the list of boards, you will notice a check box that corresponds to each title. Check this box for each and every board you wish to edit. Once selected, scroll to the bottom of the board listings and locate the set of radio buttons titled "With Selected:". Click on the radio labeled "Edit" then press the button to the right titled "Go".

On this new page, you will be given a large set of options for each of the boards you are editing:

- **Board ID**
  - This cannot be changed.
- **Name**
  - This is what your users will see. You may enter anything you wish here.
- **Description**
  - Describe this board so your users will know what the subject/ topic will be.
- **Moderators**
  - Enter the username of the members you wish to give Moderator access (seperate with commas).
- **Category**
  - Choose which category you would like this board to be a part of.
- **Board Picture**
  - Here you can assign a small picture to represent this board.
- **Zero Post Count Board?**
  - Check this box if you would like to prevent posts made in this board from increasing users' post counts.
- **Show to All?**
  - Checking this option will ensure the board is shown to all able to view the Board Index even if they are

not allowed access to the board.

- **Allow Attachments**
  - Checking this option will enable users to attach files to their posts.
- **Global Announcements**
  - Checking this option will ensure the messages in this board are shown as important on top of every board. No matter how the permissions are set, only Administrators and Global Moderators can start new topics or reply. Note: YaBB only allows a single board to have this label.
- **Recycle Bin**
  - Checking this option make this board a recycle bin for messages deleted by moderators. Note: YaBB only allows a single board to have this label.
- **Mininum Age to Access**
  - Restrict access by mininum age.
- **Maxium Age to Access**
  - Restrict access by maximum age.
- **Gender Allowed Access**
  - Restrict access by gender.
- **Allowed to Start Topics**
  - Limit which Member Groups

can start a new topic.

- **Allowed to Reply to Topics**
  - Limit which Member Groups are allowed to reply to topics.
- **Allowed to View Topics**
  - Limit which Member Groups are allowed to view topics.
- **Allowed to Create Polls**
  - Limit which Member Groups are allowed to create polls.

Once you have made your changes, scroll down to the bottom of the list and click on the button titled "Save".

^

Manage Members

Accessing Member Controls

Since YaBB is built to encourage and facilitate an active community of users, it comes with several tools to assist administrators in the management of members. To access these controls, ensure you are logged in as an Administrator and enter your

"Admin Center". Once inside, look for the 6th section down on the sidebar titled "Member Controls".

^

Manually Add Member

It may become necessary from time to time for an administrator to manually create a new member account. For example, this can often be useful to help those with a disability become a member.

From your Member Controls section on the Admin Center sidebar, click on the very first link titled "Add Member". This new page will give you a simple registration form that will allow you to add a member without having to logout. Simply fill out this form with the new member's username, password and email.

^

Banning Members

Unfortunately, users are not always filled with the great sense of community that YaBB provides. These users can become rude, break rules, harass other members, or even spam your board. This is why YaBB gives you the ability to block these troublemakers from disturbing your board. To begin banning a member, access your Admin Center and find "Member Controls" as described above. Find the link titled "Ban Members" and click on it. This new page will give you three methods for banning a member: by IP address, email and username.

IP Address
Banning by IP address will prevent anyone from accessing

your board if their IP address is listed here. While effective, this could prevent a legitimate user from logging on. It may also fail if the user is behind a proxy or has a dynamic IP. To enter a specific IP address, enter all four octets of the users IP address (example: 192.168.255.8). You may also use wildcards to block a range of IP addresses by only entering in the first few octets of the address (example: 192.168.). Enter only 1 IP address per line.

Email Address
The second method allows you to prevent anyone using a specific email address (example: bad@user.com) from registering or logging in. Enter only 1 email address per line.

Username
Finally, the

simplest way to ban a user is by their username. Enter only 1 username per line.

^

Member Groups

Member Groups give you the ability to assign a group or classification to a member. These groups can then be used to grant special privileges and/ or access to your forum or simply be used for the fun of it. If you would like to create a group, enter your Admin Center and find the section titled "Member Controls" as described above then click on the link "Member Groups".

This new page will then show you the three group types. The first are system/static groups. These can be renamed by clicking on the "edit" button for each entry, however, because of their importance, they cannot be removed. The second are "Post independent Member Groups" and are assigned to a member by an Administrator or Global Moderator as they are not tied to a user's post count. The third and final group, however, is based on how many posts a user has. YaBB will automatically assign these when a user reaches the listed number of posts.

To create a new Member Group, click on the link titled "Add Group" next to either "Post Independent" or "Post Dependent" Member Groups. This will bring up a new page with a form to add new groups.

Name: This is the name that will be shown to

everyone.
# of Stars: How many stars should this group have?
Star Type: Choose a default star type from the drop down box, or enter the path to a different one.
Color: This gives the displayed name of a group member a special color treatment. Leave blank for no color.
Post Independent Group: Should this group not be assigned based on post count?
Post Dependent Group Should this group be assigned based on post count, and how many posts should be required?

^

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(Moderator: Chris)

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Forum upgrade (Read 269 times)

Chris
YaBB Administrator

Posts: 51

Forum upgrade
28.02.2006 at 13:19:53

The forum has been upgraded to YaBB version 2. If you find any problems please let me know.

Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

Email WWW

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(Moderator: Chris)

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Powerultrasonics Forum » YaBB 2 powered!

YaBB discussion forum (bulletin board) (Read 397 times)

Chris
YaBB Administrator

Posts: 51

YaBB discussion forum (bulletin board)
12.10.2004 at 22:33:52

A bit obvious, since you're here reading it, but the other main development to the powerultrasonics site this week is this bulletin board. I should have done this years ago!

A big thank you to the kind folks at YaBB for producing such a great package in my favourite language (perl) and **letting the world use it for free!**

The quality of open source software now is just amazing. Have you seen Firefox?!

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(Moderator: Chris)

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Sonotrode calculator (Read 386 times)

Chris
YaBB Administrator

Posts: 51

Sonotrode calculator
12.10.2004 at 22:18:55

As a part of the ongoing upgrade to the powerultrasonics site I've just put up a new **Sonotrode Calculator**

This version (0.1!) only does a few simple calculations - sound velocity, tuned lengths and resonant frequency for stepped sonotrodes and rods (both of which have a tuned length of half a wavelength, ignoring the slight effects of diameter). Graphs of amplitude and stress distribution along the length are also given.

So there's plenty of room for development - I'm thinking animation, exponential sonotrodes, radial and torsional modes and a few other things, but I'm open to suggestions...

In hopes of getting some response to this I've opened up a separate board, so if you've got any ideas or requests please post them here

- Thanks.

It is an important and popular fact that things are not always as they seem. - Douglas Adams

Email WWW

IP Logged

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As a part of the ongoing upgrade to the powerultrasonics site I've just put up a new **Sonotrode Calculator**

This version (0.1!) only does a few simple calculations - sound velocity, tuned lengths and resonant frequency for stepped sonotrodes and rods (both of which have a tuned length of half a wavelength, ignoring the slight effects of diameter). Graphs of amplitude and stress distribution along the length are also given.

So there's plenty of room for development - I'm thinking animation, exponential sonotrodes, radial and torsional modes and a few other things, but I'm open to suggestions...

In hopes of getting some response to this I've opened up a separate board, so if you've got any ideas or requests please post them here

- Thanks.

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Powerultrasonics Forum

http://www.powerultrasonics.com/cgi-yabb/YaBB.pl

General >> News >> Forum upgrade

http://www.powerultrasonics.com/cgi-yabb/YaBB.pl?num=1141132793

Message started by Chris on 28.02.2006 at 13:19:53

Title: **Forum upgrade**
Post by **Chris** on **28.02.2006 at 13:19:53**

The forum has been upgraded to YaBB version 2. If you find any problems please let me know.

Chris

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Powerultrasonics Forum » General » Questions

(Moderator: Chris)

Any questions about ultrasonics technology and equipment?

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		Subject	Started by	Replies	Views	Last post
		Changing transducers	Raj	1	426	11.12.2004 at 18:19:18 **By:** Chris
		Reg ultrasonic machining	Kiran	2	468	02.12.2004 at 20:15:49 **By:** Kiran
		Sonotrode design software	Ronald	3	639	20.11.2004 at 02:38:34 **By:** Chris

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(Moderator: Chris)

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Normal Topic
Sticky Topic
Locked Topic
Sticky Locked Topic

Global Announcement
Hot Topic (More than 10 Replies)
Very Hot Topic (More than 25 Replies)

You **can** view topics in this board.
You **can not** post replies to topics in this board.
You **can not** start new topics in this board.
You **can not** start polls in this board.

