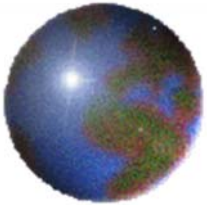
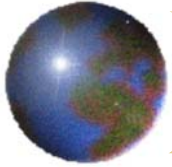


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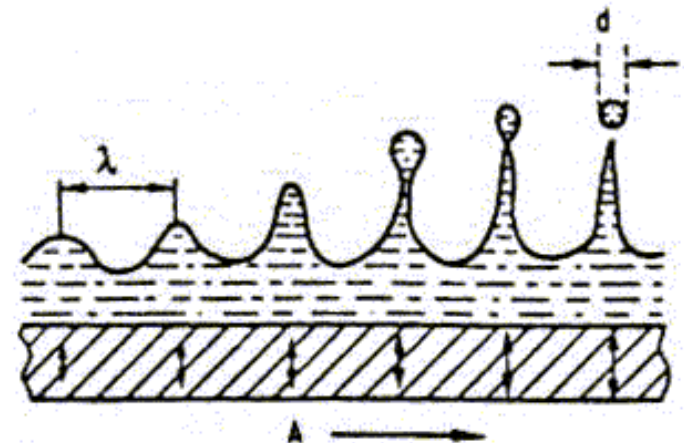


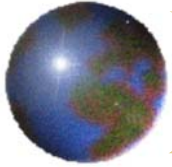
Ultrasonic Solder Powder Production



Ultrasonic Technology

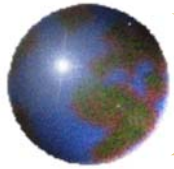
- Principle of capillary-wave atomization:
 - Vibration amplitude creates standing capillary waves.
 - On further increase of the amplitude, ligament breakup of the liquid follows and droplets are hurled from the crests of the capillary waves.
 - Drop size is correlated to sonotrode frequency, amplitude, liquid physical properties, and liquid-film thickness.





Ultrasonic Metal Atomization Limitations:

- ❑ High Temperatures limit material selection & dimensions for acoustical elements.
- ❑ Material inefficiencies require the sonotrode to be as close to the transducer as possible.
- ❑ Such a configuration is problematic for ultrasonic transducers that are inherently heat sensitive.
- ❑ High temperatures combined with high amplitude standing waves, ultrasonic cavitation, and chemical activity between liquid metal and the sonotrode are known to quickly degrade and severely limit the life of atomizing sonotrodes used in conventional ultrasonic metal atomization.



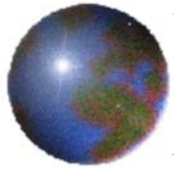
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Solder Powder Technology Development

- ❑ Off-shoot of ongoing ultrasonic atomizing development
- ❑ Metal Powder Study
 - ❑ University Pilot Plant
 - ❑ Study Metal Powder Production
 - ❑ Based on MMM ultrasonic technology



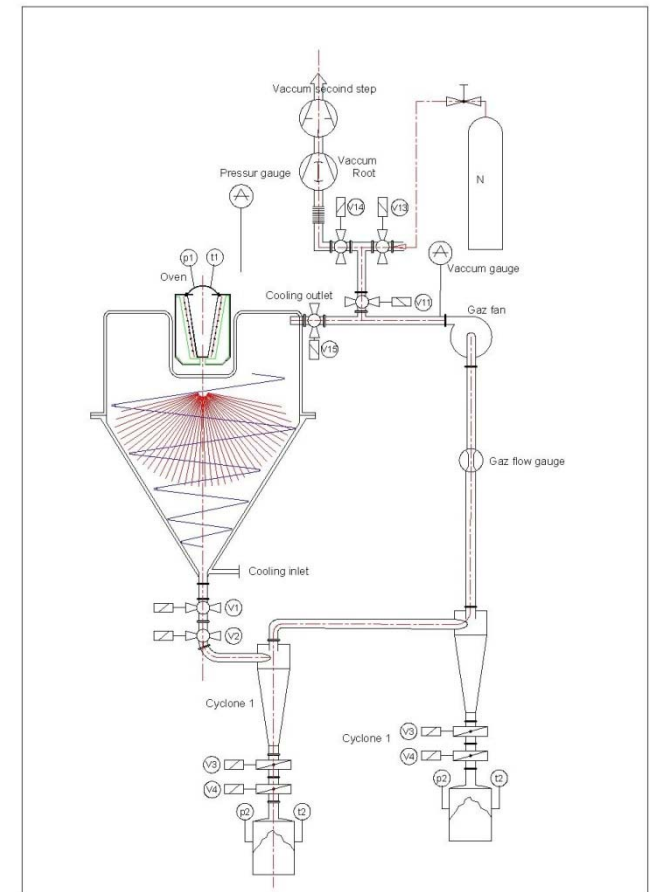


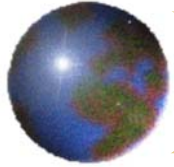
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Solder Powder Technology Development

- ❑ 2 year Development Effort
- ❑ Initial Work Based on MMM
 - ❑ University Project – Metal Atomizing
 - ❑ General Atomizing Technology
- ❑ New Enabling Ideas:
 - ❑ Improved Sonotrode Design
 - ❑ Improved Transducer Placement
 - ❑ Improved Alloy Feed & Flow Control
 - ❑ Improved Chamber & Gas Control





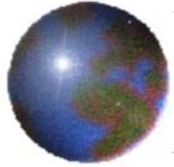
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Additional Technology Development Results:

- ❑ New Sonotrode Material
- ❑ Improved Sonotrode Life
- ❑ New Sonotrode Auto-Conditioning to remove solder build-up.
- ❑ New Sonotrode Induction Heating:
 - ❑ Simplified Placement
 - ❑ Non-Contact Automatic Temperature Control.
- ❑ New Ultrasonic Cooling System
- ❑ Higher Temperature Processing – Alloys with melt point to 500° C
- ❑ Hermetically tight atomizing chamber to improve environmental security

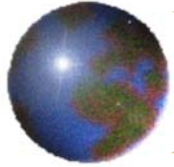




Additional Technology Development Results:

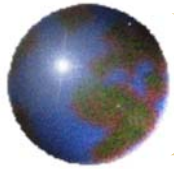
- ❑ High Yield Type 3 (25 to 45 μm) powder
 - ❑ Distribution projection:
 - ❑ 5 to 15 μm , : 5 %
 - ❑ 15 to 25 μm , class 4: 5 %
 - ❑ 25 to 45 μm , class 3: 65 to 70%
 - ❑ 45 to 75 μm , class 2: 15 %
 - ❑ 75 to 200 μm , : 5 %
- ❑ System adaptable to next phase ultrasonic equipment required for Type 4 powder.
- ❑ Production Volume:
 - ❑ 80 to 100 kg/hour for type 3 powder.
 - ❑ Future development should push flow rate 150 to 200 kg/hour for type 3 powder.





