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## **MMM ULTRASONIC STRESS RELIEF**

MMM technology in ultrasonic treatment of very big metal parts, high-tech parts, sensitive and complex metal parts, treating of biological implants, surgery, vibrothermography... (MMM = Multi-frequency, Multimode, Modulated)

**ACCELERATED ULTRASONIC STRESS RELIEF**

**ACCELERATED AGING AND PROPERTIES STABILIZATION**

**Heat Exchangers, Boilers and Pipelines preventive maintenance and real-time cleaning from deposits and scaling**

**FATIGUE LIFE TESTING**

**FAST DETECTION OF MECHANICAL DEFECTS**

**ULTRASONIC VIBROTHERMOGRAPHY**

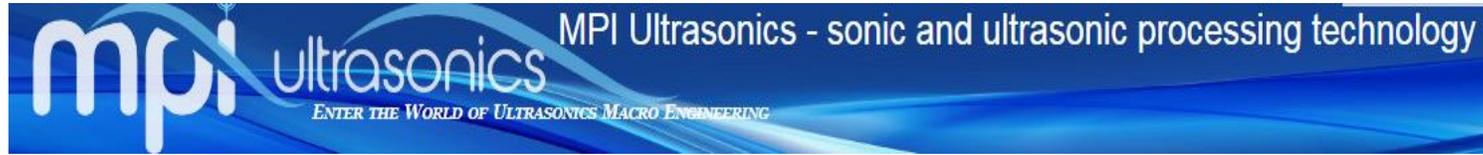
**ULTRASONIC AGITATION AND STRESS RELIEF OF VERY BIG MASSES**

**ENHANCED ULTRASONIC CLEANING & STERILLIZATION**

**ULTRASONIC DRY CLEANING**

**OPTIMIZED SURFACE COATING**

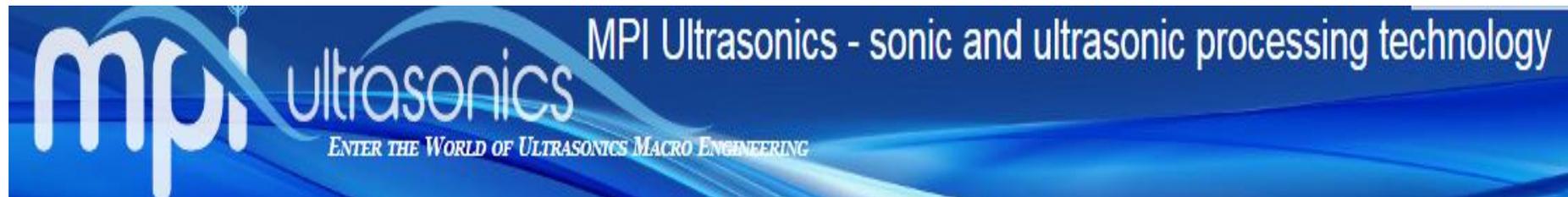
# MMM Stress Relief Applications



- **1. Stress relief by vibrating the complete very big (or small) metal parts, artificial accelerated aging and fast properties stabilization.**
- **2. Extending life-span of treated parts (longer operating life, longer fatigue life).**
- **3. Descaling and preventive, real time maintenance of Boilers, Heat Exchanges, Pipelines...**
- **4. Surface treatment under MMM vibrations: sand blasting, chemical etching, surface chemical modification, deep cleaning enabling capillary penetration of a cleaning liquid, ball peening under MMM-vibrations and deep implementation of different particles and powders in a treated metal surface.**
- **5. Vibrothermography: By uniformly vibrating certain body (using MMM vibrations), and monitoring transitional heat generation on its surface (using infrared cameras), one can notice in the areas with voids, holes, residual-stress zones, or other defects, non-uniform and increased temperature distribution.**
- **6. Stress-free quenching and hardening assisted by multi-frequency vibrations (also hardening applying ball peening).**