Adjusting ultrasonic horn frequencies (Read 656 times)

ros
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Adjusting ultrasonic horn frequencies
22.10.2004 at 11:15:58

I recently reworked one of my ultrasonic horns and I now need to tune its frequency. The horn is a 20 kHz solid steel horn that has a round diameter in the rear and narrows to a flat "blade" in the front. I do have access to a Dukane horn analyzer.

Can you tell me where I need to machine the horn to increase and also decrease the frequency?

Thank you.

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Chris

YaBB Administrator

Posts: 51

Re: Adjusting ultrasonic horn frequencies
Reply #1 - 22.10.2004 at 11:19:31

Hello Ros,

As a general rule you increase the frequency by removing material from either end, reduce it by removing material in the centre (that tends to be the more difficult option depending on the exact shape of the horn).

Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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ros
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Re: Adjusting ultrasonic horn frequencies
Reply #2 - 22.10.2004 at 11:21:02

Thank you.

By chance do you know of any books or other form of reference that explains this?

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Chris
YaBB Administrator

Posts: 51

Re: Adjusting ultrasonic horn frequencies
Reply #3 - 22.10.2004 at 11:23:49

I don't know of much that's still available - one of the best simple references was an old ZVEI handbook (German Electrical Manufacturers Association).

As a result I'm aiming to put

up some more information on the powerultrasonics site soon "Horn design 101" or similar.

Can anyone else suggest currently available reference books on sonotrode design and tuning?

Chris

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(Moderator: Chris)

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(Moderator: Chris)

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(Moderator: Chris)

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Far Field weld (Read 123 times)

Myles
YaBB Newbies

Ultra-sound!

Posts: 2

Far Field weld
30.07.2006 at 02:54:25

I am just started work with a small plastic company. we are having difficulty welding a small part. The part 38mm long 19mm diamenter . Hollow section wall thickness

2mm. Around the diameter is a 4mm hole. Due to weld length we seem to be unable to achieve a satisfactory weld .Both parts are acetal.

Any ideas

Myles

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Chris

YaBB Administrator

Posts: 51

Re: Far Field weld Reply #1 - 05.08.2006 at 06:52:09

Hi Myles,

Far-field welding can be very difficult (I suspect it's more black art than science) but I'll try to suggest a few things to look at.

1. Presumably you can't change the design of the part, otherwise making it more rigid would probably help.
2. You may be able to

improve things by changing the design of the weld concentrator, as for any welding process.
3. Finally, if you're hitting a resonance of the part then a change of frequency (up or down) might help.

Sorry I can't give you any real answers. Perhaps other readers would be willing to offer other suggestions.

Regards
Chris

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Myles
YaBB Newbies

Ultra-sound!

Posts: 2

Re: Far Field weld
Reply #2 - 07.08.2006 at 20:31:40

Thanks Chris

I give will your ideas a try

Cheers
Myles

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sonochemical pollutant abatement (Read 77 times)

Isabel
YaBB Newbies

Ultra-sound!

Posts: 1

sonochemical pollutant abatement
24.07.2006 at 14:15:05

Hello all, I am a Biochemist (from Chile, South America) . Recently, I started reading about ultrasonic applications for pollutant abatement, and I am most intereseted in this technology. As I am starting to

learn, I have some doubts, the main one is the following :
I have no idea how the "Power Input" can be calculated, it always says :“by calorimetric measurement” and I see the reference:
Mason Practical
Sonochemistry 1991 Users guide to applications in chemistry
and chemical engineering .
Regretably, I have no chance of buying or borrowing this book,
it is not available here in Chile, could you please help?
If any of you has worked in the field ,
could you give some advice?
or perhaps if you have the book. Could you possibly scan those pages and send them to me??
I would be most grateful for any help

you could provide..

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Chris
YaBB Administrator

Posts: 51

Re: sonochemical pollutant abatement
Reply #1 - 24.07.2006 at 14:39:28

Hi Isabel,

I'm not a specialist in sonochemistry (or any other kind of chemistry) but isn't calorimetric measurement used quite commonly for measuring the heat generated by a chemical reaction? Essentially just an insulated container and a thermometer measuring the temperature change.

Presumably by comparing the expected heat gain / loss in a reaction without ultrasonics to the actual measurement you would know how much energy was supplied by the ultrasonics. Alternatively, provided the density and viscosity of the reagents don't change too much you could perhaps sonicate them separately to see how much energy is supplied in the absence of any chemical reaction.

On a more practical level, most ultrasonic equipment does come with a power indicator which should be good at least for an indication of the supplied power. For better accuracy you could calibrate it with calorimetric measurements on water or a non-reactive fluid of similar density and viscosity to your reagents.

Hope that helps. If you have any other questions please don't hesitate to ask.

Chris

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sonochemical pollutant abatement (Read 78 times)

Isabel
YaBB Newbies

Ultra-sound!

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Mason Practical Sonochemistry 1991 Users guide to applications in chemistry and chemical engineering .
Regretably, I have no chance of buying or borrowing this book,
it is not available here in Chile, could you please help?
If any of you has worked in the field ,
could you give some advice?
or perhaps if you have the book. Could you possibly scan those pages and send them to me??
I would be most grateful for any help

you could provide..

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YaBB Administrator

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Long time no posts (Read 65 times)

tester
YaBB Newbies

Ultra-sound!

Posts: 1

Long time no posts
14.07.2006 at 13:27:39

So, is this board still alive or what?

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Posts: 1

Long time no posts
14.07.2006 at 13:27:39

So, is this board still alive or what?

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Power calculation of ultrasonic generator (Read 443 times)

saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Power calculation of ultrasonic generator
28.05.2006 at 08:33:35

Hello Chris,

I have a doubt regarding the power calculation for an ultrasonic generator. Kindly clarify.

All ultrasonic generator manufacturers are telling the power in terms of watts. 1000W, 1500W, etc. Can you please tell how to calculate this power and what parameters are required for this? Generally for a rotating spindle in any machine, we calculate spindle power as (2*pi*N*T)/60 Watt, where N=spindle speed in RPM and T is torque in N-Meter. Like that is there any _expression for calculating the ultrasonic power?

My basic requirement is to calculate the power requirement for machining a ceramic material, whose properties area known viz. fracture toughness, etc.

Thank you in advance.

Regards
Kiran

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Chris
YaBB Administrator

Posts: 51

Re: Power calculation of ultrasonic generator
Reply #1 - 28.05.2006 at 14:29:16

Hello saikiran,

Unfortunately the answer to your question is not very straightforward. Of course normal physical relationships apply - power is work done per unit time, work is force times distance travelled but in the case of ultrasonic systems force is very rarely constant and distance travelled may also be hard to evaluate. Even taking a probe system for which the vibration amplitude is known (eg. by measuring with a proximity sensor) the movement of the workpiece may be quite different because the probe loses contact with the workpiece for much of the cycle.

The other important point to bear in mind is that the quoted power of a system is typically a maximum rated value. For the type of application you mention, very few modern systems run at constant power; instead the amplitude is (approximately) constant and power varies according to the amount of load, up to the maximum rated value. You also need to look closely at the power rating since it may also be associated with a maximum permissable time or duty cycle.

So in deciding the power rating required for an ultrasonic machining operation I would take a pragmatic approach - start with a relatively low power generator (600 to 1000W) and a probe system with a scaled-down version of your process and test different conditions to establish what works best. Some variables to test would be amplitude, tip size, applied force, whether the tip is rotated and speed of rotation etc. Testing the process under different conditions should give you an appreciation of what works and by measuring the power required for the tests you will have a good basis for calculating how to scale up to the full production speed and size.

I guess that's not the answer you were hoping for but I just don't think it's possible to provide a simple formula to tell you how much power you will need. Of course if anyone can do so I'd be most happy to be contradicted!

You don't necessarily need to purchase equipment for such trials - a manufacturer or university may be willing to undertake test work for you to obtain these answers. In fact, I might even suggest you contact another member of this forum, bahman, who's having some success drilling ceramics with equipment he made himself (see this thread on ultrasonic drilling. Since then he's sent me some great photos and videos of the drill in action which I'll be putting up on this site shortly.

Although I realize I failed to answer your question I hope I've given you something more to think about.

Regards
Chris

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #2 - 31.05.2006 at 13:57:41

Hi Chris,

Thank you for your prompt reply. I agree with your reply that there is no direct relation of power to amplitude and frequency. But In piezo.com site in FAQs section they just gave how much mechanical and electrical power we can extract from a given sheet. It must be experimentally obtained value.

I'm pasting the those answers here thinking that it may be useful for the readers of this thread.

One more doubt I've is: How the transverse movement of the piezo crystal is arrested or minimized in ultrasonic head. Any consequences?

I shall contact Bahman. But can you pls

tell how to raise an alert or attract attention of Bahman (for that matter any other member in the forum) by just replying to this mail?