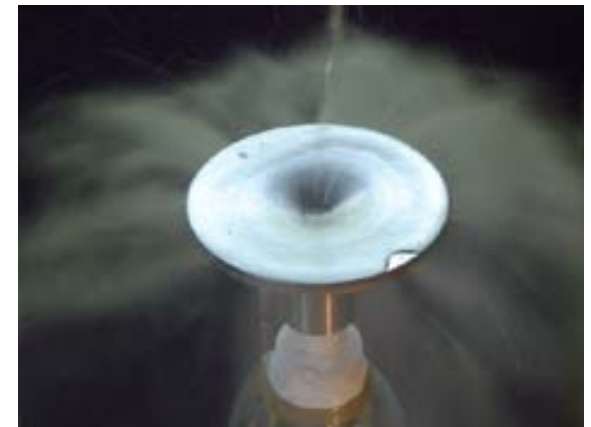
Production Projections:

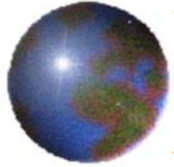
- ❑ 1 System Annual Production Type 3 powder @ 90 kg/hr x 240 days:
 - ❑ 5 to 15 μm : 13 tons
 - ❑ 15 to 25 μm , class 4 : 13 tons
 - ❑ 25 to 45 μm , class 3 : 182 tons
 - ❑ 45 to 75 μm , class 2 : 39 tons
 - ❑ 75 to 200 μm : 13 tons
- ❑ 1 System Annual Production Type 3 powder @ 180 kg/hr x 240 days:
 - ❑ 5 to 15 μm : 26 tons
 - ❑ 15 to 25 μm , class 4 : 26 tons
 - ❑ 25 to 45 μm , class 3 : 364 tons
 - ❑ 45 to 75 μm , class 2 : 78 tons
 - ❑ 75 to 200 μm : 26 tons



Project Status

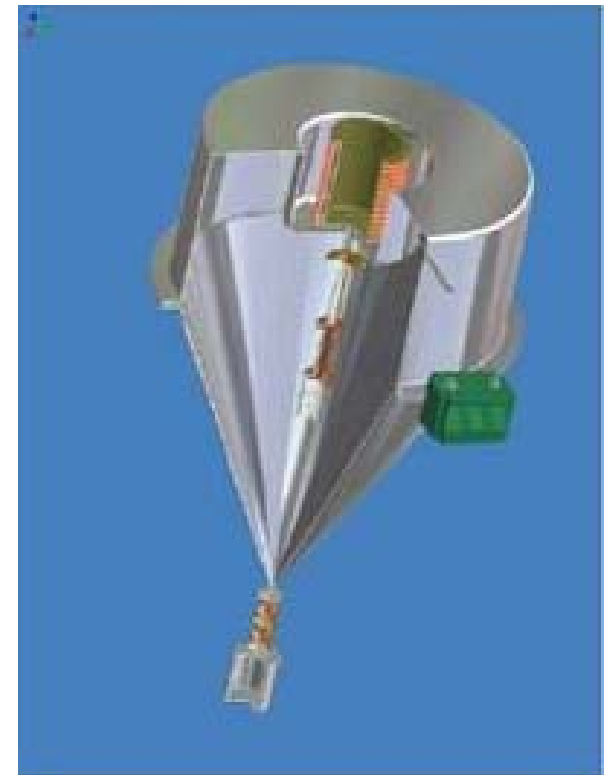
- ❑ Ultrasonics System
 - ❑ Sonotrode Design for type/class 3 powder (25 to 45 μm): *Complete*
 - ❑ Design for type/class 4 powder interchangeable. Design work to be complete in parallel with 1st system.
 - ❑ Rotational System *Complete*
 - ❑ Generator, Converter, Booster System *Complete*

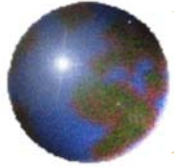




Project Status

- ❑ Alloy Melt & Feed System:
 - ✓ *Design Complete*
- ❑ Atomizing Chamber:
 - ✓ *Design Complete*
- ❑ Gas Circulation & Control:
 - ✓ *Design Complete*
- ❑ System Control:
 - ✓ *Design Complete*



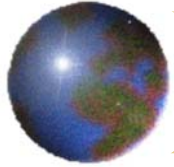


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System Components - Plate Sonotrode



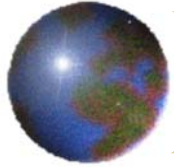


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System Components - Plate Sonotrode (video)



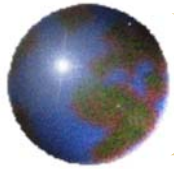


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System Components - Univ. Pilot Plant