# MMM Stress Relief Applications

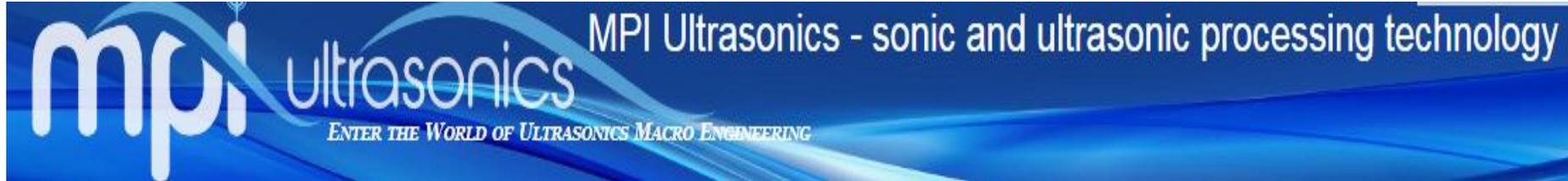
- 7. Improved coating of metal parts under vibrations: by immersion in coating liquid and/or by dry ball-peening in MMM ultrasonic chamber. Deeper coating and particles implementation realized ultrasonically. Accelerated stabilization of coating layer.
- 8. Welds treating by ultrasonically vibrating the parts: extending fatigue life of welds several times (3 to 5 times). Redistributing and minimizing stress concentration caused by welding.
- 9. Accelerated free radicals de-excitation and neutralization in cases of treating plastics and composites (applicable also in cases of coating).
- 10. Vibrations accelerated polymerization (or de-polymerization in case of applying very strong vibrations).
- 11. Ultrasonically assisted degassing and de-bubbling.
- 12. Ultrasonically improved alloying and casting. Production of homogenous biocompatible alloys.
- 13. Ultrasonically facilitated implantation and/or penetration of metal objects into biological and composite structures.
- 14. Deep penetrating cleaning applications.



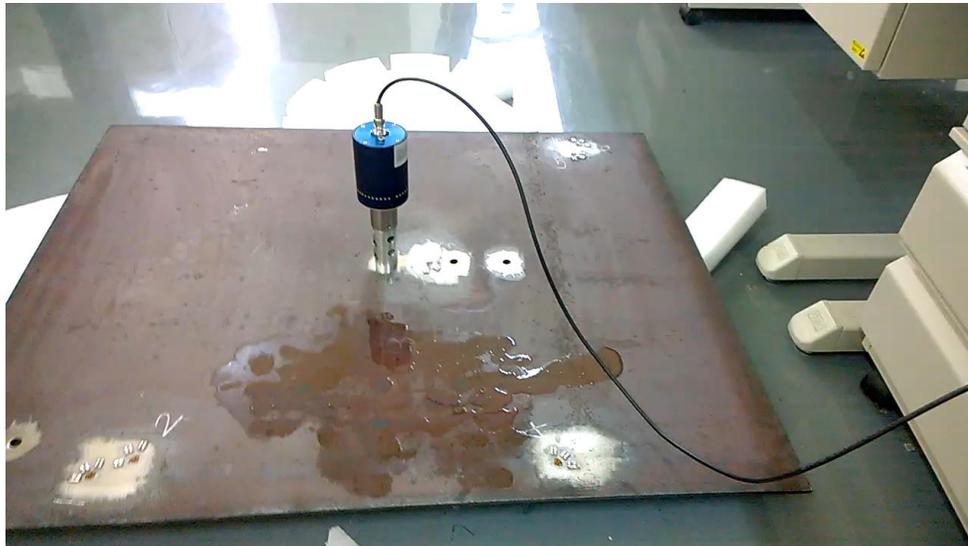
# MMM Stress Relief Applications

High Power ultrasound offers a wide range of opportunities to assist in rapid testing and surface treatment of components and assembled systems. Some examples include:

- • Accelerated 3-D Shock / Vibration test with Ultrasonic SHOT PEENING
- • Accelerated Surface Treatment with Ultrasonic SHOOT PEENING
- • Accelerated leakage and sealing test in a liquid ULTRASONIC BATH
- • Accelerated testing of humidity resistance, corrosive resistance, or salt resistance using an ULTRASONIC VAPOR chamber
- Applications: Hi-Tech, Watch-Industry, Microelectronics, Micromechanics, Military, Aerospace, Medical, Surgical Components and implants, etc.
- All of above mentioned tests and treatments could be realized in a specially designed ultrasonically vibrating chamber.