Here is stuff from piezo.com

How much mechanical power can I get out of one sheet?

In theory, one standard PSI-5A sheet (1.5" x 2.5" x .0075") used as an "extender" can do .00035 joules of work on the outside world in a quasi-static cycle (i.e. a slowly executed sinusoidal cycle). When operated just under its first longitudinal resonance of 15 KHz, the theoretically available output power from the sheet would be around 5 watts. In practice it is difficult to collect more than 10% of this work. Resonant designs can be considerably more efficient.

How much electrical power can I get out of one piezo sheet in principle?

Assuming that we stretch a PSI-5A (1.5" x 2.5" x .0075") sheet to ±500 microstrains quasistatically at a frequency just below its fundamental longitudinal resonance of 15 KHz, and that we collect 100% of the stored electrical energy at its height twice per cycle we would get approximately 9 watts of electrical power from the sheet. The mechanical energy input under these assumptions would be in excess of 100 watts. Resonant designs can be considerably more efficient. However, the mechanical apparatus for achieving the above mentioned 15 KHz high strain excitation is not available, and there is no known electronic method for extracting 100% of the available energy.

Kiran

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #3 - 31.05.2006 at 14:01:54

Hi Chris,

I noticed that in one of the threads in this forum, you've replied to a person designing a ultrasonic cleaning equipment that instead of his chosen 12V 70W generator, it would be better to start with 600 or 700 W.

Can you tell how you arrived at such rough value? Is it due to experience or some calculation?

Regards
Kiran

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Chris
YaBB Administrator

Posts: 51

Re: Power calculation of ultrasonic generator
Reply #4 - 31.05.2006 at 14:47:50

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> But In piezo. com site in FAQs section they just gave how much mechanical and electrical power we can extract from a given sheet. It must be experimentally obtained value.

Thanks for the info. To me that looks more like a theoretical value but in any case it's not the answer to the question I thought you were asking... Power ultrasonic transducers are capable of delivering typically between 1 and 3 kW at 20kHz, but even if, for example, a 3kW transducer is driven by a 3kW generator you still cannot know how much power will be delivered without defining the working conditions. The power required to drive the transducer and booster / sonotrode is quite low, perhaps 50W or less, and under no load that is how much power the generator will deliver. As the load increases, generator power increases to match.

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> One more doubt I've is: How the transverse movement of the piezo crystal is arrested or minimized in ultrasonic head. Any consequences?

The piezo-ceramic disks are designed to expand and contract in the direction of the transducer axis.

Sure there is also transverse movement, as with all elastic materials, but provided the diameter is small enough to avoid resonances in the radial direction it's not an issue (this is really the limiting factor on the maximum diameter of a transducer).

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> I shall contact Bahman. But can you pls tell how to raise an alert or attract attention of Bahman (for that matter any other member in the forum) by just replying to this mail?

As a general rule to contact another member of a forum you can send a private message and he should find it on his next visit. In this case I will also be putting up some images he sent so the credit on that page may also give you an idea of where to find him!

Quote from saikiran on 31.05.2006 at 14:01:54:

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Are you referring to this thread? If so I think you misunderstood it - the existing system featured 12 transducers of 50W each (600 W total) and the aim was to replace all of them with a single transducer of 600W. If you meant a different thread please give me a link so I can remember what I was talking about!

Chris

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #5 - 03.06.2006 at 12:21:20

Thank you Chris. The thread I was referring to is by Jurag. Your reply is as given below. Of course, it seems you have given that power value out of your experience.

I'd suggest the best equipment to start with would be a probe-type ultrasonic system with a high gain and a small tip. This will give you high amplitude on a small area and so a high energy density - ie. lots of energy concentrated into a very small volume of water. Typical "sonicator" type systems working at 20-30kHz, 500-1000W would be suitable.

Another thread where you could roughly predict the power suitability is :

Hi Shon,

Sorry but as a mere mechanical engineer my knowledge of the electronics is very limited. 600V for cleaning equipment sounds about right though (considerably higher for welding systems).

......

This question is just for clarification. However, I understood that there is no direct relation for power in terms of freq. and amplitude.

Thank you once again.

Regards
Kiran

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(Moderator: Chris)

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

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Posts: 51

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YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #2 - 31.05.2006 at 13:57:41

Hi Chris,

Thank you for your prompt reply. I agree with your reply that there is no direct relation of power to amplitude and frequency. But In piezo.com site in FAQs section they just gave how much mechanical and electrical power we can extract from a given sheet. It must be experimentally obtained value.

I'm pasting the those answers here thinking that it may be useful for the readers of this thread.

One more doubt I've is: How the transverse movement of the piezo crystal is arrested or minimized in ultrasonic head. Any consequences?

I shall contact Bahman. But can you pls

tell how to raise an alert or attract attention of Bahman (for that matter any other member in the forum) by just replying to this mail?

Here is stuff from piezo.com

How much mechanical power can I get out of one sheet?

In theory, one standard PSI-5A sheet (1.5" x 2.5" x .0075") used as an "extender" can do .00035 joules of work on the outside world in a quasi-static cycle (i.e. a slowly executed sinusoidal cycle). When operated just under its first longitudinal resonance of 15 KHz, the theoretically available output power from the sheet would be around 5 watts. In practice it is difficult to collect more than 10% of this work. Resonant designs can be considerably more efficient.

How much electrical power can I get out of one piezo sheet in principle?

Assuming that we stretch a PSI-5A (1.5" x 2.5" x .0075") sheet to ±500 microstrains quasistatically at a frequency just below its fundamental longitudinal resonance of 15 KHz, and that we collect 100% of the stored electrical energy at its height twice per cycle we would get approximately 9 watts of electrical power from the sheet. The mechanical energy input under these assumptions would be in excess of 100 watts. Resonant designs can be considerably more efficient. However, the mechanical apparatus for achieving the above mentioned 15 KHz high strain excitation is not available, and there is no known electronic method for extracting 100% of the available energy.

Kiran

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #3 - 31.05.2006 at 14:01:54

Hi Chris,

I noticed that in one of the threads in this forum, you've replied to a person designing a ultrasonic cleaning equipment that instead of his chosen 12V 70W generator, it would be better to start with 600 or 700 W.

Can you tell how you arrived at such rough value? Is it due to experience or some calculation?

Regards
Kiran

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Chris
YaBB Administrator

Posts: 51

Re: Power calculation of ultrasonic generator
Reply #4 - 31.05.2006 at 14:47:50

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> But In piezo.com site in FAQs section they just gave how much mechanical and electrical power we can extract from a given sheet. It must be experimentally obtained value.

Thanks for the info. To me that looks more like a theoretical value but in any case it's not the answer to the question I thought you were asking... Power ultrasonic transducers are capable of delivering typically between 1 and 3 kW at 20kHz, but even if, for example, a 3kW transducer is driven by a 3kW generator you still cannot know how much power will be delivered without defining the working conditions. The power required to drive the transducer and booster / sonotrode is quite low, perhaps 50W or less, and under no load that is how much power the generator will deliver. As the load increases, generator power increases to match.

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> One more doubt I've is: How the transverse movement of the piezo crystal is arrested or minimized in ultrasonic head. Any consequences?

The piezo-ceramic disks are designed to expand and contract in the direction of the transducer axis.

Sure there is also transverse movement, as with all elastic materials, but provided the diameter is small enough to avoid resonances in the radial direction it's not an issue (this is really the limiting factor on the maximum diameter of a transducer).

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> I shall contact Bahman. But can you pls tell how to raise an alert or attract attention of Bahman (for that matter any other member in the forum) by just replying to this mail?

As a general rule to contact another member of a forum you can send a private message and he should find it on his next visit. In this case I will also be putting up some images he sent so the credit on that page may also give you an idea of where to find him!

Quote from saikiran **on 31.05.2006 at 14:01:54:**

> I noticed that in one of the threads in this forum, you've replied to a person designing a ultrasonic cleaning equipment that instead of his chosen 12V 70W generator, it would be better to start with 600 or 700 W. Can you tell how you arrived at such rough value? Is it due to experience or some calculation?

Are you referring to this thread? If so I think you misunderstood it - the existing system featured 12 transducers of 50W each (600 W total) and the aim was to replace all of them with a single transducer of 600W. If you meant a different thread please give me a link so I can remember what I was talking about!

Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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saikiran
YaBB Newbies

Ultra-sound!

Posts: 4

Re: Power calculation of ultrasonic generator
Reply #5 - 03.06.2006 at 12:21:20

Thank you Chris. The thread I was referring to is by Jurag. Your reply is as given below. Of course, it seems you have given that power value out of your experience.

I'd suggest the best equipment to start with would be a probe-type ultrasonic system with a high gain and a small tip. This will give you high amplitude on a small area and so a high energy density - ie. lots of energy concentrated into a very small volume of water. Typical "sonicator" type systems working at 20-30kHz, 500-1000W would be suitable.

