

## Tubular Clamp-On Multifrequency Liquids & Gasses Processing Reactors

Main Web Site: <http://www.mpi-ultrasonics.com>

Download Server: <http://mastersonic.com>

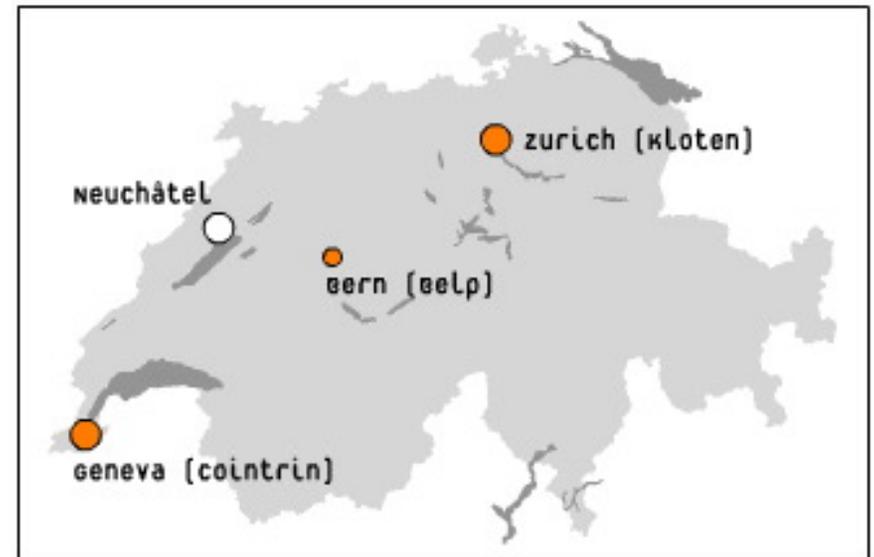
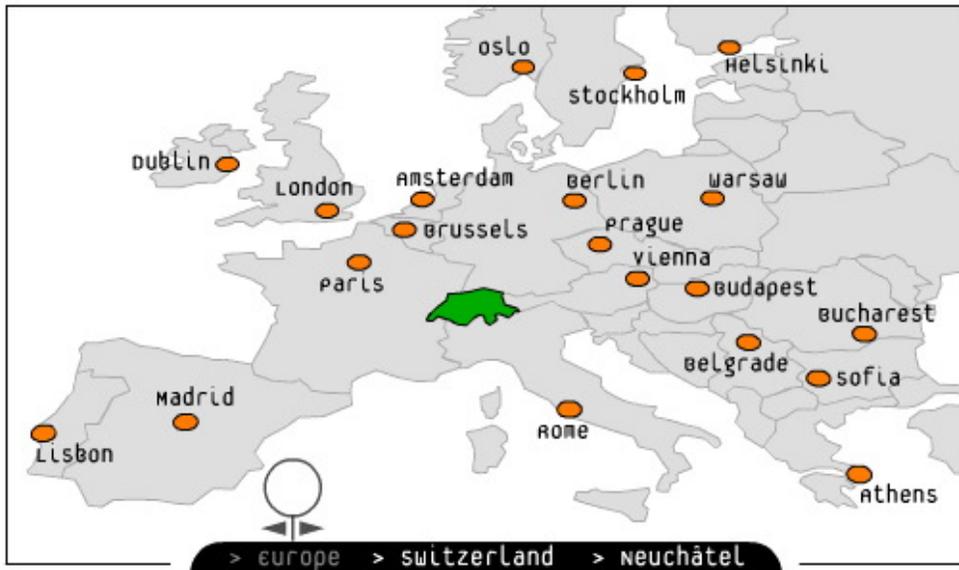
Email: [mpi@bluewin.ch](mailto:mpi@bluewin.ch)

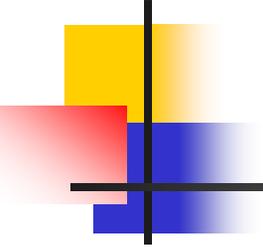
**MPI** *Interconsulting*

ULTRASONICS - SONOCHEMISTRY - INNOVATION

## Location:

### Neuchâtel, Le Locle, Switzerland





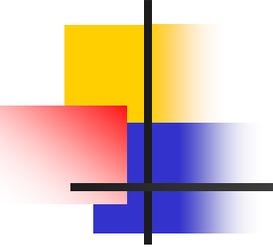
## MMM Fluids Processing Basics

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- ❑ Multi-Frequency Multimode, Modulated Sonic & Ultrasonic Technology (MMM Power Supplies).
- ❑ A totally new approach in the world of acoustic technologies.
- ❑ Unlike Fixed-Frequency systems we adapt through advanced Digital Signal Processing (DSP) of feedback waveform and new modulation techniques producing wide frequency band acoustic field. Any pipe or vessel can be agitated using MMM Power Supplies.

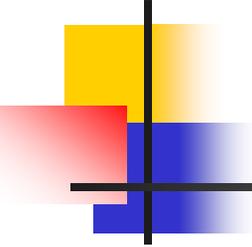
## MMM Technology Advantages

- Sonic and ultrasonic parameters in MMM Power Supplies are fully programmable and controllable to offer high operating efficiency and effectiveness for any complex mechanical system, consisting of arbitrary resonating elements.
- MMM creates powerful 3D sonic and ultrasonic activity in liquids and solids with arbitrary shapes and sizes.
- MMM Sonic & Ultrasonic Vibrations are covering and sweeping an extremely wide frequency band to create uniform and homogenous distribution of acoustical activity inside of the vibrating medium.
- Standing waves are eliminated and the whole medium is fully agitated.
- Adapt to any kind of transducer, any number or any power.