**Ultrasonic stress relief of very big and heavy metal parts and metal constructions. We can avoid heat treatment and make it fast, without spending lot of energy on thermal cycling. Very big metal parts usually cannot be treated thermally since it will be necessary to find sufficiently big ovens and spend big amount of heat energy (See movie files below; -Water on the vibrating surfaces is intentionally placed there to visualize acoustic activity and MMM vibrations. Water spray is also indirectly visualizing stress relief and descaling process).**



## MMM Ultrasonic Macro Engineering in Action



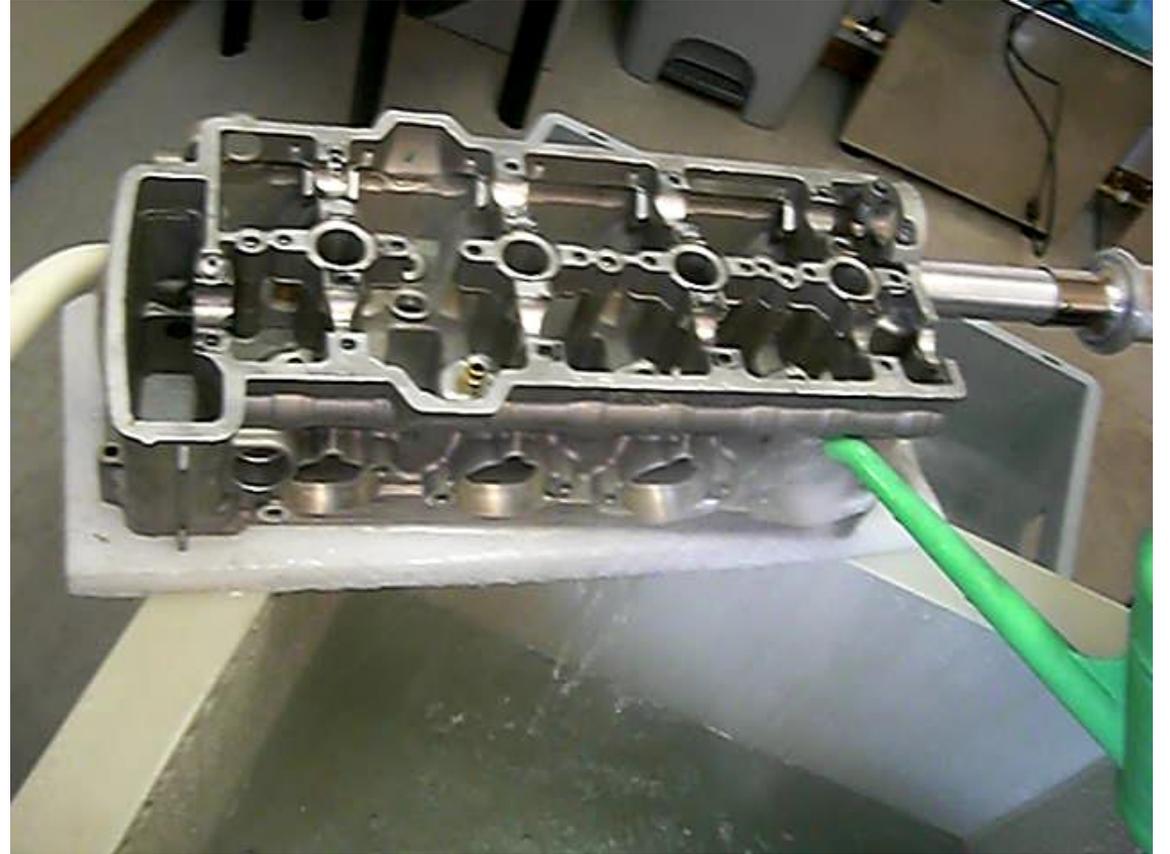
# 9 m long machine table

(for agitating very big metal parts will be necessary to use several ultrasonic MMM agitators)



# Automobile Parts Stress Relieving

(Under MMM excitation hard metal is getting «softer» and easy for cutting)



# MMM Ultrasonic stress relief of metal tubes

(see movie files below: Surface is uniformly agitated without standing waves)