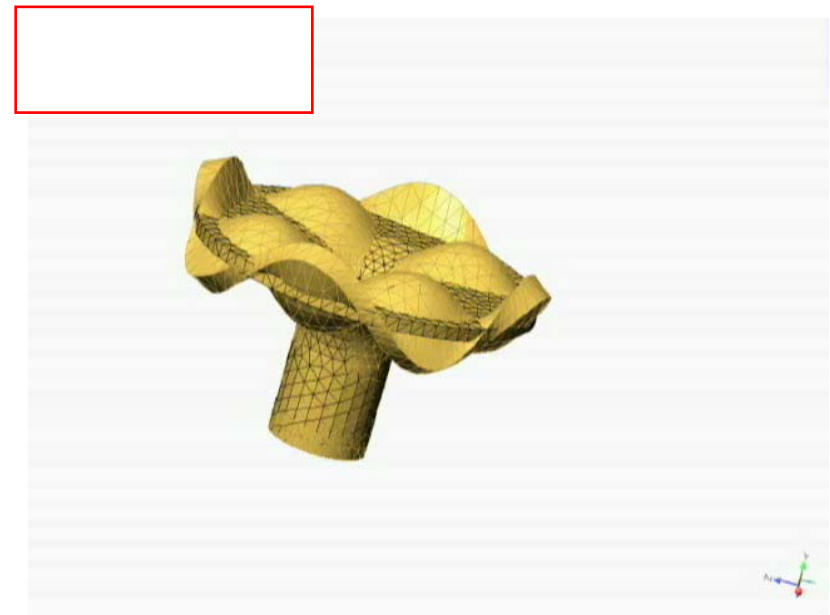
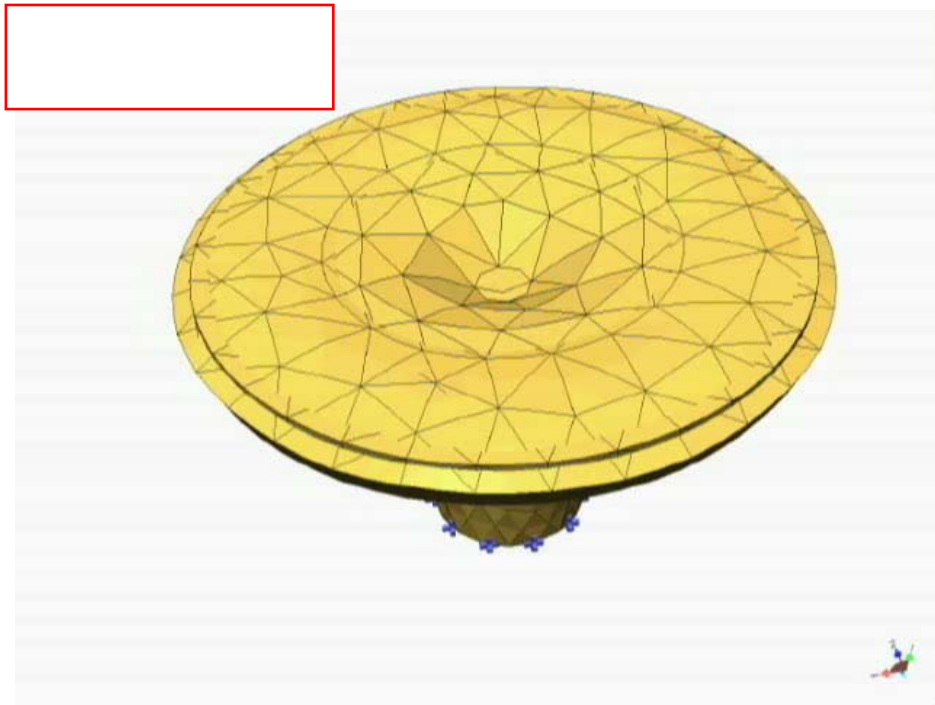


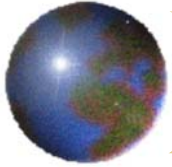
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System Components

Advanced FEA Modeling

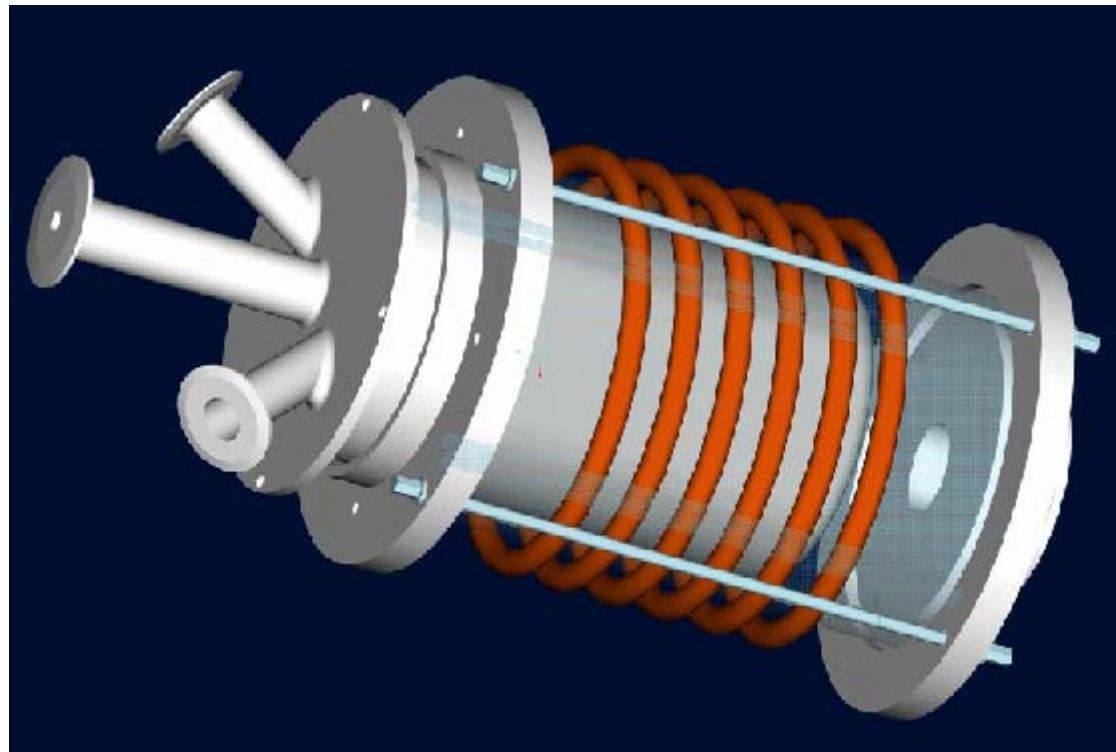


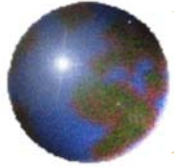


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System Components Advanced Modeling Designs