# MMM Tubular, Clamp-On Reactors Driving

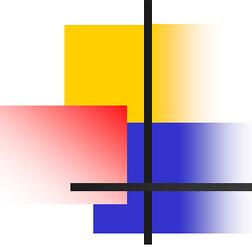
- We offer generator and transducer components for systems integrators and OEMs to make Ultrasonic Fluids Processing systems. We offer our clients the freedom to construct and supply their own pipe resonator systems.
- **Fixed Frequency Systems:**
- When matched with our Fixed-Frequency generators the ring resonators must be tuned to operate at the system resonant frequency.
- **Multi-Frequency Systems:** MPI now offers the industry's most advanced ultrasonic technology for In-Line Liquid Processing applications. When properly adjusted our patented MMM (Multifrequency, Multimode, Modulated) ultrasonic generators can stimulate highly efficient wideband (sonic to megahertz) acoustic energy to nearly any reactor shape. Key benefits to the MMM ultrasonic technology are:
  - Wideband (sonic to megahertz) acoustic energy provides greater fluid stimulation to improve any Sonochemistry-related process beyond the limitations of standard fixed frequency systems.
  - MMM eliminates the standing waves seen in fixed frequency systems.
  - Fully programmable power and modulation technology
    - Power adjust 0% to 100% (standard power modules in 300 watts, 600 watts, 1200 watts, and up to 20 kW on request)
    - Pulse Width Modulation Period (Period 10 ms to 1,000 ms)
    - Pulse Width Modulation Ratio (0% to 100%)
    - MMM special modulation settings (fast sweeping, sweeping, & tracking)
    - Center Frequency settings (large interval)
- Programmable features allows greater processing flexibility with all kinds of fluids.
- MMM technology will drive most any pipe shape (round, oval, square, rectangle), even very large mass systems.
- MMM converters may be connected to most any efficient point on the acoustic load.
- A field adjustable resonant frequency option allows rings to be built without specific tuning. This means ring resonators designs can be simplified and produced at lower cost.
- **The MMM Clamp-On system can adapt to most any other manufacturers installed pipelines systems allowing a simple field upgrade.**



# MMM, Clamp-On Applications

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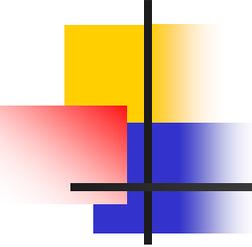
- Fluids mixing, Cleaning of internal tube area, Liquid Atomizing, Homogenizing, Tubes Cleaning in Nuclear Industry, Facilitating flow and removing fluid friction, ordinary and precession cleaning, Nano-particles production, Stress Relief, Sonoreactors and applications in Sonochemistry & Electrochemistry, Extractions, Mining Industry, Fuels and oil mixing & blending, Facilitating powders transport in pipe conduits, Large Surfaces Defoaming, Birds and Animals Repealers, Sonar applications, Liquid Metals Processing, Extrusion, Ultra-Filtration, Waste waters treatment, Sterilization, Zebra Shells Repealing, Boilers protection and cleaning, Fuel Injection and Atomizing, Washing Machines, Pulp & Paper Technologies, Ice and snow-making, Dust Removal, Incineration of Liquids, Degassing, Cracking of petrochemicals, Fuel Cells...
- Industrial fluids atomizers & gas mixing (air conditioning, semiconductor technologies...)
- Water & fuel atomizers
- Liquid alloys atomizers & solder atomizers
- Incineration of waste and dangerous liquids by atomizing
- Large volume humidifiers & dust removal
- Air and water filtering, purification, decontamination & sterilization (nuclear, included)
- Micro-encapsulation, coating, surface impregnation
- Food and Pharmaceutical applications (surface decontamination)
- Electrochemistry & Sonochemistry process integration (nano technologies)
- Extruders, Wires & Tubes Drawing, Atomizers, Liquid Alloys Treatment, Defoaming, Mixers, homogenizers, Sonochemical Reactors, Waste Waters Processing, Supercritical, Liquid CO-2 Reactors, Extractions, MMM Cutting, Degassing, Fast meat defrosting, Meat preparation before fuming and drying, Relaxation and massage therapies, petrochemicals cracking (diesel etc.), precious metals extractions, perfumes extractions, ...



# Pipe Clamp-On Applications

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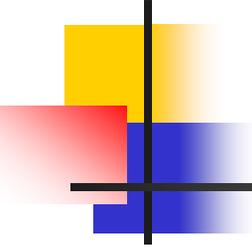
- ***Any Pipe Thickness:***
  - Although the MMM technology will drive most any pipe thickness (e.g. 1mm to 30mm) there are tradeoffs that must be considered.
  - In normal applications with pipe diameters of 25 mm (1") to 100mm (4") the MMM technology delivers the most amplitude and best multi-frequency harmonic modes with a thinner wall thickness from 1mm to 2.5mm.
  - Applications requiring a wall thickness greater than 2.5mm may also be driven with good success however more power will be required to drive the system with somewhat less amplitudes and some lesser excitation of multi-frequency harmonic modes.
- ***Any Pipe Diameter:***
  - MMM Pipe-Clamps may be designed for most any size pipe.
  - Active Ultrasonics can redesign the clamp dimensions to adapt to your specific pipe dimension.
- Larger pipes may require modified designs to allow mounting of multiple converters.
- ***Any Pipe Length:***
  - The unique nature of the MMM generator technology also allows us to create flexible system design that will treat any length of pipe.
  - The length of pipe effectively activated by one clamp is very dependent on many factors and must be tested for each application: Variables are:



# Pipe Clamp-On continued

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- ◆ Pipe diameter
- ◆ Pipe wall thickness
- ◆ Free standing pipe segment or attached to other pipes or equipment.
- ◆ Power limit of the MMM generator
- ◆ The converter / transducer used
- ◆ The viscosity and volume of material under treatment
  
- □ Longer pipe sections may be driven with more ultrasonic energy through the use of multiple clamps driven by one or more MMM generators. Some application examples are:
  - ◆ Extended atomizing or powder manufacturing through a long pipe section.
  - ◆ Extended treatment time for liquids flowing through a pipe section.
  - ◆ Long pipe friction and pressure reduction.
  - ◆ Continuous cleaning (anti-fouling or anti-film) of long pipe sections (e.g. dairy applications such as milk or yogurt, heat exchangers, etc.)