Another thread where you could roughly predict the power suitability is :

Hi Shon,

Sorry but as a mere mechanical engineer my knowledge of the electronics is very limited. 600V for cleaning equipment sounds about right though (considerably higher for welding systems).

......

This question is just for clarification. However, I understood that there is no direct relation for power in terms of freq. and amplitude.

Thank you once again.

Regards
Kiran

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Good News!! ultrasonic assised drilling (Read 278 times)

bahman

YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Good News!! ultrasonic assised drilling

14.04.2006 at 09:19:51

Hi Chris
As you remember, I sent an email near 5 month ago about Ultrasonic Drilling. The good news is I made it and tested it this week!!
It works like hell.
I finished Ansys analysis near 2 month ago.

It took almost a month to learn how to work with the software and after another month I succeeded in running the first analysis. At first I used stepped horn on analysis but I couldn’t reach 20KHz resonance frequency with it (Because of the addition of drill and stud screws and the size of either ends) So I designed a new horn type!! I mixed conical and stepped horn together!! After that I reached the 20 KHz resonance frequency with very good stress safety factor (about 3.5) . Then I started to make the horn (I used AL7075 as the horn material). This Monday after I assembled all acoustic head's parts together, I used Network Analyzer device to check what the resonance frequency of whole system is. The answer was unbelievable! It was exactly the same as the Ansys analysis. I must say that resonance frequency is directly related with the length of the drill and how much its out of the horn. I came to this conclusion with both Ansys analysis and Network Analyzer device. I strongly recommend Ansys modal analysis for designing acoustic head's parts. The horn which I used is very complicated. It is designed to install drill on it and 4 stud screws will be fasten on it. I simulated the exact horn with Ansys and the result was accurate. That day I did a test on brick, stone and ceramic, results were unbelievable. It drills every hard material with out adding any pressure to the system, with very simple HSS drill and you know I didn't rotate the drill!! Actually I haven't tested it on any metal yet (My thesis subject is Ultrasonic Assisted Drilling on Aviator Alloys, such as Inconel.) Fortunately nothing happened to the drill and it's own resonance wasn't near the system resonance. (you were concerned about this matter)

I recorded the tests with my camera and I also took some photos. If you want I can send them to you. (Just tell me for which address should I send them to)
I must thank you very much because I learned a lot from your website. I just have one request from you. Could you possibly make the FEA chapter of your thesis available online? It will be very useful for all of us.

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Chris

YaBB Administrator

Posts: 51

Re: Good News!! ultrasonic assised drilling
Reply #1 - 14.04.2006 at 14:16:43

Hi Bahman,

Thanks for the update - that's terrific!

It's good that you went ahead with the full FEA analysis. Yes, it does take a lot of work to get to the stage where you can get useful results but when you get there it's worth it! Ansys gave me some excellent results too, despite the limitations on model size imposed by the low-powered computers available to me at the time.

I'm not surprised you're getting good results with hard, brittle materials - those are normally the ideal for ultrasonic drilling. It will be interesting to see how it works on metals.

Perhaps you'll get more of the ultrasonic machining effects as seen on lathe tools.

I'd love to see the pictures. Not sure if you wanted my mail or e-mail address but you can find both on the contact page on this site. I would also like to be able to show them somewhere on this site with your permission - if you do send something please let me know whether this would be ok and what attribution you would prefer.

On the thesis, I do have a full copy available online for download. The aim is to offer this free to researchers / students or at a small charge to commercial

organisations - one more job that I never quite seem to get to...
Anyway if you'd like a copy please contact me privately via PM or e-mail and I'll send you a login.

Thanks again for the good news. I hope you'll be back again with more as your research progresses.

Regards
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Good News!! ultrasonic assised drilling (Read 279 times)

bahman
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

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how to start (Read 358 times)

kadora
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

how to start
27.02.2006 at 23:29:06

Sir,I am new on this board,new in ultrasonic art and I am interested in water cavitation. I would like to perform some experiments with water heating by cavitation on my own. I have read a lot of

articles on internet about ultrasonic principles and aplications and I have got so many informations that I am completly confused now. Reason why I need some help is that I dont know where and how to start.
My questions-
1,
How powerful transducer I need to create cavitation bubbles.
2,
Which kind of booster and sonorode is the most suitable for this job.
3,
How depend feeding power and frequency on the size of cavitation bubbles.

Thank you for your answer.

best wishes from Slovakia
--- juraj

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Chris
YaBB Administrator

Posts: 51

Re: how to start
Reply #1 - 28.02.2006 at 22:54:22

Hello Juraj, welcome to the forum.

First, if your aim is really water heating, forget ultrasonics. There are so many easier ways to heat water (a kettle would be my first choice!)

Now, assuming you're still reading, really you should start by looking at amplitude, which relates closely to intensity, rather than frequency or power. I'd suggest the best equipment to start with would be a probe-type ultrasonic system with a high gain and a small tip. This will give you high amplitude on a small area and so a high energy density - ie. lots of energy concentrated into a very small volume of water. Typical "sonicator" type systems working at 20-30kHz, 500-1000W would be suitable.

Be aware that used in this way the probe will be subject to very high stresses and you may well break a few. If you find you don't need so much intensity then a lower gain system with a larger tip would be the safer option.

As for the size of the bubbles, that's really beyond my limited knowledge but intuitively I would think a lower frequency (giving more time for the bubbles to expand) and higher amplitude (giving greater pressure differentials) should give you larger bubbles.

Hope that helps somewhat...

Regards
Chris

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It is an important and popular fact that things are not always as they seem. - Douglas Adams

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kadora
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Re: how to start
Reply #2 - 02.03.2006 at 08:10:08

SIR ,Thank you for your answer. Glad to read your clear explanation.

Water heating is only one from my ideas which I would like to play with. Now I have to find some transducer producers to compare prices and parameters.

thank you
juraj

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ultrasonic cleaning (Read 233 times)

ewoud
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

ultrasonic cleaning
16.02.2006 at 20:56:16

I am interested in the application of ultrasonic aqueous cleaning (pre-treatment) of parts to be Ni plated. We apply barrel playting. Is it at all possible to get sufficient efficiency of the ultrasonic cleaning effect inside the perforated PP barrel?

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Chris
YaBB Administrator

Posts: 51

Re: ultrasonic cleaning Reply #1 - 24.02.2006 at 14:26:42

Hello ewoud,

This is really a question of geometry, and without dimensions of your parts it's impossible to give an informed opinion.

However (here comes the uninformed opinion!), to me a "perforated barrel" implies something where the holes are very small compared to the diameter. If this is the case then it could be a difficult job for ultrasonic cleaning - while the cleaning process is good for getting into small holes you won't necessarily get much energy passing through small holes into a central void.

Of course if one or both ends is open during cleaning then this may not be an issue. Also, if your component has relatively thin walls then the vibration energy might go through them, particularly if you can hit a resonant frequency.

All in all this is probably one to discuss with a local supplier who should be able to test your product in a cleaner, let you see the results and work with you from there.

HTH
Chris

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ultrasonic cleaning (Read 234 times)

ewoud
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

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Generators (Read 252 times)

Shon
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

Generators
24.02.2006 at 04:35:16

I am designing a generator with variable frequency and voltage; the specs for my transducer are P=50w Cs= 4nf Zm<30ohm F=44khz (cleaning transducer). I do not understand the

relationship of these specs and the fact that I keep seeing 600 volts supply for some of the circuit designs? What is the type of signal do they use positive square, negative square, square, full sine?
Thanks
shon

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Chris
YaBB Administrator

Posts: 51

Re: Generators
Reply #1 - 24.02.2006 at 14:12:20

Hi Shon,

Sorry but as a mere mechanical engineer my knowledge of the electronics is very limited. 600V for cleaning equipment sounds about right though (considerably higher for welding systems).

As for waveform my understanding is that square waves tend to be used mainly because of the electronic devices required to handle this sort of power. Obviously anything but a pure sine wave has the potential to excite harmonic modes. In the context of cleaning that could be a good thing, while for high-Q welding systems the harmonics will probably be filtered out by the mechanical properties of the system.

You might be interested in Miodrag Prokic's site www.mpi-ultrasonics.com and particularly the e-books he offers (they're way over my head!).

Maybe someone with more knowledge will provide better answers, or correct mine...

HTH
Chris

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Aphalina Ltd - Russian manufacturer (Read 440 times)

kant
YaBB Newbies

Posts: 1

Aphalina Ltd - Russian manufacturer
21.05.2005 at 08:02:33

Has anybody had recent business dealing with a Russian manufacturer of magnetostrictive transducers, Aphalina Ltd?

http://mitglied.lycos.de/aphalina/

For the last few weeks, I have been trying to contact them but their e-mail address is not in use and their telephone number is the 'wrong number'.

