

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, 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.



3-Clamp-On Reactor



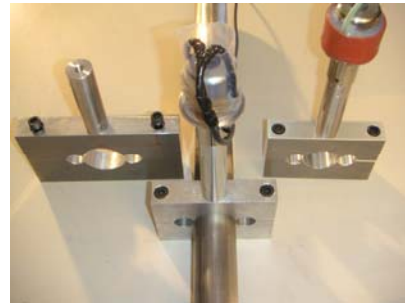
Clamp-On Ceramic tube for Liquid Metals Treatment

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.

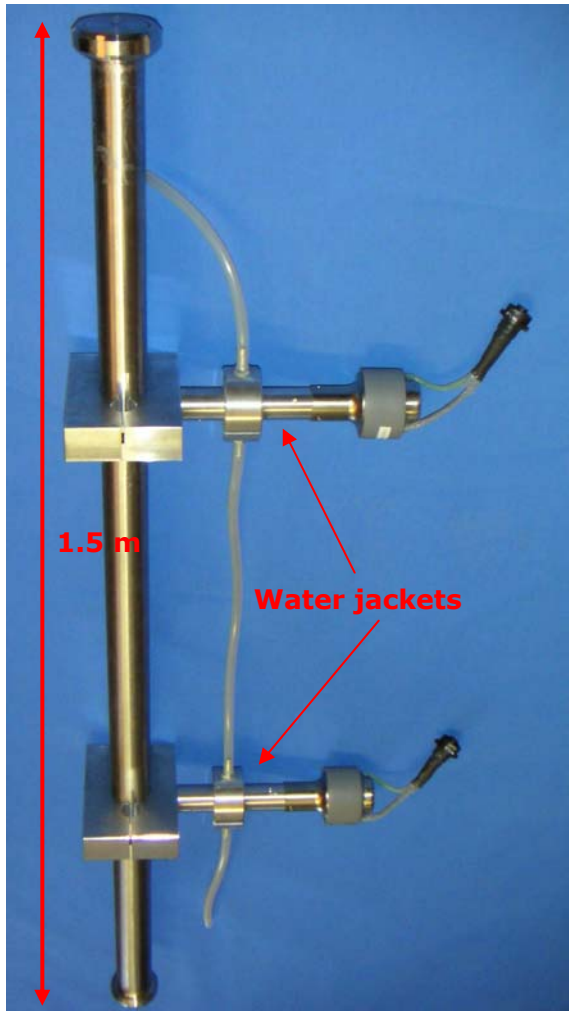
Key Features:

- 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 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



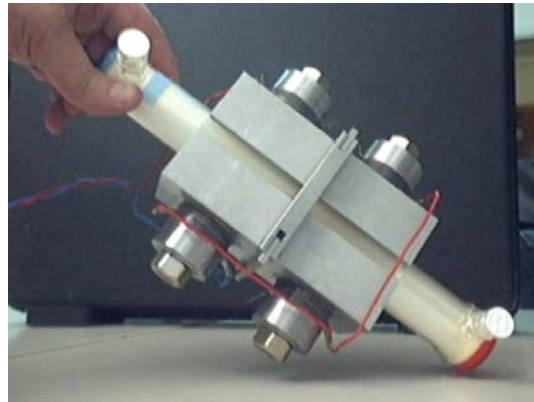
Special Clamp Systems

- 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 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.

Water coupling layer could have content of certain sterilizing chemistry in order to maintain the perfectly clean and safe environment.

Internal tube should be made of some acoustically transparent material (to pass maximum of ultrasonic energy to the internal liquid content). The best materials regarding acoustic transparency are different plastic foils (high density PVC, PVDF, PTFE...). MPI clients are also using Pyrex glass tubes (but glass is not as acoustically-transparent as some plastic foils).

Clamp-On reactor can be delivered with end flanges or in any other similar configuration (as you can see on the MPI web sites).

During 10 minutes or shorter it would be possible to sonicate easily much more than 20 liters (just by making a closed liquid flow).