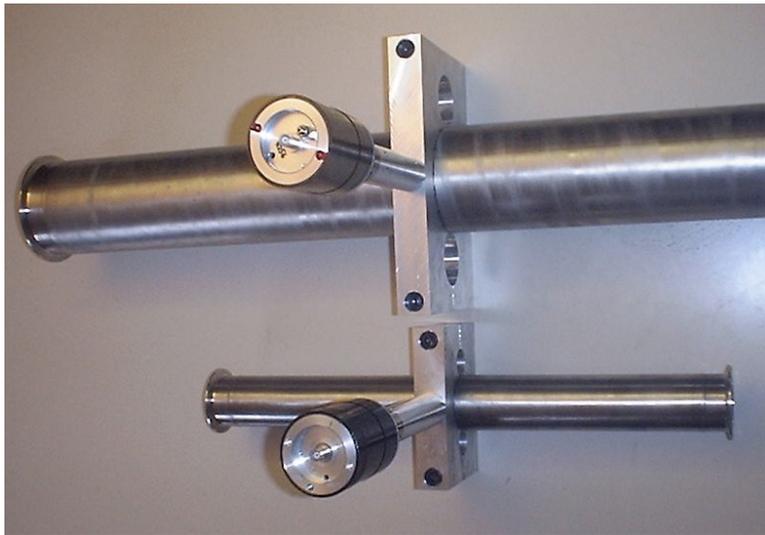
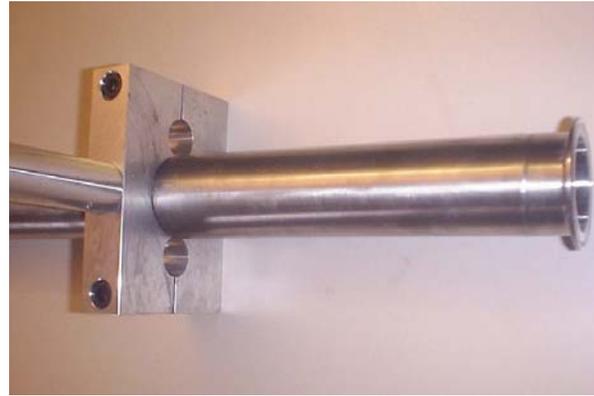
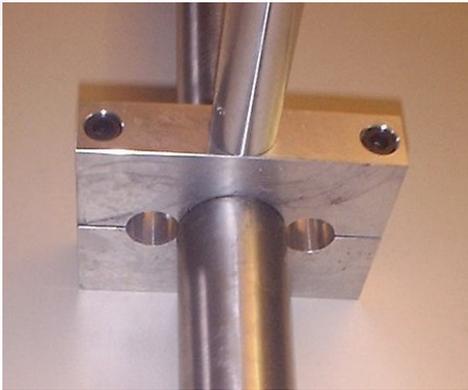


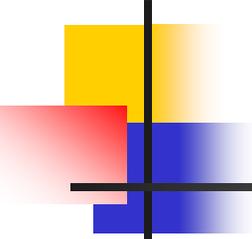
# Pipe Clamp-On continued

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- Shorter pipe sections may also be fitted with multiple clamps to improve the ultrasonic power density for the given volume. Applications that may benefit from more intense ultrasonic energy are:
  - Some Sonochemical treatments
  - Ultrasonic Cleaning
  - Very high volume atomizing or powder production.
- ***High Temperature Environments:***
  - Another key advantage to the MMM generator technology is its ability to drive variable length Wave-Guides. Normal Wave-Guides are 100mm to 200mm in length. When driving pipes that contain materials with high temperature the Wave-Guides may be extended from 1 to 3 meters. This allow us to distance the converter from the source of heat, thereby helping to protect the heat sensitive piezo-electric elements.

# Simple Clamp-On Design Options





# Clamp-On Reactors - Developments

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- **Drive New Pipes and Reactor-Vessels Shapes:**
  - Square, Rectangle, Oval
  - Barrels, Half-Barrels
- Fluids Filtering, Mixing and Homogenization
- Multi-Transducers
- Flexible Transducer Placement
- Long Wave-guide Driving
- Any Power for Any Size Reactors (until 100 kW)
- **MMM Frequency Agility:** The same DSP technology that allows the MMM generator to be adaptable to any shape reactor vessel is used to provide unprecedented frequency agility. Other fixed-frequency systems are driving the total acoustic system (converter & reactor) at a frequency optimized for the converter without full consideration of how the reactor frame is changing the whole system resonant frequency. Rather than fighting physics our systems are adapting to the new resonant frequency when an un-tuned mass (the reactor vessel) is attached to a converter.
- **MMM Converter Agility:** Additional system flexibility is provided through adaptive inductive compensation that allows attachment and efficient driving of converters from other manufacturers. This allows us to improve existing ultrasonic systems through a simple MMM retrofit.

## MMM Clamp-On Liquid Treatment in Action



(movie files)

# MMM Clamp-On Atomizing in Action



(movie files)



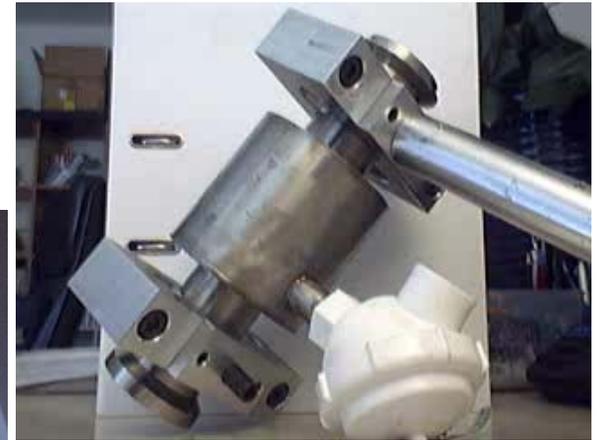
# MMM Sono-Futuristic Thunderstorm in Action

(movie file right side)