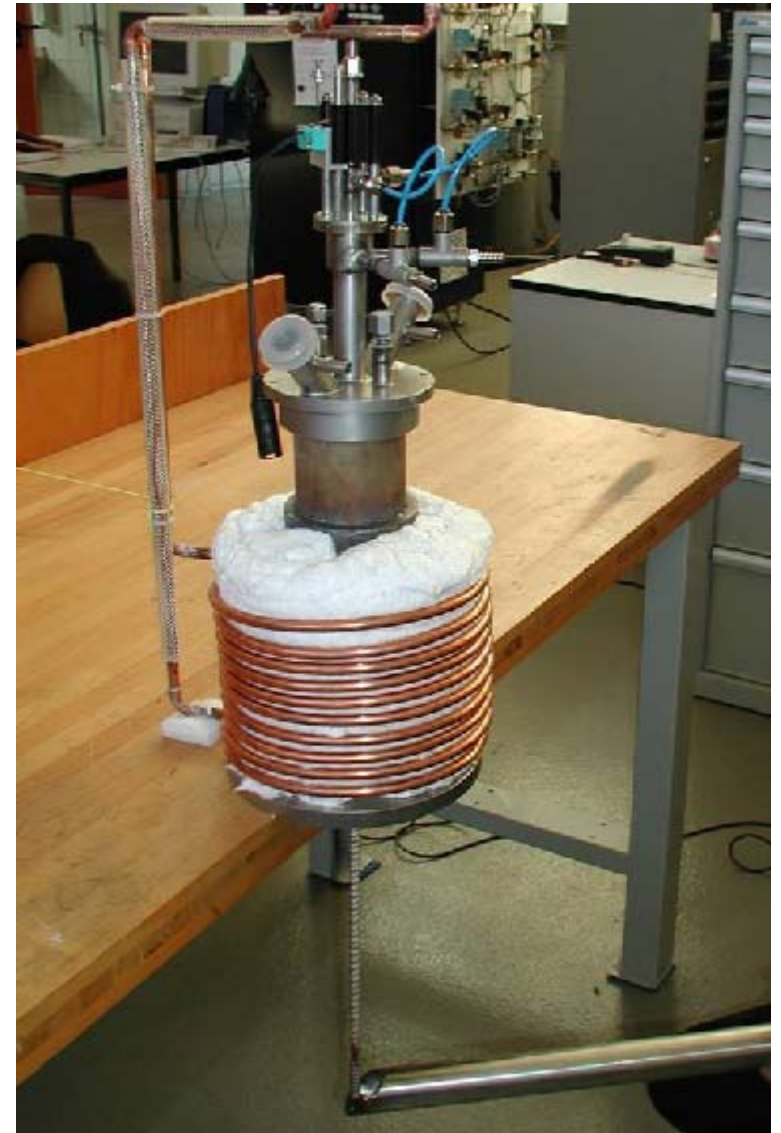


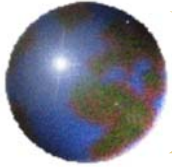
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System Components

Induction Melt Oven



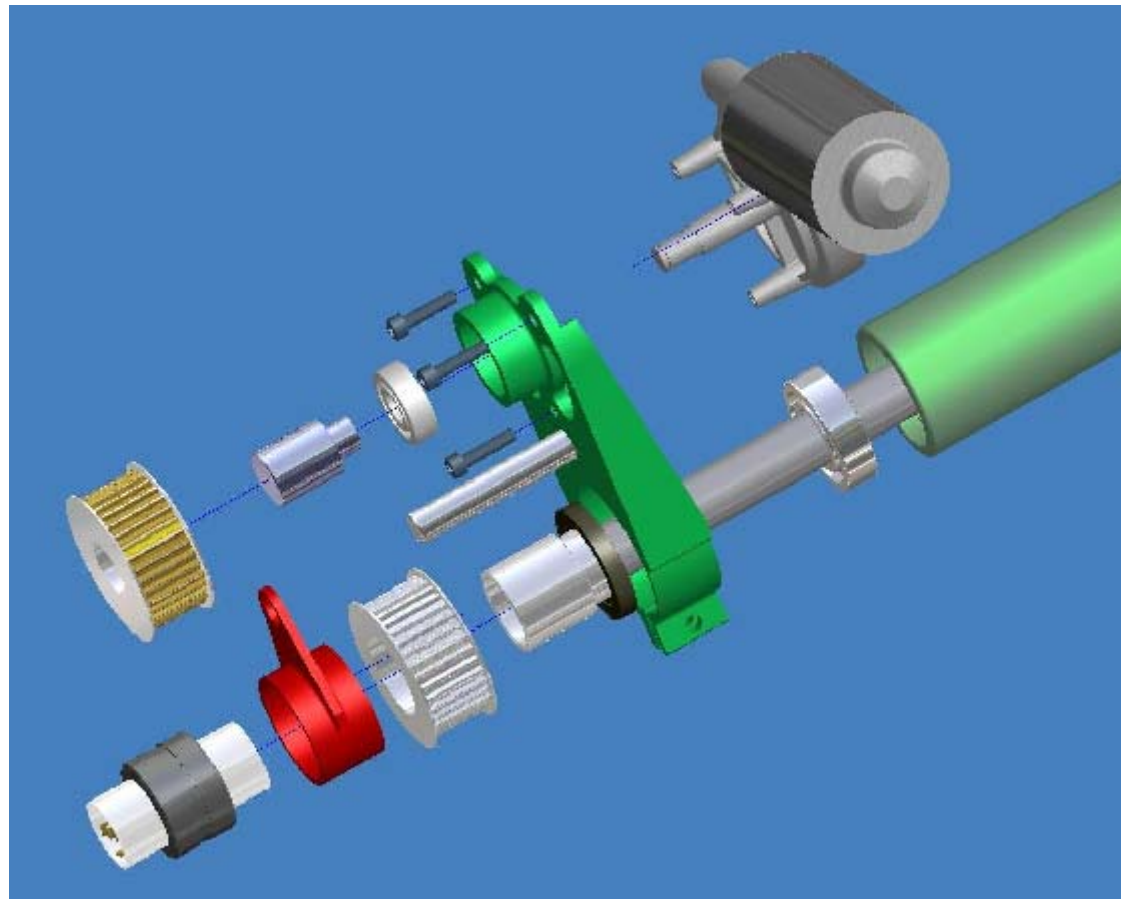


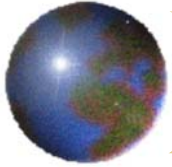
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System Components