Are they still in business?

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ruhman
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Re: Aphalina Ltd - Russian manufacturer
Reply #1 - 23.01.2006 at 08:50:38

Yes, russian Aphalina is still exist!

That page you tryed to get http://mitglied.lycos.de/aphalina/ is old.
Our new site www.aphalina.biz will start it's work after 4th of February 2006.

You may apply directly to e-mail aruhman@km.ru

Ltd Aphalina
General director
A. Ruhman

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Re: Aphalina Ltd - Russian manufacturer
Reply #2 - 23.01.2006 at 08:53:06

Forgot,

phone number +74955002447

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Chris
YaBB Administrator

Posts: 51

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Re: Aphalina Ltd - Russian manufacturer
Reply #3 - 23.01.2006 at 13:52:48

Thanks for the information.
I look forward to seeing your new web site.

Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Ultrasonic cutting (Read 237 times)

Sergi
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

Ultrasonic cutting
12.01.2006 at 15:56:17

Congratulation for this excellent forum !!
Best wishes for 2006 !

I am working with several commercially available devices that cut materials and they have obviously distinct cutting efficiencies.
I would like

to physically characterize the devices and their cutting abilities.
I guess they differ in power, resonance frequency, micro-motion amplitude in the X, Y, and Z axes, cutting power and probably many other parameters that I even don't know about.
My question is (simple, hopefully the answer is simple as well) what to measure , how or where to measure all these parameters.
It is difficult, expensive, complexe, etc...

Best wishes to Chris and every body else
Sergi.

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Chris
YaBB Administrator

Posts: 51

Re: Ultrasonic cutting
Reply #1 - 12.01.2006 at 21:00:57

Hi Sergi,

Thanks for those kind words and best wishes for the New Year to you too!

I think you've got all the most important ultrasonics parameters there - frequency amplitude and power. No doubt you'll also be monitoring the cutting process itself (eg. force, velocity along and into the cut, quality of cut edges).

Measuring techniques:
Frequency is easy - just use a cheap digital frequency meter (I'm assuming you'll already have automatic frequency control on the generators to maintain resonance).
Power - not too difficult; there are power meters around (often built into the generators). Just be careful that you're measuring true power not volt-amps as the phase angle can be a bit variable around resonance... (understatement!)
Amplitude is the most difficult and

expensive, at least if you want accurate results. AFAIK laser interferometry would be the best option (and in some cases can measure both in-plane and out-of plane motion).
I've used a non-contact inductive sensor in the past but it was only for out-of plane motion and I think ferromagnetic materials were out.
Finally there's always the old standby - a microscope and strong light source. Not the most accurate but cheap and simple for out-of-plane motion.
Perhaps in your application you could make two sets of measurements - one looking at the edge of the blade, the other at the side.

Hope that gives you some idea where to start anyway. Please come back if you have further questions. Is there any chance that you'd be willing to share the results of your research when you're done?

Regards
Chris

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Sheffield Cavitron-Anyone Heard Of It? (Read 296 times)

Amplitude
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Sheffield Cavitron-Anyone Heard Of It?
21.12.2005 at 20:31:14

Hi Everyone, as my post title states, I'm looking for information on the Sheffield Cavitron, Ultrasonic Machining Systems.

From what I have learned from my research, these were made by The Sheffield

Corp. in Dayton, OH. To make a long story short, I found the company that bought out the Cavitron line, and they refuse to sell me anything for it.

I also found a gentlemen that had ran a Cavitron when he worked for a government agency, but he didn't respond to my requests.

So does anyone have any information on the wonderful little Cavitrons? I would L-O-V-E to get a copy of the manuals for one, or any information on them. From my research, there appears to have also been some books/publications made by Sheffield, "Machining the Unmachinable" and I think another one is "Ultrasonics for Machining".

Or has anyone ran one of these puppies before, and could relate their experiences to me?

Thanks for taking and the time to read this, and I would VERY much appreciate any help you could offer!

Thanks again!

Eric

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Chris
YaBB Administrator

Posts: 51

Re: Sheffield Cavitron-Anyone Heard Of It?
Reply #1 - 23.12.2005 at 01:23:11

Hi Eric,

That's a little before my time - I had to do some searching to even work out what it was. So for the benefit of others reading this (I think Eric knows this already), there's a good description by JimK on the Practical Machinist forum. Here's a snippet:

Quote:

> Think of a Sinker EDM for non conductive

> stuff.
>
> The surface finish and the "overcut" are determined by the abrasive size.
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> The accelerators are made with a parabolic taper and Monel Metal seems to be preferred. This shape seems to react with the frequencies at which the transducer operate and give the hammer a little more Oomph.
>
> Although they don't tell you, this is not a machine for women or men with sensitive hearing. The process is called "ultrasonic" but there are vibrations and resonances that are audable and go all the way up to low radio frequencies. The thing drove me nuts.

So, an axial-mode ultrasonic machining device using a diamond slurry along with the hammer action of an ultrasonic probe to drill through hard materials...

Eric, if the original manufacturers are unable / unwilling to help maybe a manufacturer of modern high power ultrasonic equipment would be able to give you some general information, and perhaps still be in contact with some of their retired staff who had experience of similar 60s stuff. Perhaps they're avidly reading this forum (I wish!) but alternatively you could try contacting them directly. I think Bullen Ultrasonics is in the same business and may be a neighbour of yours?

I hope you get some more useful answers from people with personal experience to share. Good luck with the project in any case. If I can help please let me know.

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Amplitude
YaBB Newbies

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Re: Sheffield Cavitron-Anyone Heard Of It?
Reply #2 - 23.12.2005 at 20:09:23

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Yep, Bullen is the one that bought out the Cavitron line, and does not want to sell me anything. I suspect that if I knew the right people there, I would be in business, but unfortanely, thats not the case.

The most frustrating part of this is where it came from they probabley have the manuals for it, (bought it new) but being a big University... well you know how that is.

Why they sold it was that the guy that knew about it/ran it got killed in a plane crash, and the guy thats in charge of the shop now knew nothing about it, so they sold it to me.

I have ran it, and boy am I excited about it!

Thanks again Chris,

for your time!

Eric

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hello sir wanted to know what is the life of a hor (Read 258 times)

VAIBHAV_INDUSTRIES
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

hello sir wanted to know what is the life of a hor
18.11.2005 at 05:54:54

hello sir,
i am into non standard bearing manufacturing, to get the cost of the bearing down i have designed a plastic retainer which hold the balls at equidistant also i have desined a capping for it so that the grease filled

in is retained without any dust moving in the groove . i did the suceessful welding of it (derlin).but the machines manufacturers say that the cost of horn designed for me is to be beared by me i am ready for it but they say they cannot exactly tell me for how many welding times will this horn be intact which is making it difficult for me to deceide the costing of final product.i would love to show u the picture of the component if possible. bearing dimenision is weld area is just (12.5 - 7.5)that is a thin rim u can say of just about 2mm in width

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Chris
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Re: hello sir wanted to know what is the life of a
Reply #1 - 18.11.2005 at 19:12:12

Hello,

Unfortunately there really is no way to tell in advance how long a horn will last. The main problem is you don't know how much amplitude will be needed to weld your component - more amplitude may give you a better quality weld but will certainly shorten the horn life.

But even if you knew the amplitude and could calculate the stresses exactly (and finite element analysis will get pretty close to this) fatigue fracture is still a rather random process. At best you'd get only a rough indication of how long the horn might last.

So I think the only real option is to make one and test it. Sorry, I know that's not the answer you wanted!

Regards
Chris

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Ultrasonic drilling (Read 263 times)

bahman
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Ultrasonic drilling
02.11.2005 at 21:32:58

Hello Chris
I'm a Ms.C student and my Thesis is about Ultrasonic drilling. Right now I want to make a stepped horn (Sonotrode). In the papers and books which I have read up to now, they all say

that the length of the horn must be half of the wave length and step must be at middle of horn (wave length/4) , I know there is also a correction coefficient that u must multiply with this length for calculating the exact dimension of the horn, and if the diameter of the horn in regard to the length of the wave is small we can forget this coefficient and put the step exactly at wave length/4. My teacher insists that I must simulate acoustic head with Ansys software and after that I must design horn related to Ansys results. I'm working on Ansys since 1 month ago. I must spend at least another month to simulate all acoustic head and horn. Then regarding to the results I can find out what must be the exact horn dimensions. I wanted to know your opinion about this matter, Is it worth spending a lot of time on simulation program to obtain horn dimension? You think there will be so much difference between software results and the simple method? (Length wave/4) I have another question!! I was thinking that if the drill tip contacts the part, part and fixture will be joined to system and we will loose a lot of power

and .... I'm not sure that I'm right about this matter, but I'm sure that there must be an optimum position for drill tip (I mean drill length) that at that length the system has little loss and works better.
Are you familiar with this matter??