Just imagine what kind of acoustic activity should be inside the tube

# Unlimited Clamp-On Reactors Options

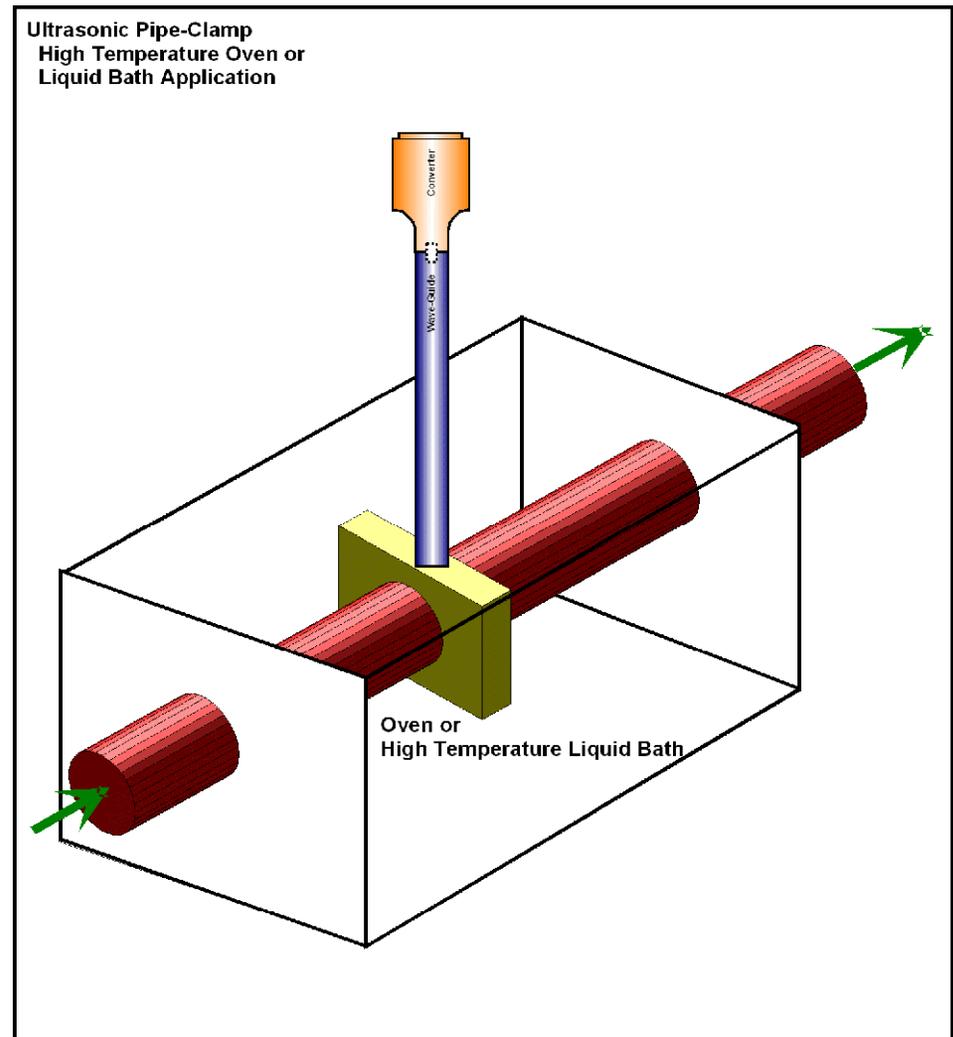


(movie files)



# Application: MMM Clamp-On High Temperature

- ❑ Oven Pass-Through
- ❑ Submersed in Hot Liquid Bath
- ❑ Long Wave-Guide removes transducer from heat
- ❑ Water or Air Cooling to Wave-Guide or Transducer.
- ❑ Reduced Friction Improves Flow Rate
- ❑ Ultrasonic Mixing and Homogenizing



# Water Jacket for Heavy Duty, Clamp-On Applications



## ***Operational Heat Protection:***

- ❑ Pipe-Clamp applications that require continuous maximum power delivery should provide cooling to the mechanical system for protection of the ultrasonic converter / transducer.
- ◆ One of the most effective cooling methods are water cooling jackets mounted on the wave-guide. Active Ultrasonics.
- ◆ In addition clients may provide additional air cooling when necessary.