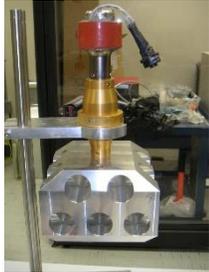


## **MMM Ultrasonic stress relief of metal tubes**

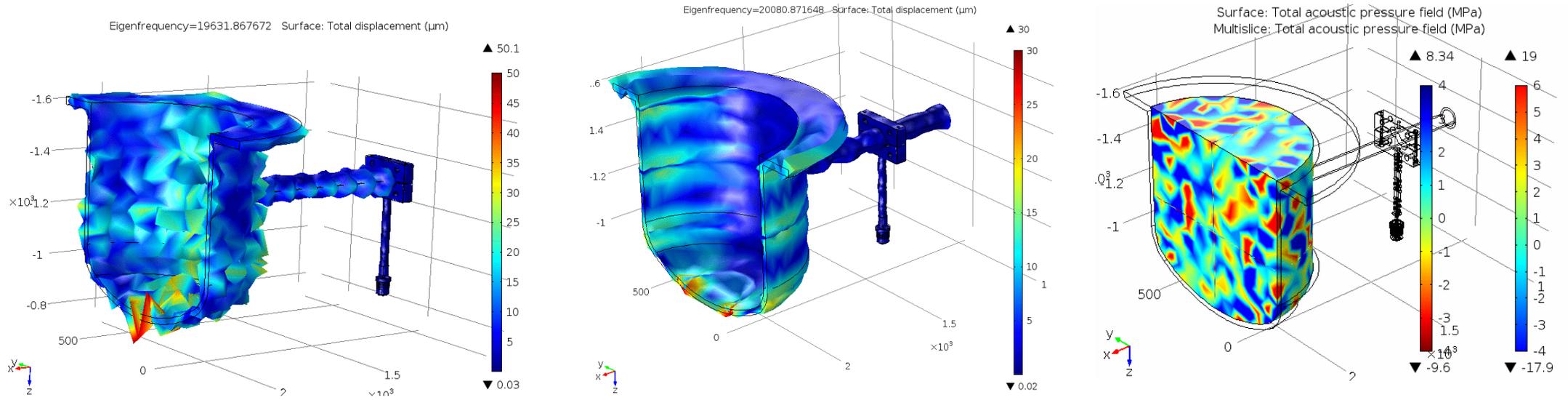
(see movie files below: Surface is uniformly agitated without standing waves)



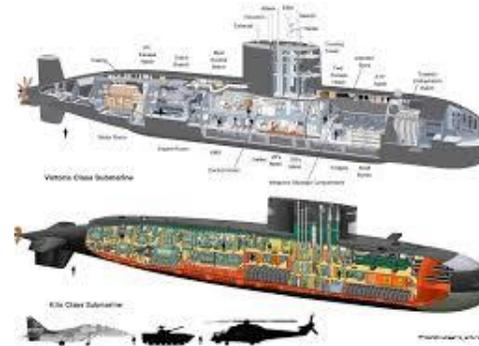
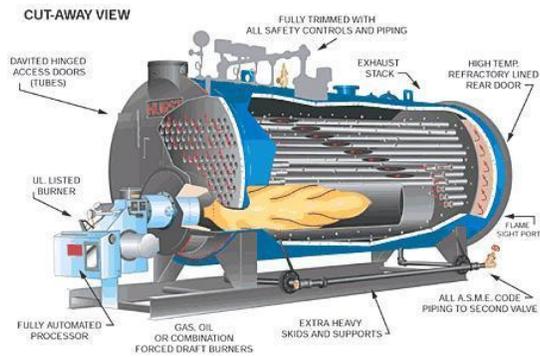
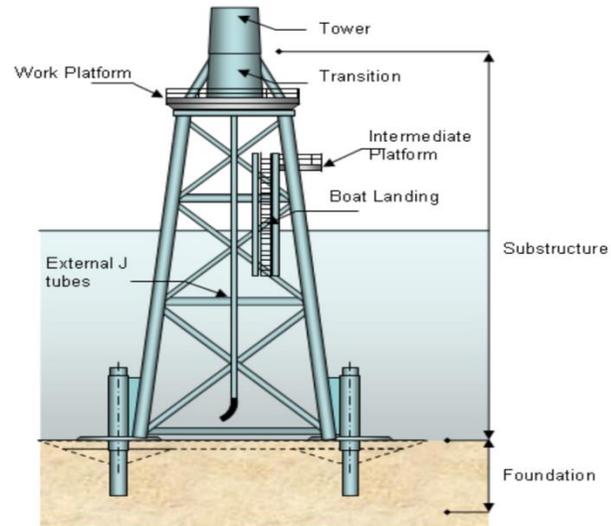
**ANYTHING CAN BE ULTRASONICALLY VIBRATED FOR REALIZING:  
Fast Stress Relieve  
Fatigue Life Extension  
Materials Processing  
Cleaning, Descaling, Cutting, Liquid Metals Agitation...**