Best regards
Bahman

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Chris
YaBB Administrator

Posts: 51

Re: Ultrasonic drilling
Reply #1 - 02.11.2005 at 22:46:08

Hi Bahman,

For a simple stepped horn design I would tend to agree with you that FEA is unnecessary, but I think there are three other things to consider here:

1. Your teacher may

feel that using Ansys to verify the design is important as a way of training you to handle more complex designs (where simple wavelength / 4 will not work) or simply as a way to give you real experience using FEA software.

2. When you start to consider the effect of the drill on the horn you may find that the design isn't so simple after all:

Will the drill be another tuned length? If so then it shouldn't affect the resonant frequency of the horn. If not (a more likely scenario) then it will act like a dead weight on the end of the horn, changing the resonant frequency.

But by how much? As a rough guide you might want to shorten the horn tip so as to remove mass equal to that of the drill but I wouldn't rely on that being accurate in all situations.

A good Ansys model would allow you to add the drill and see the results for yourself.

3. Finally, and perhaps most important, I'm guessing a fairly standard drill with a relatively small diameter compared to its length. Quite apart from its effect on the horn resonance a drill like this may have several interesting resonances of its own - mainly bending

modes that would be very hard to predict accurately without FEA.

If one of these resonances appears close to the frequency you're using then you can expect some interesting effects (I'm imagining very little drilling and lots of broken drills!).

Anyway, best of luck with your project, whichever way you decide to go - it's good to see students working in this field and asking good specific questions. If you have more feel free to ask again, or just come back and give us a progress report.

Regards
Chris

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Ultrasonic drilling (Read 264 times)

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and .... I'm not sure that I'm right about this matter, but I'm sure that there must be an optimum position for drill tip (I mean drill length) that at that length the system has little loss and works better. Are you familiar with this matter??

Best regards
Bahman

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Chris
YaBB Administrator

Posts: 51

Re: Ultrasonic drilling Reply #1 - 02.11.2005 at 22:46:08

Hi Bahman,

For a simple stepped horn design I would tend to agree with you that FEA is unnecessary, but I think there are three other things to consider here:

1. Your teacher may

feel that using Ansys to verify the design is important as a way of training you to handle more complex designs (where simple wavelength / 4 will not work) or simply as a way to give you real experience using FEA software.

2. When you start to consider the effect of the drill on the horn you may find that the design isn't so simple after all:

Will the drill be another tuned length? If so then it shouldn't affect the resonant frequency of the horn. If not (a more likely scenario) then it will act like a dead weight on the end of the horn, changing the resonant frequency.

But by how much? As a rough guide you might want to shorten the horn tip so as to remove mass equal to that of the drill but I wouldn't rely on that being accurate in all situations.

A good Ansys model would allow you to add the drill and see the results for yourself.

3. Finally, and perhaps most important, I'm guessing a fairly standard drill with a relatively small diameter compared to its length. Quite apart from its effect on the horn resonance a drill like this may have several interesting resonances of its own - mainly bending

modes that would be very hard to predict accurately without FEA.

If one of these resonances appears close to the frequency you're using then you can expect some interesting effects (I'm imagining very little drilling and lots of broken drills!).

Anyway, best of luck with your project, whichever way you decide to go - it's good to see students working in this field and asking good specific questions. If you have more feel free to ask again, or just come back and give us a progress report.

Regards
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Develop Ultrasonic Plastic Welder (Read 346 times)

j_shirazi
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

Develop Ultrasonic Plastic Welder
15.08.2005 at 10:39:18

Dear Readers,

I need to develop my own plastic welding system but i am new to this field.

I want to build 2000Watts 20 KHz Plastic welding system, I think I should have the followings for start:

1- Ultrasonic Generator (I want found more sources.)
2- Ultrasonic 2KWatt 20 KHz transducer (Like 5020-6PS made by Master Sonic)
3- Maybe Ultrasonic Booster!!(I don't know it is Optional or not? And why we should use it?)
4- Horn (I Think it is equal to Sonotrod, Please tell me am I right?)

Please help me if you have any more information or any documents.

Best Regards
Ali

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Chris
YaBB Administrator

Posts: 51

Re: Develop Ultrasonic Plastic Welder
Reply #1 - 22.08.2005 at 02:12:46

Hi Ali, welcome to the forum.

I can't help thinking you may out of luck here - most people who know how to build plastic welding systems do it as a business, so might not want to help you (a potential competitor) to develop your own...

Perhaps you could start by purchasing a system and learning how to use it and apply ultrasonics to different welding processes. The suppliers database will give you some contacts to start with.

As to your other questions:
3. In all ultrasonic

systems a booster is used to change the output amplitude to suit the needs of horn and process. In most plastic welding systems it also serves another purpose - to support the entire stack, so one is always required.
4. Yes, horn and sonotrode are the same thing - the ultrasonic tool that contacts the workpiece. 'Horn' is generally used in the USA while 'sonotrode' is more common in Europe.

Good luck with your endeavours!
Chris

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Boss cracking after insert welding (Read 344 times)

alban
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Boss cracking after insert welding
10.08.2005 at 02:49:34

For mobile handset , we weld nut insert to the plastic panel for assembling the top and bottom panels. The OD of the insert is 2.45 mm and the boss ID is 2.2 mm.The machine used is of 20 khz (2000 W). after welding the bosses are developing horizontal cracks (across the boss) inside.Can somebody give advice?

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Chris
YaBB Administrator

Posts: 51

Re: Boss cracking after insert welding
Reply #1 - 10.08.2005 at 20:35:50

Hi Alban,

You really need a plastic welding expert for this one - can you ask your equipment supplier?

With my limited knowledge of the subject two thoughts come to mind:
1. If the direction of the cracks is always consistent, this could be caused by distortion

of the panel during welding (so that returning to its old shape it stresses the boss). How well does your support match the shape of the panel - could you improve this?
2. The parts seem quite small for a 20kHz system - you might get more control over the weld process at a higher frequency.

Hope that helps.
Chris

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alban
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Re: Boss cracking after insert welding
Reply #2 - 11.08.2005 at 10:26:19

Hi Chris,
Thank you for the advice.We are also on the same line of changing the machine to 40k.Pleas give some info on the testing of the welding strength of nutinserts and some benchmarks..
Thanks,
Alban

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Chris
YaBB Administrator

Posts: 51

Re: Boss cracking after insert welding
Reply #3 - 12.08.2005 at 02:52:08

Alban,

Sorry, can't help you with strength figures - as I said it's not really my field. But for that kind of application I would think the geometry of both the insert and the hole would be critical. Can't your suppliers (either equipment or insert suppliers) give you any example data?

Regards
Chris

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U/S power cable length (Read 323 times)

sohkl66
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

U/S power cable length
25.06.2005 at 11:15:23

I have a project which needs to use long cables. The length is about 60 feet. A few cables to be prepared: U/S cable to transducer and interface cables to handling unit. I think the interface cable is not an issue since they are generally digital signal. I am not sure if the what is the maximum U/S cable length. Anyone can help?

Questions:
1. Is the U/S cable length an important? What are the effects?
2. If I want to use long U/S power cable, what should I do?

Thank you.

SohKL

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Chris
YaBB Administrator

Posts: 51

Re: U/S power cable length
Reply #1 - 30.06.2005 at 06:01:55

Hi SohKL,

There are certainly potential problems from using a long cable between generator and transducer if the electrical properties of the cable (I guess particularly capacitance) become significant in relation to the properties of the transducer.

I think up to 10 or 20 feet isn't normally a problem (at least at 20kHz). You might still be ok at 60 feet but in any case the manufacturer may be able to adjust their control system to cope. Can you ask your supplier for recommendations?

If not, well, I keep hoping someone better qualified than me might stop in here to answer difficult questions like this!

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sohkl
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 3

Re: U/S power cable length
Reply #2 - 30.06.2005 at 08:52:50

Hi, Chris.

We are trying at this length to make sure that the weld is still fine. Actual length to use is just about 30~40 feet.

After trying the 60 feet cable, the weld is OK. Might need to do more work to ensure the weld quality is maintained.

Thank you for your reply.

Regards.

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Square sonotrode (Read 380 times)

sohkl
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 3

Square sonotrode
18.06.2005 at 01:52:01

Hi.

I am very new to ultrasonics and would like to learn from you all. Thanks in advance. :)

I have an square sonotrode that was crack at the center. Is it possible to get it repaired?