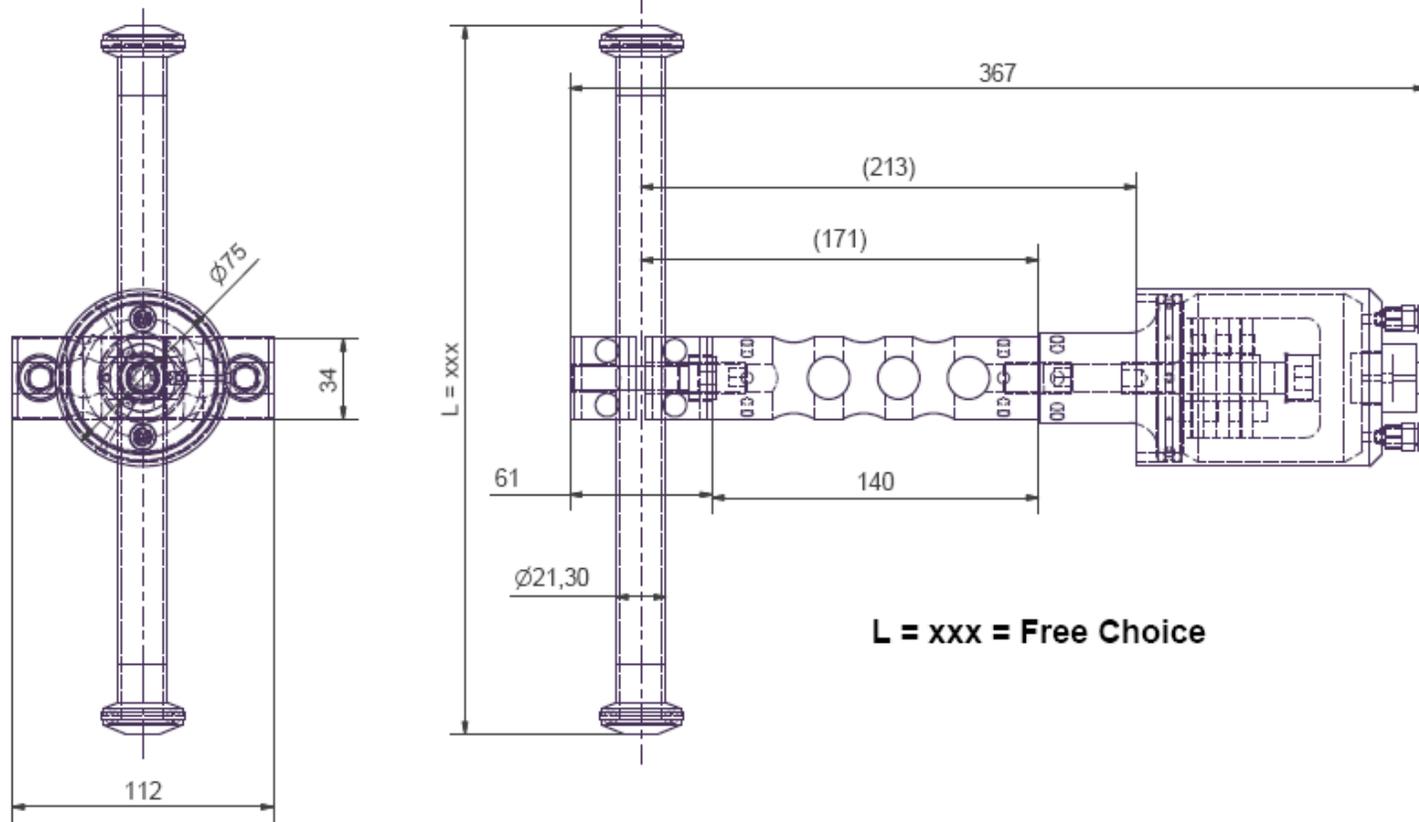
# Easy & Simple Connectivity



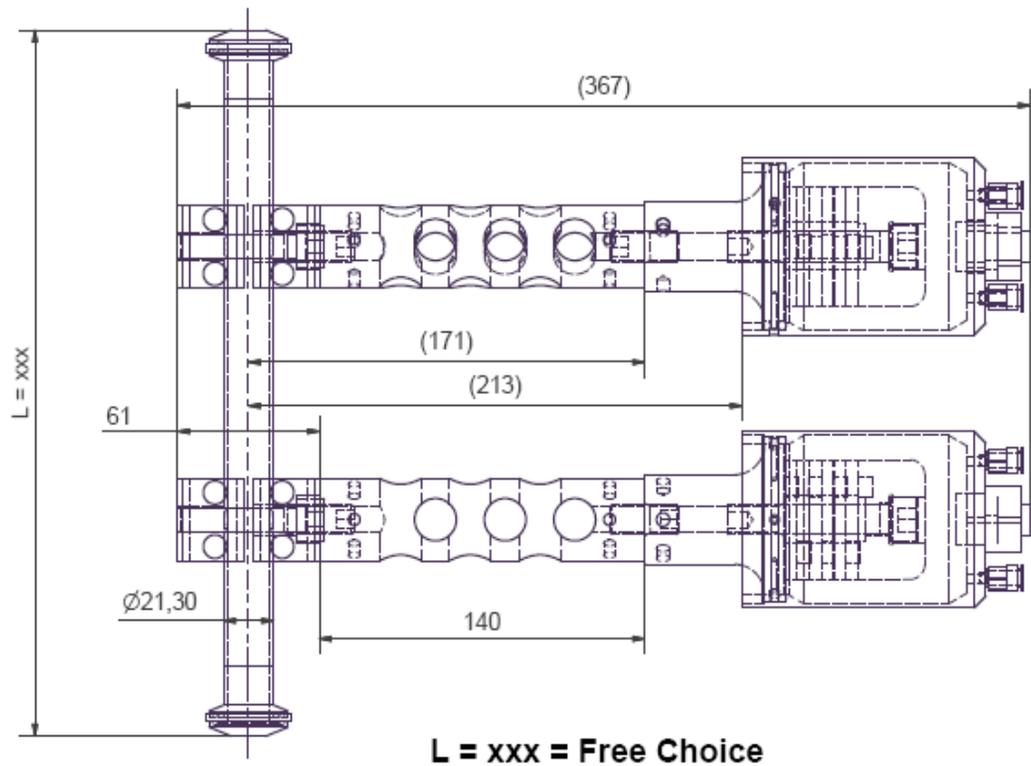
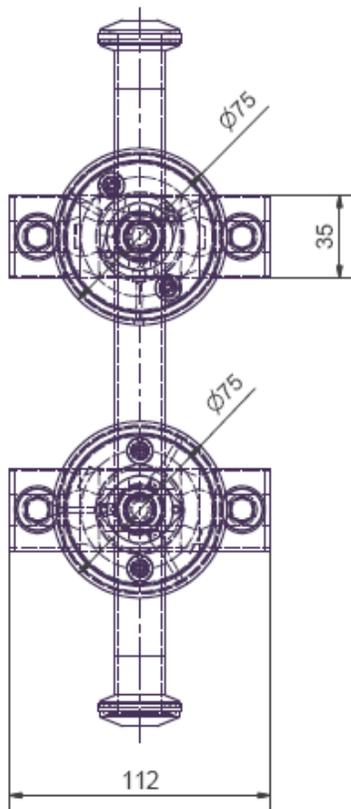
# Clamp-On Reactors: Design Examples



# Design Examples



# Design Examples



## Ultrasonic Liquid Processing, Sonochemistry, and Extractions

Applications of Flow Through or Static Cylindrical Reactor Systems: For organic or inorganic material processing:

- **Disruption and Cell Lysing** - will break open biological tissues and cells to extract enzymes and DNA, **prepare vaccines**. This technology provides a method for **ultrasonically lysing cells and spores** in a liquid flowing continuously or intermittently through a cylindrical reactor.
- **Transdermal Drug Delivery** (no more needles).
- **Bioengineering and genetic research** (extracting cells' fluids).
- **Activation of seeds:** almost 100% successful germination and healthier plants.
- **Filtering**
- **Sterilization**
- **Extractions**
- **Food products treatment**
- **Sonochemistry**
- **Electroplating & Electrochemistry processes optimization**
- **Reaction Acceleration** - cavitation accelerates chemical and physical reactions.
- **Cracking in petrochemical technologies**
- **Fine Particle Dispersion** - e.g. nanoparticles processing
- **Liquid food processing.**
- **Homogenization** - making uniform mixtures of liquids or liquid suspensions.
- **Emulsification** - processing foods,



3-Clamp-On Reactor

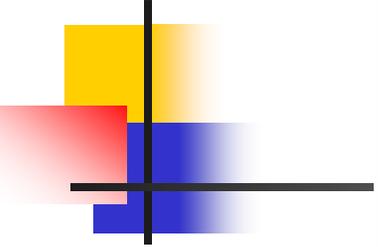


# Continued: applications

- pharmaceuticals, and cosmetics.
- **Dissolution** - dissolving solids in solvents.
- **Degassing** - removing gases from solutions without heat or vacuum.
- **Inline pipe cleaning**, removes scale or build/up without disassembly (also nuclear industry...).
- Cylindrical **360° internally radiating** chamber.
- Internal or external **liquid atomizing or powder making** sonotrode.
- **Powders production in liquid phase** by precipitation (minimizing the particle sizes including surface treatment).
- **Quenching optimization**: uniform and immediate vapor and bubbles layer removal.