# MMM ultrasonic agitation of big boilers, tanks, heat exchangers, reservoirs (FEA animations)



# ANYTHING CAN BE ULTRASONICALLY VIBRATED FOR: Fast Stress Relieving, Descaling, Algae, Barnacles & Biofilm removal Fatigue Life Extension...



# MMM Stress Relief Applications

## Accelerated 3-D Shock / Vibration test with Ultrasonic SHOT PEENING

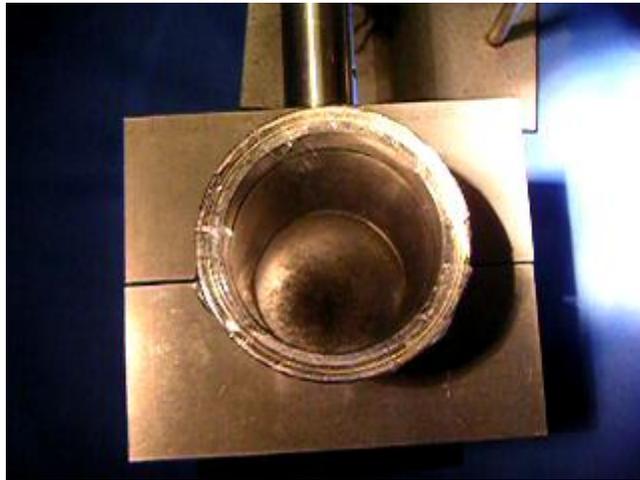
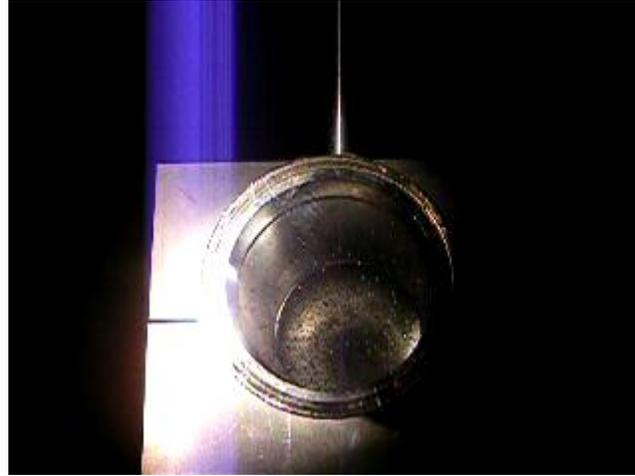
Small stainless steel balls in a specially designed ultrasonic chamber will be mechanically stimulated to impact parts placed in the chamber. The part is randomly and uniformly impacted in 3-spatial-dimensions by the steel balls with sufficient force to create a wide range of stresses. Some applications include

- Ultrasonically accelerated mechanical and structural stability testing (of Watches, Micro-systems and Hi-Tech components).
- Accelerated bolt unscrewing test (Watch industry, Micro-Systems).
- For the companies involved in the production of high tech micro-electronic and micro-mechanic components and systems it would be valuable to have a testing tools that can give rapid answer about mechanical reliability. It is possible that such mechanical bombardment is able to simulate in just minutes of testing results equivalent to several weeks or months of testing using traditional testing methods.
- This is particularly interesting in the R&D phase of new products when it is extremely profitable to have such accelerated testing possibilities. Immediate feedback about certain product resistance properties would significantly impact future exploitation and product reliability. Normally products are given to specialized testing laboratories, what usually takes weeks or months of different vibrations-testing, while the R&D team waits for positive or negative results. With accelerated testing important product and design improvements can be quickly analyzed and implemented to improve time-to-market and product reliability.
- In one implementation the piece to be tested is hanging in the middle of ultrasonic chamber. Small metal balls (introduced in the same chamber) are randomly scattering and bouncing inside of the chamber, realizing uniform 3-D bombardment of the hanging solid piece (watch case, micro-mechanical system, high-tech component...). A few minute of such treatment may correspond to more than a week of traditional 3-D vibration and shock testing.