If I want to make a new square sonotrode, can I just copy the shape? How about the materials. I am not sure if I can get the same material in my area! If I need to do tuning, what equipment do I need? Can I use the US generator to do the testing, any possible problem to it. I am scare of damaging the US gen coz it is very expensive (Branson 2000ea, 30Khz, 1500W).

Where can I get used US gen at 30kHz?

Thank you very much for your time.

Regards.

Sohkl

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Chris
YaBB Administrator

Posts: 51

Re: Square sonotrode
Reply #1 - 30.06.2005 at 06:32:49

Hi Sohkl, welcome to the board.

Quote:
> I have an square sonotrode that was crack at the center. Is it possible to get it repaired?

No, once it's cracked you're left with an expensive paperweight...

Quote:
> can I just copy the shape?

As long as it's a fairly simple shape with no dimensions greater than about 3/4 of its length, you can probably get away with this. If you use a high-strength aluminium or titanium alloy (whichever the original was made from) you'll probably get somewhere near the same sound velocity, which determines the dimensions.

But even then you'll probably still need to go through a tuning process - make the horn a few mm longer than the original and gradually machine down the length to achieve the correct resonant frequency. Unfortunately this really needs a specialised horn-analyser.

I doubt if you'd damage the Branson generator by testing it with an untuned horn (it ought to protect itself) but you might well get no information from it about how to tune the horn. (Disclaimer: if you do want to fit the expensive Branson generator with an untested horn then you do so entirely at your own risk!).

Because of the difficulty tuning you might consider asking a specialist to manufacture the new horn for you - most people will work from drawings or old parts to make replacements.

Quote:

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Well strange as it seems I've heard of used ultrasonic equipment being sold on Ebay... Otherwise a google search for used ultrasonic plastic welding equipment turns up a few possibilities. www.bymultrasonics.com looks like a possibility (I don't know them - just that their site came up first in that search).

Hope that helps and good luck with your project...

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I love YaBB 1G - SP1!

Posts: 3

Re: Square sonotrode
Reply #2 - 30.06.2005 at 08:33:25

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How to make 1 mm ultrasonic amplitude !? (Read 464 times)

bane
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

How to make 1 mm ultrasonic amplitude !?
01.03.2005 at 17:22:19

Hello for all !

There is one theoretical and, could be, practical problem:

If the (30 Khz/50 W) magnetostrictive ultrasonic acuator oscillate 5 microns, and we want to increase amlitude to 1000 microns with steel sonotrode amplifier, what is the best way to do it ?

Suppose the diameter stepped snotrode amplifier have diameter ratio 2:1 (max. 4x amplification). Then, we could make 4 steps section with 4 steps of the sonotrode. If the calculation : 4x5 microns=20, 4x20=80, 4x80=320, 4x320=1280 microns ! Is it possible in practice ? Is there too much stress and loss ?

It could be very nice polich tool or kind of ultrasonc drill !?

Bane

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Chris
YaBB Administrator

Posts: 51

Re: How to make 1 mm ultrasonic amplitude !? Reply #1 - 02.03.2005 at 17:26:03

Hello Bane,

1 mm amplitude at 30kHz - now that would be something to see!

Sadly I don't think it's possible with current materials. There could be some way to get around the power losses (ie. supply much more power than the 50W you mention!) but stress is unavoidable. Using the sonotrode calculator even for a straight rod I get 1338 MPa stress in aluminium or 2118 MPa in titanium - enough to yield any of the regular alloys instantly (in practice much less amplitude would cause fatigue fracture in only a few cycles).

I wonder if anyone's working on metal-matrix composites for power ultrasonic applications. I remember some of the ceramic-whisker reinforced aluminium materials having fantastic strength-to-weight ratios. But of course you'd need a very good financial case for going to such exotic materials. I'd love to hear from anyone with relevant information.

Bane, thanks for bringing up the topic. Maybe one day it will happen...

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Re: How to make 1 mm ultrasonic amplitude !?
Reply #1 - 02.03.2005 at 17:26:03

Hello Bane,

1 mm amplitude at 30kHz - now that would be something to see!

Sadly I don't think it's possible with current materials. There could be some way to get around the power losses (ie. supply much more power than the 50W you mention!) but stress is unavoidable. Using the sonotrode calculator even for a straight rod I get 1338 MPa stress in aluminium or 2118 MPa in titanium - enough to yield any of the regular alloys instantly (in practice much less amplitude would cause fatigue fracture in only a few cycles).

I wonder if anyone's working on metal-matrix composites for power ultrasonic applications. I remember some of the ceramic-whisker reinforced aluminium materials having fantastic strength-to-weight ratios. But of course you'd need a very good financial case for going to such exotic materials. I'd love to hear from anyone with relevant information.

Bane, thanks for bringing up the topic. Maybe one day it will happen...

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Question about horn design (Read 508 times)

spudbone
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

Question about horn design
12.02.2005 at 23:55:08

Hello Chris and thanks for providing a place for fellow Ultrasonics enthusiasts to share information.

I am relatively new to Ultrasonics, although I have over 30 years of professional experience in audio production and audio acoustics. I have worked with what I thought was some seriously amplified systems, but they really don't compare to the power demands of transducers.

So I have two questions:

1) I recently obtained a Langevin bolt-type transducer and want to design and create a suitable clamp-on type Horn (or Sonotrode) for its 28khz frequency. I am using your calculator to determine the ideal parameters, however I am unclear whether the horn should be hollow or a solid piece. My experience with driver-loaded audio horns (ie. Public Address systems) have been open type horn designs, which are designed to throw the acoustic signal a certain distance in space.

My application is to experiment with Ultrasonic water disassociation (cavitation) during electrolyis. The clamp-on type horn would allow a convenient method of coupling to an existing electrolysis system (clamped tube diameter would be 1" in diameter) .

2) My experience with electronics makes be want to build my own power system as it needs to be portable, cost-effective and driven from a 12 volt supply. Any suggestions on what would be required to drive this 70 watt transducer? Any source for such information?

I love to study so any recommendation on books is very welcome!

Regards,
Tom

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Chris
YaBB Administrator

Posts: 51

Re: Question about horn design
Reply #1 - 15.02.2005 at 23:59:18

Hi Tom,

Thanks for your contribution to the forum (good to see some new blood here!) and sorry for the delayed response - I'm up to my neck in a server upgrade right now.

I can't help feeling that a 12V 70W transducer is not what you need for experimenting with cavitation - particularly with a clamp-on system since this inevitably gives some power losses. At 28kHz you should be able to find a transducer to give you at least 500-1000W; whether you could set up a 12V PSU for that I don't know...

If your application demands low power 12V operation (eg. for use in the field) then I'd suggest using a probe system instead of clamp-on - this would give you much more efficient transmission and higher power density.

In any case my little sonotrode calculator really isn't suitable for clamp-on systems - they're much too complicated for the simple assumptions built into that. If you haven't seen it already I'd suggest you study Miodrag Prokic's site eg. http://www.mpi-ultrasonics.com/clamp-on-sonics.html as he's the pioneer of clamp-on systems (maybe this will tempt him to comment here!)

Re: books, again apologies for the lack of updates to the books page here (so many jobs, so little time!). If you want to get into transducer design you could try the downloads on Miodrag's site (warning: VERY technical!). For sonotrode design there really isn't much available, probably the best bet is to do some experimentation for yourself either using FEA if you have access to it or just make and test - with your background you could probably rig something up to test the resonant frequency, and then tuning is a matter of machining the part down gradually until you get it's resonance right... (yes, that is oversimplifying!)

Anyway good luck with it and feel free to come back with some more specific questions or (even better) results.

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http://www.powerultrasonics.com/cgi-yabb/YaBB.pl

General >> Questions >> Far Field weld

http://www.powerultrasonics.com/cgi-yabb/YaBB.pl?num=1154224466

Message started by Myles on 30.07.2006 at 02:54:25

Title: **Far Field weld**
Post by **Myles** on **30.07.2006 at 02:54:25**

I am just started work with a small plastic company.we are having difficulty welding a small part. The part 38mm long 19mm diamenter .Hollow section wall thickness 2mm. Around the diameter is a 4mm hole. Due to weld length we seem to be unable to achieve a satisfactory weld .Both parts are acetal.

Any ideas

Myles

Title: **Re: Far Field weld**
Post by **Chris** on **05.08.2006 at 06:52:09**

Hi Myles,

Far-field welding can be very difficult (I suspect it's more black art than science) but I'll try to suggest a few things to look at.

1. Presumably you can't change the design of the part, otherwise making it more rigid would probably help.
2. You may be able to improve things by changing the design of the weld concentrator, as for any welding process.
3. Finally, if you're hitting a resonance of the part then a change of frequency (up or down) might help.

Sorry I can't give you any real answers. Perhaps other readers would be willing to offer other suggestions.