Advanced Modeling Designs



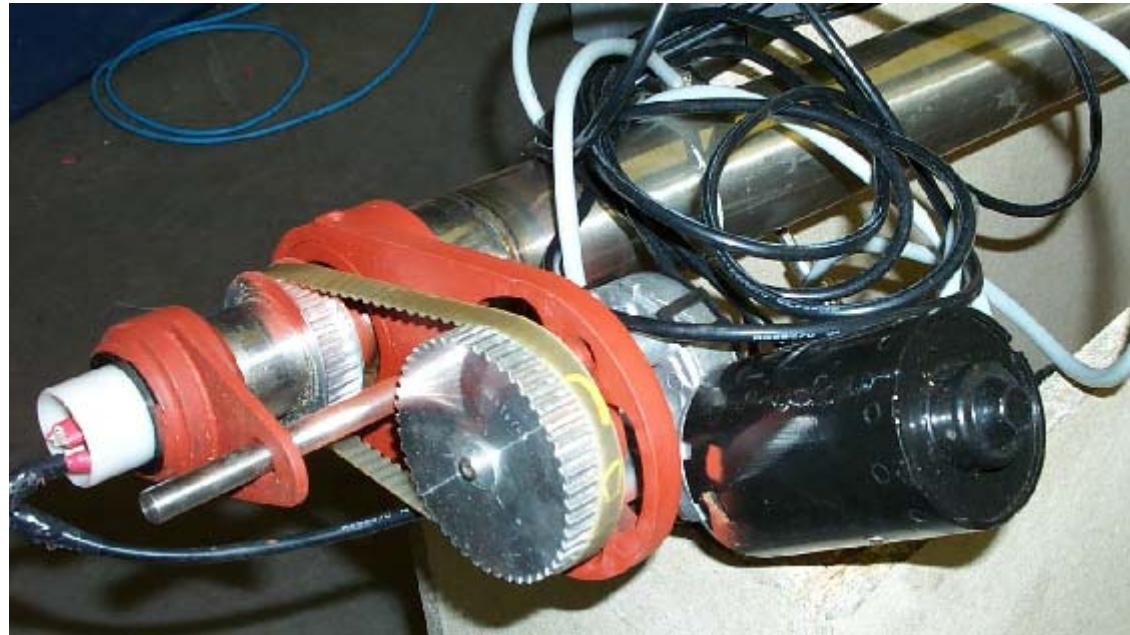


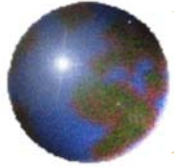
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System Components

Ultrasonic Rotational System



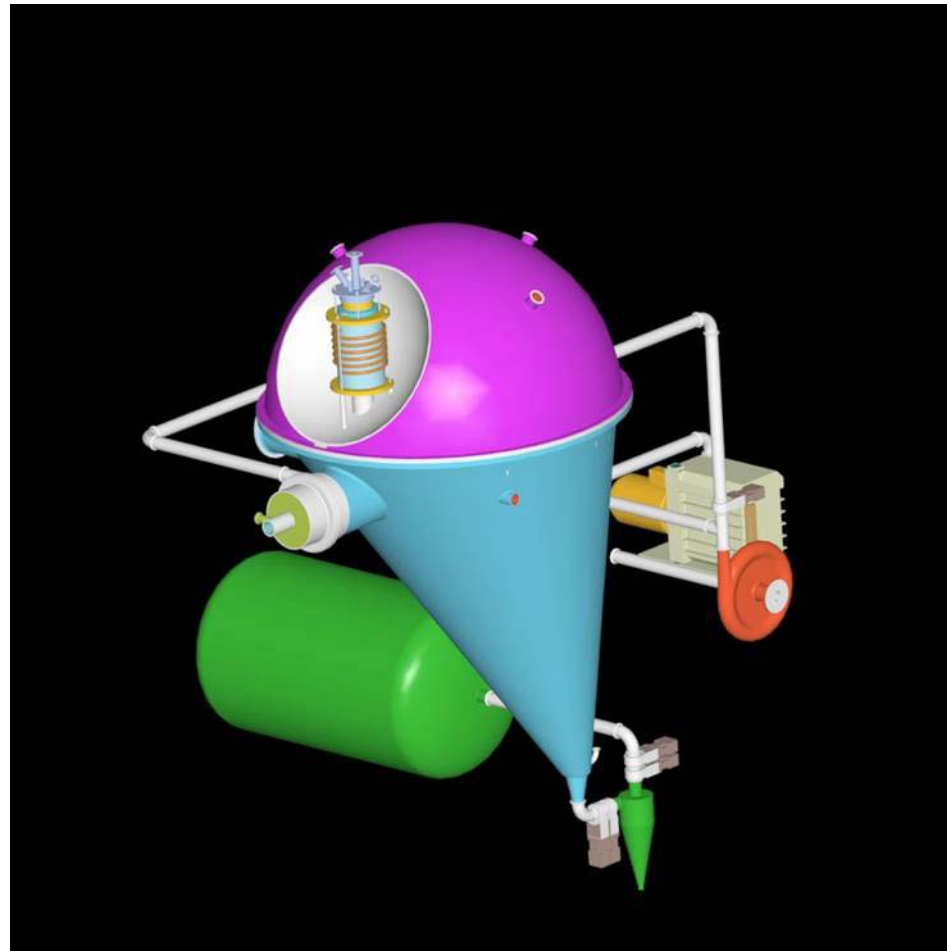


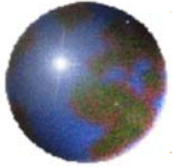
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System Components