**Clamp-On Ceramic tube for Liquid Metals Treatment**



A new method of continuous or intermittent inline ultrasonic processing for any liquid material or food that requires ultrasonic treatment. Single or multiple transducers are connected to custom clamps designed to fit nearly any size tube or pipe constructed of aluminum, stainless steel, or titanium. Our unique MMM technology offers a highly efficient transfer of ultrasonic energy to the metal pipe or tube. The pipe / tube becomes a radiating element allowing internal or external material treatment.

These assemblies will turn nearly any suitable pipe or tube into a highly efficient ultrasonic reactor. Longer pipe sections may be driven with multiple clamps powered by one or more MMM generators.

Key Features:

- MMM technology will drive most **any pipe thickness** (e.g. 1mm to 30mm) at high power.
- May be designed for most **any diameter** pipe or tube (e.g. 25mm to 150 mm).
- Flexible system designs for **any length** of pipe.
- **Flow through design** allows easy adaptation to lab and industrial systems.
- Long wave guides options allow for very **high temperature applications**.
- Wide ranging power options offer:
  - Low power non-cavitation



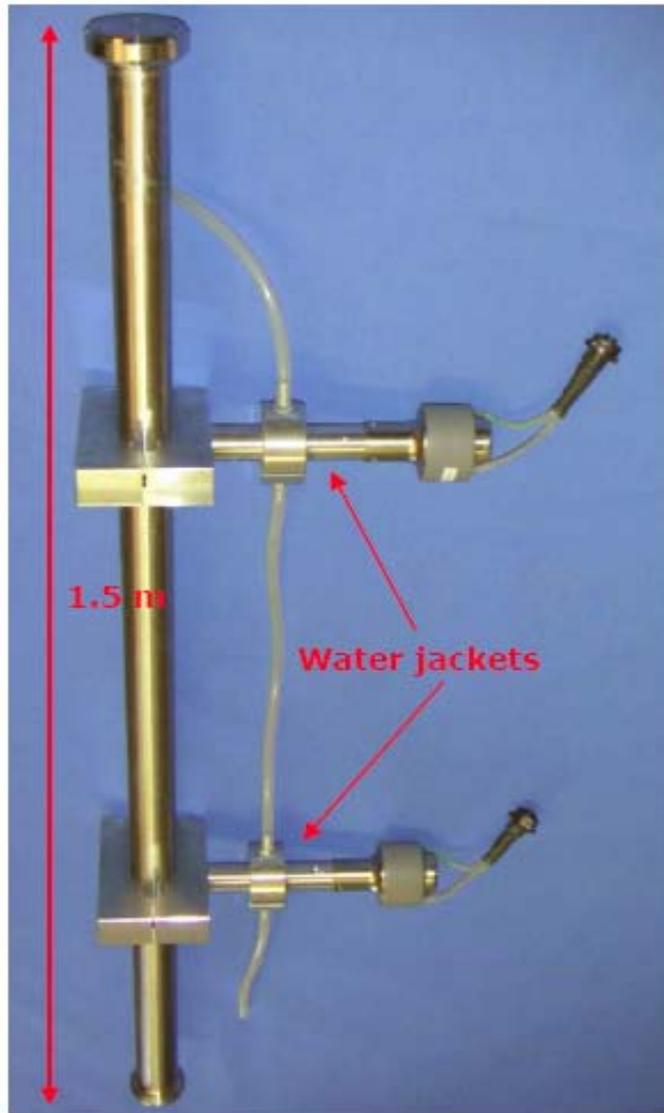
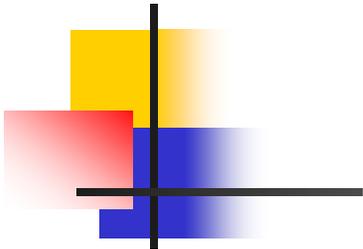
# Continued: applications

- treatment
  - High power strong cavitation treatment
  - 0 to 100% power control
  - Advanced modulation techniques to modify and improve acoustic effects.
  - Standard systems from 300 watts to 2,000 watts. Custom systems to 120,000 watts.
- Simplified tube design without seams or joints allows easy internal cleaning and sterilization.



**Multi-parameters PC-controlled (fully overload-protected)**

**Solving problems with air bubbles in liquid food products using MMM, Clamp-On Ultrasonic technology**



**Fruit and vegetable processing plants.**  
**Degassing products that have small air bubbles in the mixture.**  
**Milk degassing, blending and homogenizing.**  
**Wines degassing, homogenizing and aging.**  
**Heat exchange optimizing by removing gas bubbles.**  
**Filters deblinding.**





## Pipes cleaning in NPP (Nuclear Power Plants)

Removing builds-up

High temperatures...

High radioactivity

Any size, length, shape



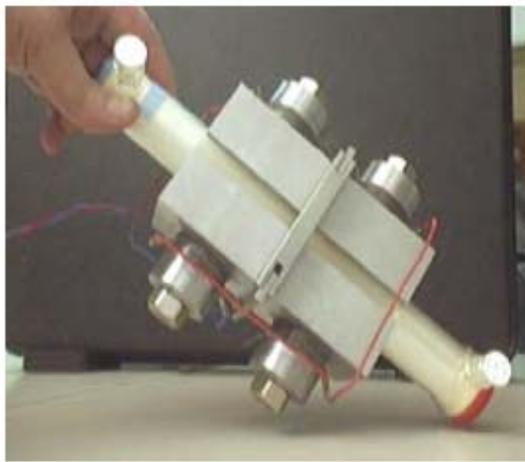
### Special Clamp Systems

- Glass, Quartz, or Plastic Tube Chambers:
  - Using special interface materials and clamp designs we can apply ultrasonic energy directly to a glass tube for treatment of liquid materials or chemicals.
  - Alternatively glass tubes may be submersed into water filled stainless steel pipe system for indirect 360° ultrasonic treatment.