Regards
Chris

Title: **Re: Far Field weld**
Post by **Myles** on **07.08.2006 at 20:31:40**

Thanks Chris
I give will your ideas a try

Cheers
Myles

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YaBB Newbies

Ultra-sound!

Posts: 2

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gill
Ex Member

(spam deleted) 09.06.2006 at 10:21:35

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« Last Edit: 09.06.2006 at 12:37:41 by Chris »

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Ultrasonic Chocolate (Read 465 times)

Matt_Schweizer
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Ultrasonic Chocolate
24.02.2006 at 18:14:27

Hello Dr. Chris Cheers, or whomsoever else would care to comment on my culinary quandaries.

I am a chef and somewhat new to the world of ultrasonics. I am interested in the feasibility of using a sonicator as part of the chocolate making process. From what I have read thus far it seems as though ultrasonics may be able to facilitate in many aspects of chocolate production. But, to begin this discussion I would like to talk about the possibility of ultrasonic milling on a small scale.

As chocolate production is practiced now, the nibs (the inner “meat” of the cocoa bean) are ground (like coffee beans except much much finer) and transformed into a dark liquid known as cocoa liquor (cocoa liquor is comprised of 50% cocoa solids and 50% cocoa butter). The grinding of the nibs does two things:

1. It breaks open the bean cells to release the cocoa butter and

2. Breaks those cell particles down so they are

imperceptible to the tongue as “gritty”. The final particle size needs to be between 15-30 microns. in order for the finished chocolate product to have that familiar velvety mouth feel.

So, my question is, if I do an initial grinding of nibs and transform them into a chocolate liquid that has the approximate viscosity of motor oil with cocoa solids suspended in the liquid – do you think that a sonicator could break apart those cocoa solids to 15-30 microns?

I would be happy to provide more chocolate making details if necessary. For purposes of experimentation I have a sonicator XL 2020 with a ½” flat tip.

Thank you for your time.
Regards
Matt.

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Chris
YaBB Administrator

Posts: 51

Re: Ultrasonic Chocolate Reply #1 - 28.02.2006 at 22:23:39

Mmm, chocolate!

Hello Matt, welcome to the forum (and sorry for the delayed reply)

When looking at possible new applications I like to start with the physics of the current process and how it might change with ultrasonics. Thinking about a coffee grinder (the closest thing in my personal experience) a whole coffee bean hit by a blade will be cut while a tiny particle will more likely bounce off, because of its lower mass. So I suspect that the particle size would be dependent on the preipheral speed of the blades - as they move faster they will be able to cut smaller particles.

Unfortunately the speed of motion in ultrasonic devices is relatively low (tiny movement, modest speed, enormous acceleration) so I don't really see ultrasonics enhancing the conventional mechanism.

Instead, let's move on to a different mechanism - cavitation (I guess you were already thinking that way since you mention a liquid medium). There might be something in that - cavitation can do some amazing things - but I suspect in this case once again the small particles might just move around instead of breaking down. However it's easy enough to try - I'd suggest starting with a small sample and a probe with a small diameter tip to achieve maximum possible intensity.

One final thought - if the reason for the limit on particle size is that smaller particles can bounce off the blades then perhaps we should find a way to prevent them doing this - ie. provide an anvil. So then you'd be looking at a larger diameter sonotrode (perhaps the 1/2" one you already have) with a very smooth flat tip working against a solid flat surface. This would be much harder to set up, particularly pumping the liquid through the gap, but intuitively it seems like a more direct way to crush those particles...

Hope that gives you some food for thought and that you'll come back with more ideas, questions and perhaps even experimental results.

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Matt_Schweizer
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 2

Re: Ultrasonic Chocolate Reply #2 - 10.03.2006 at 21:45:13

Hello again,
Sorry about the delay in my reply, there are simply not enough hours in the day.

I have been running some experiments with ultrasonic cavitation to reduce cocoa particle size using a ½" sonotrode. Unfortunately, thus far I have met with little success. It seems as though, as you suggested, the particles are just moving around instead of breaking down.

My procedure has been this: 1) Pre-grind the nibs with low heat to release the cocoa butter and turn the mixture into a liquid. 2) Place the liquid cocoa or chocolate liquor (about 200 ml or 1 cup.) into a vile and sonicate at 20KHz.

You mentioned in your previous posting "pumping the liquid through the gap...". I have been trying to cavitate while the chocolate liquor is standing still. Should a liquid be moving in order for cavitation to take place?

Another problem I have

encountered is viscosity. Chocolate is in its least viscose state when it is warm, yet too warm and the chocolate will burn. I have in my experiments burned some samples. If you had any comments or suggestions on how to approach this viscosity problem I would love to hear them. A side note on the burnt chocolate I have produced is that it does not taste like chocolate I have burned in the kitchen when not paying enough attention. I thought this might have something to do with sonochemestry, as chocolate is quite the chemically complex substance. Is there any way to predict what volatiles will be effected and how? From the little I have read on the subject of sonochemestry, it seems as though trail and error is the only answer, as it is such a burgeoning field.

Another quick thought on that anvil idea you mentioned. Do you think that two sonotrodes running in the same sample would facilitate cavitation?

Thank you again for your time and the food for thought.

Regards.
Matt

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Chris
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Posts: 51

Re: Ultrasonic Chocolate Reply #3 - 11.03.2006 at 01:43:22

Sorry Matt, I should have explained myself better. Really I was talking about two options:

1. Straight cavitation (what you're doing now).

In this case you'd need a lot of amplitude / intensity - a fine-tip probe will give you more amplitude than your 1/2" one but perhaps it still wouldn't be enough...

Also your point about sonochemical changes is a valid one, and any such changes would be more likely / more pronounced at higher intensity. For more information on this you really need a sonochemistry specialist (and still probably trial-and-error!).

2. Crushing action with the sonotrode working against an anvil (ie. any solid flat surface).

This is entirely my speculation but intuitively seems like it could be a way to break down the particles using lower amplitude so with less chance of other chemical changes. However if you line up your probe close to a flat surface with a small gap containing liquid and turn on the ultrasonics I think you'll find that the liquid will be squeezed out rather rapidly! So then you need some way to move unprocessed liquid into the gap - hence my earlier random thoughts about pumping liquid through the gap.

Something rather similar happens in a through-flow processing unit (products like the "Flocell") but normally with a significantly larger gap for the liquid to flow through. With such a small gap you would probably need very high pressure to achieve any useful flow rate, but perhaps for such a high-value product such processing could still be viable.

Two probes placed boxer-fashion could

also also help but would give you significant extra practical problems pumping the liquid, since you'd probably need to pump through one of the sonotrodes. Otherwise I wouldn't expect much benefit from using two probes except for increased volume / reduced processing time.

Hope that makes my random thoughts a little more understandable (whether they're practical of course is another story altogether!). Please let me know how your trials go.

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2. Crushing action with the sonotrode working against an anvil (ie. any solid flat surface).

This is entirely my speculation but intuitively seems like it could be a way to break down the particles using lower amplitude so with less chance of other chemical changes. However if you line up your probe close to a flat surface with a small gap containing liquid and turn on the ultrasonics I think you'll find that the liquid will be squeezed out rather rapidly! So then you need some way to move unprocessed liquid into the gap - hence my earlier random thoughts about pumping liquid through the gap.

Something rather similar happens in a through-flow processing unit (products like the "Flocell") but normally with a significantly larger gap for the liquid to flow through. With such a small gap you would probably need very high pressure to achieve any useful flow rate, but perhaps for such a high-value product such processing could still be viable.

Two probes placed boxer-fashion could

also also help but would give you significant extra practical problems pumping the liquid, since you'd probably need to pump through one of the sonotrodes. Otherwise I wouldn't expect much benefit from using two probes except for increased volume / reduced processing time.

Hope that makes my random thoughts a little more understandable (whether they're practical of course is another story altogether!). Please let me know how your trials go.

Regards
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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Material compatabilities (Read 287 times)

cenmac
YaBB Newbies

I love YaBB 1G - SP1!

Posts: 1

Material compatabilities
07.12.2005 at 05:17:17

I have a need to join polyethelene and polyester film. They seem to be incompatable, looking for a barrier that may be compatable to both

jim

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Chris
YaBB Administrator

Posts: 51

Re: Material compatabilities
Reply #1 - 07.12.2005 at 19:33:30

Hi Jim,

Unfortunately I don't think either PE or polyester (PET / PBT) are compatible for ultrasonic welding with any materials other than themselves. This compatibilty table from Branson seems to confirm.

For thin films you may be better off looking at heat sealing anyway. Perhaps you could contact some manufacturers who offer both heat sealing and ultrasonic systems so they could give you an unbiased opinion.

HTH
Chris

It is an important and popular fact that things are not always as they seem. - Douglas Adams

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