Advanced Modeling Designs



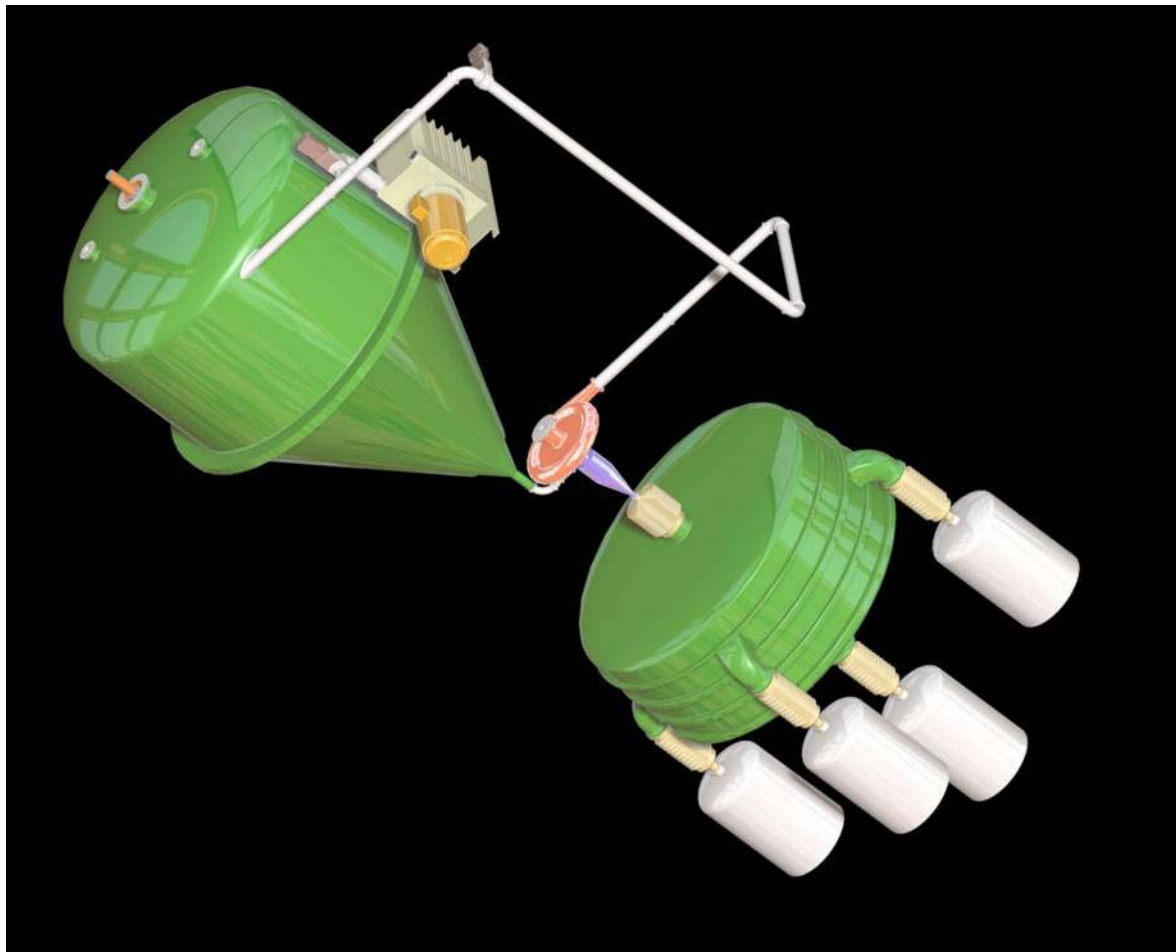


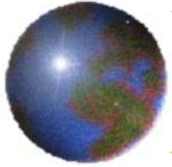
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System Components

Advanced Modeling Designs



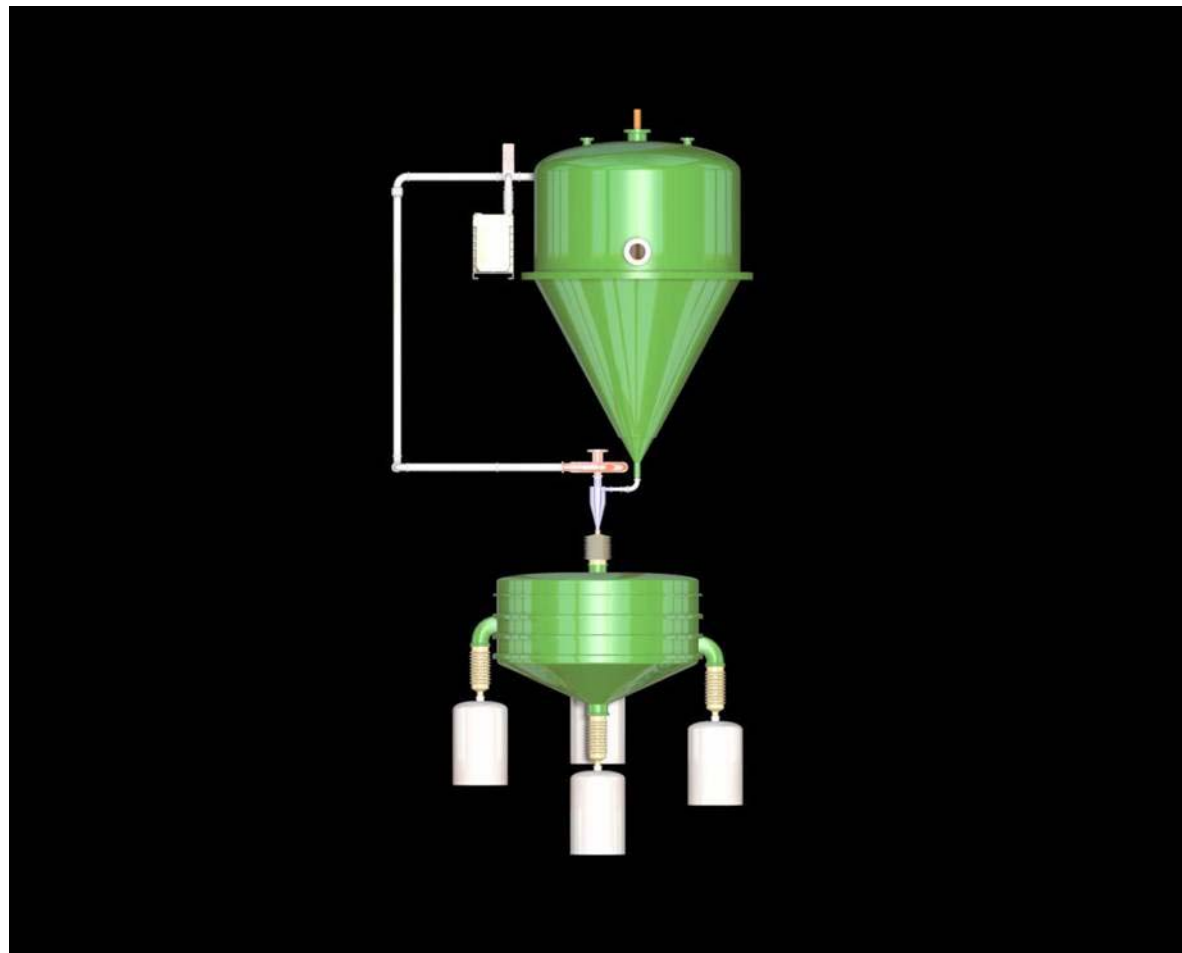


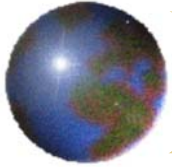
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System Components