## Custom System Designs and Consulting:

- MPI provides consulting services and custom reactor designs.
- High amplitude probe flow cells
- Unrestricted flow-through cylindrical systems



### Flow-Trough Cylindrical Reactors: Important Comments:

This system uses a new ultrasonic generator technology that allows us to make reactors from cylindrical pipes and tubes. As you will see the size can be customized for any length and diameter of reactor. The amount of power delivered to such systems is a function of the mechanical load (pipe size and liquid contained). For example the cylindrical reactor shown on the application note (50 mm diameter x 600 mm length) is driven by three clamp/transducers and we recommend a 600 watt limit. We could deliver a 1200 watt generator for this system but over-driving with too much power will lead to mechanical damage to the reactor and excessive heating to the mechanical components. A larger reactor would of course take more power. The key benefit to this cylindrical reactor system is the possibility to make batch or inline flow-through production. The system also offers a unique capability for applications requiring use of glass or quartz tubes for a controlled sterile reaction vessel in lab testing or batch production. By closing one end of the cylindrical reactor it may be mounted in a vertical position and filled with water. A glass tube may then be inserted through the top opening. In this way ultrasonic power is delivered 360° around and to the entire length of the tube. This technique will give a more homogeneous application of ultrasonic power to the liquid and improve reaction time.

We can also offer a high power ultrasonic probe system (sonicator) for conventional ultrasonic mixing, homogenizing, and cell disruption. See our web-server page with products overview: [http://mastersonic.com/documents/mmm\\_products\\_overview.pdf](http://mastersonic.com/documents/mmm_products_overview.pdf) for this alternative system. This is a conventional system and has limitations. In general terms a brief comparison of the two systems can be summarized as follows:

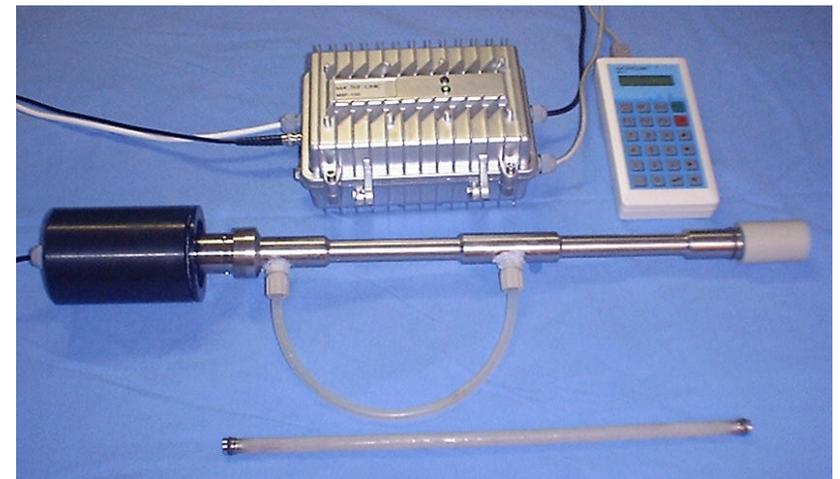
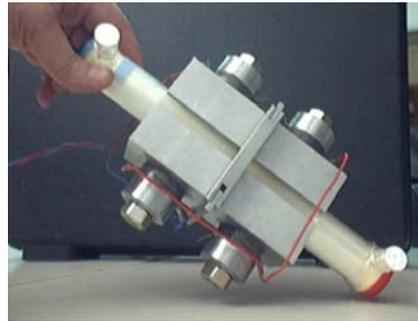
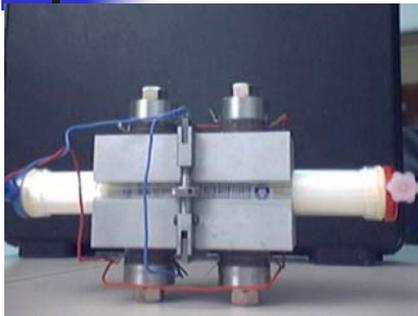
**Cylindrical Reactor** - this system offers more even homogeneous application of ultrasonic energy, a simple in-line flow-through option, high temperature possibilities, high pressure possibilities, batch option, a sterile glass or quartz tube option, and finer control of applied power that can give good acoustic energy with little or no cavitation or at high power will give both strong acoustic energy and high cavitation. Due to the extra machining and in one example three converters the cost is much higher for this system but it offers new possibilities for bio research and production.

**Probe System** - this equipment gives very high focused energy to the probe tip that allows strong acoustic streaming and mixing with strong cavitation on an area around the probe tip. Simple system but little control of cross-contamination, limited control of power distribution and only moderate control of power output.