# Accelerated Surface Hardening and Stress Release without heating using Ultrasonic SHOOT PEENING

- The shot peening process is based on the effect of introducing compressive stresses in the surface of a metal part by controlled impinging with spherical particles. By this the resistance against fatigue will be increased and therefore also the life of a part. In the space and aircraft-industries the advantages of the shot peening process are already known: the increase of the fatigue-life of critical parts without weight increase. We propose to use a specially designed ultrasonic chamber where the treated part is randomly and uniformly impacted in 3- dimensions. Some applications include:
- Watch-Industry parts, Various Micromechanics, Military Parts, Aerospace
- Parts, Medical Parts, Surgical Components and Implants
- Some of the known beneficial effects that can result due to high power peening treatment are:
  - 1. Formation of a white layer up to 10 microns in depth with exceptional corrosion resistance, abrasion resistance, and lubricity.
  - 2. Plastic deformation of the surface.
  - 3. Elimination of tensile stress and the introduction of favorable compression stress up to 12 millimeters in depth.
  - 4. Altering the surface finish resulting in a smoother surface and eliminating defects.
  - 5. Improvement in endurance and corrosion resistance. Up to 250% and 400% respectively.
- Shot peening is also used in applications where the effects of fatigue were caused by grinding, electrical discharge- and electrochemical-machining (EDM and ECM), electroplating, anodizing, thermal spraying and welding. It also can help increase resistance to fretting, galling, cavitation erosion, stress-corrosion cracking, intergranular corrosion and hydrogen-embrittlement.

# Examples of Shot Peening in Action (movies)



# Ultrasonically accelerated surface coating with multi-component powders

- Here we employ small stainless steel balls in a specially designed ultrasonic chamber that are mechanically (or ultrasonically) stimulated to impact parts placed in the chamber. In this case we also include a powder mixture that we wish to imbed into a surface of the treated part. The part is randomly and uniformly, spatially impacted by the steel balls and surrounding powders with sufficient force to allow penetration of powder particles into the surface of the bombarded part (with penetration depth until 150 micrometers).
- Powders may include: Metal powders, Ceramic powders, Polymer powders, and combinations of different powders.
- Some applications include: Watch-Industry parts, Various Micromechanics, Military Parts, Aerospace Parts, Medical Parts, Surgical Components and Implants coatings, painting and surface protection.

# **MMM Stress Relief Related Applications**

- **Accelerated Leakage & Sealing Test in a Liquid ULTRASONIC BATH:**
- An ultrasonic chamber filled with water (or some other liquid) may be used for leak testing, sealing, and corrosion resistance tests on watchcases, high-tech components, or microsystems.
- **Accelerated Humidity Resistance testing, Corrosive Resistance, and Salt atmosphere testing**
- **Resistance testing in and ULTRASONIC VAPOR:**
- An ultrasonic chamber filled with water vapor (or some other liquid vapor) may be used for humidity resistance testing, sealing, and corrosion resistance tests on watchcases, high-tech components, or microsystems.



## **Resume: MMM technology in ultrasonic treatment of high-tech parts, sensitive and complex metal parts, treating of biological implants, surgery...**

- **Applications: Stress relief, Accelerated aging, Extending life-span, Surface treatment**
- **Ultrasonic sand blasting**
- **Ultrasonic chemical etching,**
- **Shor & Ball peening**
- **Surface implementation of different particles and powders**
- **Ultrasonic quenching and hardening**
- **Ultrasonic coating Welds treating Extending fatigue life**
- **Accelerated free radicals neutralization**
- **Polymerization**
- **De-polymerization Degassing and de-bubbling. Improved alloying and casting**
- **Production of homogenous biocompatible alloys. Facilitated implantation and/or penetration**
- **Deep capillary cleaning applications.**