Advanced Modeling Designs



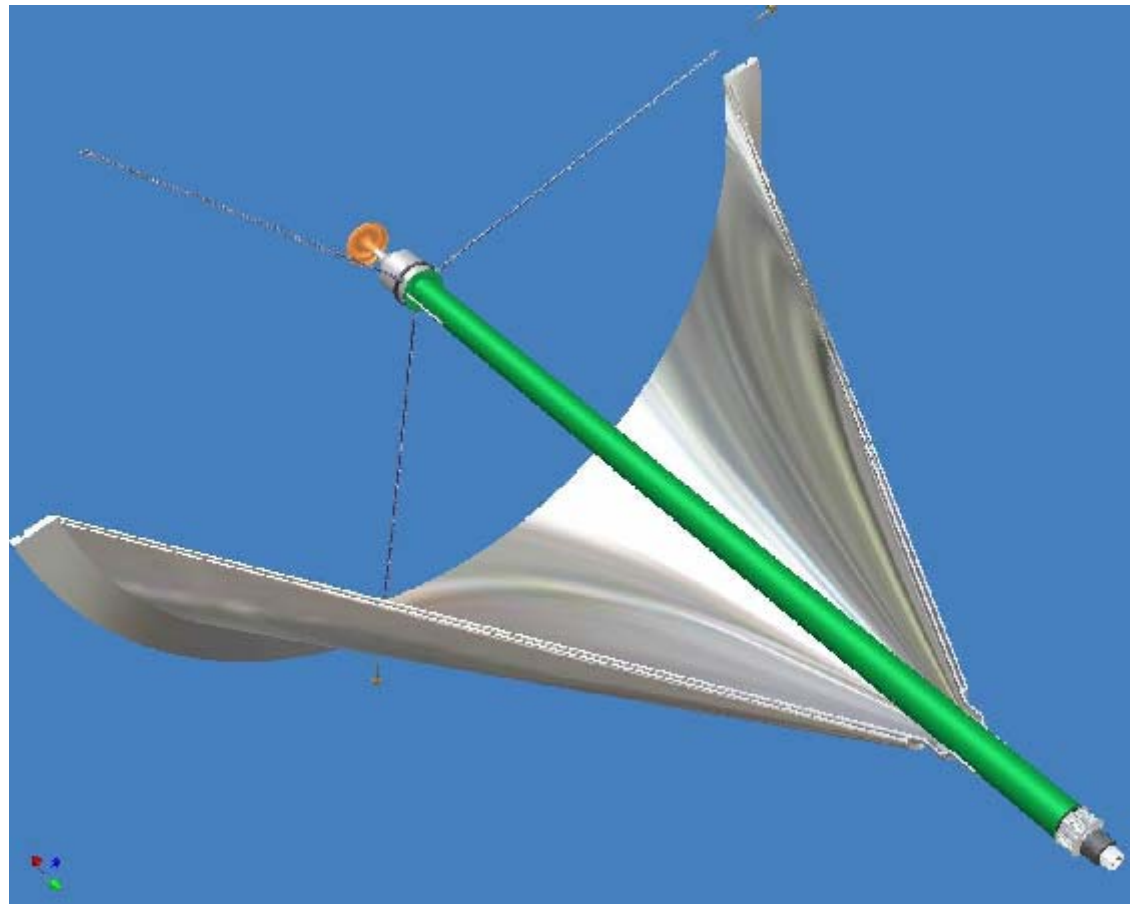


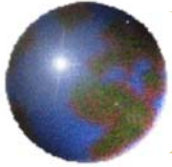
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System Components

Advanced Modeling Designs

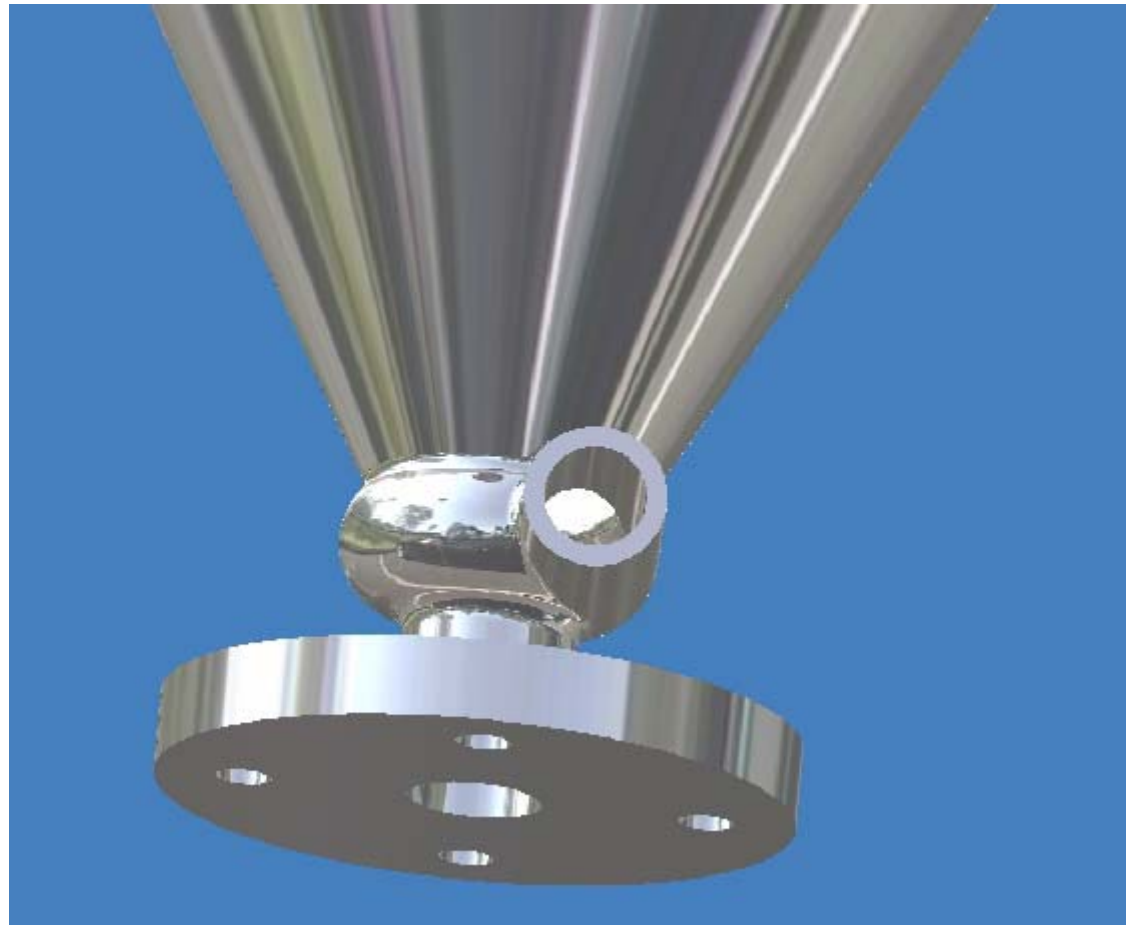


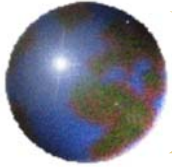


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System Components Advanced Modeling Designs