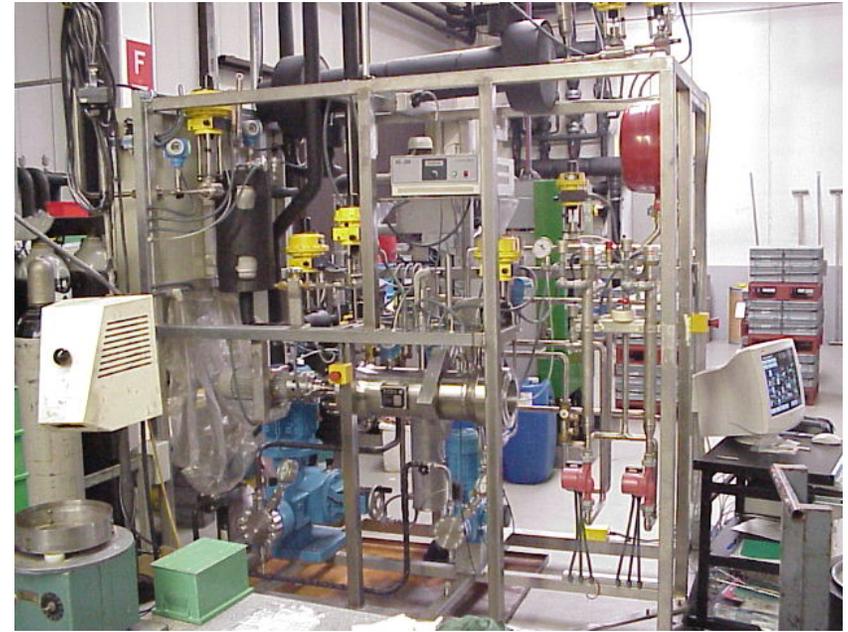
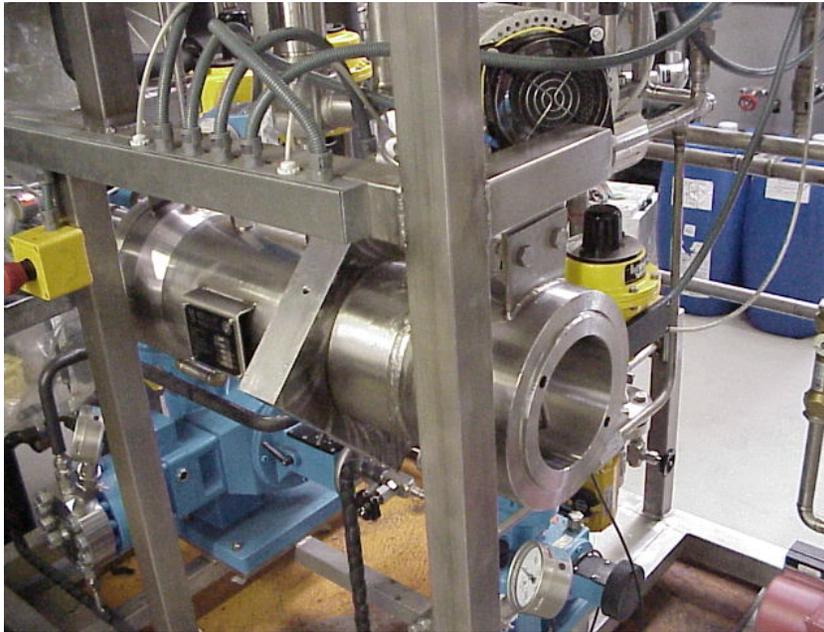
Which is best for you depends on what you wish to achieve. If you wish to make cell lysing then the cylindrical reactor is offering the most flexibility and control.

**Clamp-On ultrasonic reactor** - is the MMM resonating stainless steel tube (open on both ends, which can also be closed on both ends). Clients of MPI are using such tubular reactors for processing non-aggressive, "ordinary industrial liquids" directly (inside of the tube). In case/s of ultrasonic processing of aggressive liquids, and/or biologically or pharmaceutically sensitive liquids, the best is to create coaxial tubular reactor-system for indirect ultrasonic treatment, as for example: to fill water in the 3-Clamp-On tube, and pass another glass or plastic tube inside, coaxially. Water would serve as an acoustic coupling medium for passing ultrasonic vibrations to the internal tube with sensitive, aggressive or biological material. External water shell could be connected to a thermo-regulating system in order to keep constant operating temperature during sonication. Usually, the client would need to solve design details regarding watertight fixation around both stainless-tube ends in order to keep water inside of the tube and to have easy passage of internal tube which will be sonicated. The liquid which should be ultrasonically treated (internal plastic tube content) can have certain flow rate in order to process large quantities, or static in case of processing laboratory samples.

# Ultrasonic & Ultra-Filtration



# Supercritical CO<sub>2</sub> Clamp-On Reactor



**Clamp-On Agitation of the Liquid, Supercritical CO<sub>2</sub> Reactor (300 Bar applications, 25 mm wall thickness)**

**Applications: Extractions, Precision Cleaning**

# Examples: MMM CLAMP-ON APPLICATIONS IN PROCESS INDUSTRY



**Easier liquids flow and higher flow rate; Friction removal**

# Clamp-On & Heat Exchangers



**Heat Exchanging Applications: Longer operating life before cleaning**

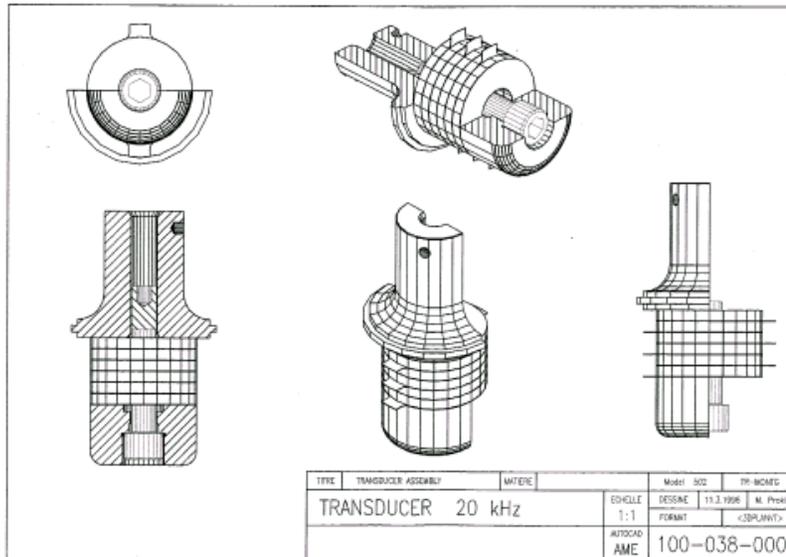
# Clamp-On & Soft-Mass Treatment



**In-Line Filtering, Separation,  
Mixing, Homogenizing**

**Extruders & pumps: Higher flow  
rate, reduced friction**

# Converters for Clamp-On Applications



**Applications:** Extruders, Wires & Tubes Drawing, Atomizers, Liquid Alloys Treatment, Defoaming, Mixers, Sonochemical Reactors, Waste Waters Processing, Supercritical, Liquid CO-2 Reactors, Extractions, MMM Cutting, Degassing, Clamp-On Systems...

# Converters for Clamp-On Reactors Applications

## METAL HOUSING CONVERTER



MMM, Metal-Housing converter (air cooling): MPI-20kHz-3kW-MH-AC



MMM, Metal-Housing converter (air + water cooling): MPI-20kHz-3kW-MH-AC-WC