# **Resume: MMM technology in ultrasonic treatment of high-tech parts, sensitive and complex metal parts**

- **We can find lot of published information about ultrasonic descaling and heat exchangers... MMM structural agitation and descaling is working on a similar way, but much more efficiently and faster... (Multi-frequency, multimode, modulated ultrasonic agitation).**
- **MMM agitation is in the same time good for stress relief (without manual peening). Of course, manual peening is very efficient and excellent for stress relief method, but it is taking lot of time... and it is not elegant and comfortable as MMM structural agitation. MPI peening is very robust, and much more efficient than similar equipment from competitors...**
- **Combination between alternating magnetic field and MMM or peening agitation will certainly produce better and faster stress relief and boiler, pipelines and heat exchangers descaling...**
- **The advantage of MMM-technology applications is that we can use almost the same MMM equipment for heat exchangers preventive maintenance, descaling and continuous in-line cleaning, and for stress relief... (we only need to apply different settings on MMM ultrasonic generator software).**
- **According to published and experimental work information and experiences, also alternating magnetic field applied on pipelines and heat exchangers is effective both for descaling and stress relief (because magnetic field is producing mechanical vibrations in ferromagnetic bodies), meaning that we can combine acoustic and magnetic agitation...**
- **Applying multiple MMM agitators and enough ultrasonic power, 90% or more of a big ship's hull or even a complete drilling rig can be destressed, on a very clean, quiet, fast and elegant MMM way (instead of peening every weld and joint), and only minor ship areas can be additionally, manually treated with the peening tool... just for increased security. We can also make complementary combinations with alternating electromagnetic destressing... just to increase stress relief efficiency in zones with difficult access.**

# MMM-Patent application

(19) 	Europäisches Patentamt European Patent Office Office européen des brevets	(11)  <b>EP 1 238 715 A1</b>
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(84) Designated Contracting States: <b>AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR</b> Designated Extension States: <b>AL LT LV MK RO SI</b>	(71) Applicant: <b>Miodrag Prokic</b> <b>2400 Le Locle (CH)</b> (72) Inventor: <b>Miodrag Prokic</b> <b>2400 Le Locle (CH)</b>	

(54) **Multifrequency ultrasonic structural actuators**

(57) The propagation of ultrasonic energy in arbitrary shaped solid structures (D), heavy and very-thick-walls metal containers, pressurized reservoirs, very-thick metal-walls autoclaves, in different mechanical oscillating structures and systems... is realized using a novel ultrasonic structural, multifrequency actuator (including very particular multifrequency ultrasonic power supply, also the subject of this invention), able to initiate ringing and relaxing, multimode mechanical oscillations (harmonics and sub harmonics) in any heavy-duty, bulky and rigid system, producing pulse-repetitive, phase, frequency and amplitude-modulated bulk-wave-excitation (covering and sweeping extremely large frequency area). Such ultrasonic driving is creating uniform and homogenous distribution of acoustical activity on a surface and inside of the vibrating system, while avoiding creation of stationary and standing waves structure, making that the complete vibrating system is fully agitated. Multifrequency ultrasonic structural actuator is

ideal for agitating arbitrary distant and arbitrary shaped liquid and solid masses placed in different open or pressurized vessels, containers, autoclaves, reservoirs and pipes, transferring vibrations via wave-guide solid rod fixed between the transducer and a loading mass (where loading mass presents an oscillating body, and/or oscillating vessel, autoclave, container...). This invention presents an extension and continuation of the previous patent, originating from the same Author/Inventor (see 1 060 789 A1), explaining the additional aspects of particular electronics necessary to drive ultrasonic transducers in a multifrequency and multi-mode oscillating regime/s, while keeping high efficiency of electric and ultrasonic energy transfer and/or transformation. Fields of possible applications related to this invention are: Ultrasonic Cleaning, Welding, Material Processing, Sonochemistry, Liquid Metals treatment, Atomization, Materials Testing, Aging and Stress Release, Homogenization, Process Industry, etc.

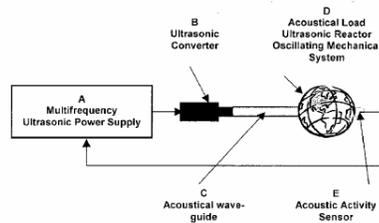


Fig. 1 Block Diagram of a Multifrequency Structural Actuator

EP 1 238 715 A1