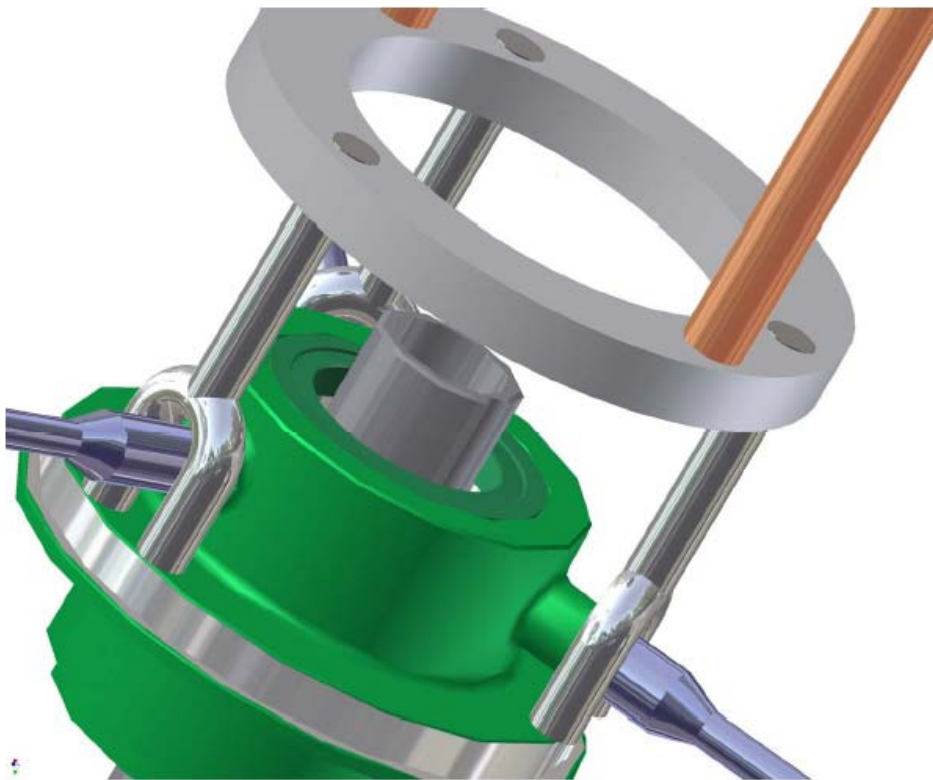


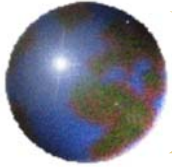


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System Components Advanced Modeling Designs

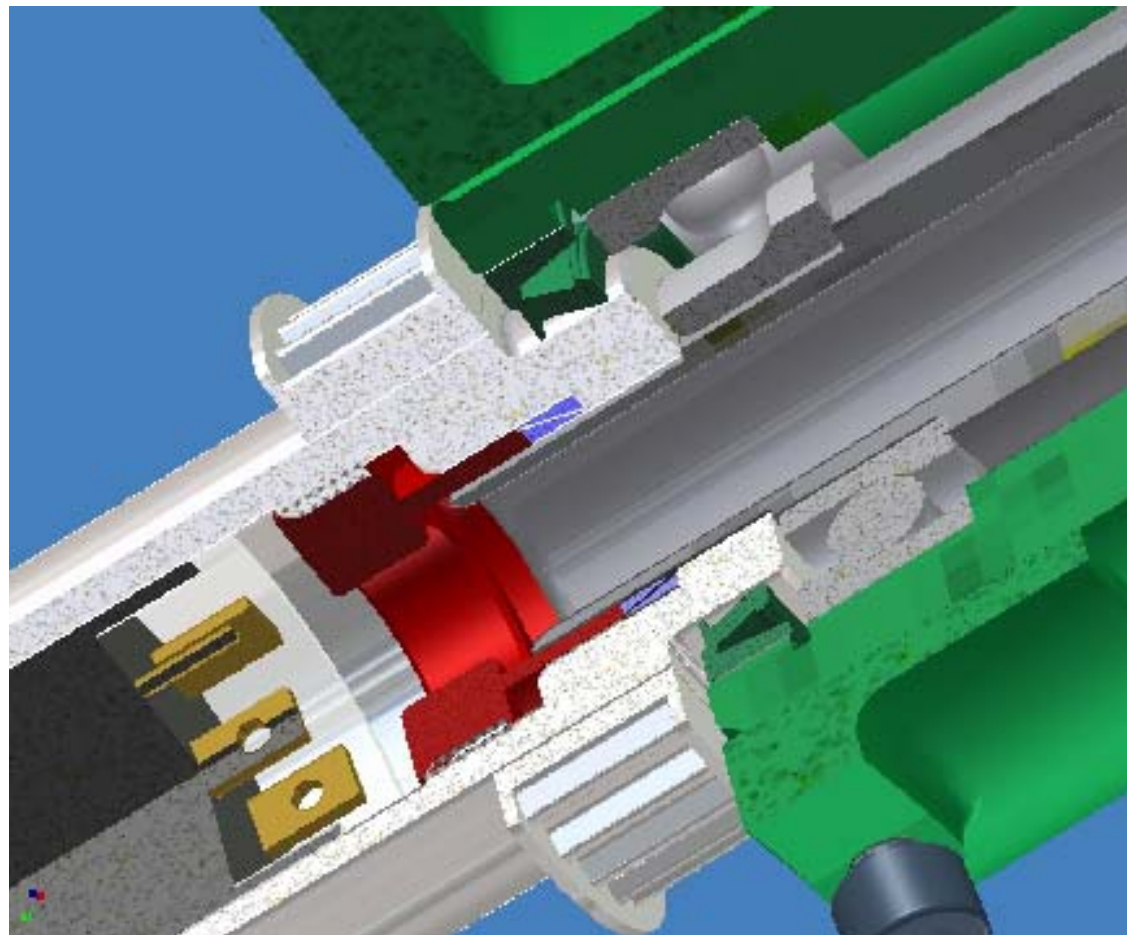


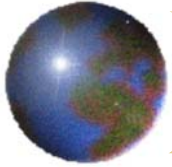


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System Components Advanced Modeling Designs



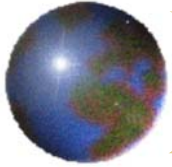


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System Components Advanced Modeling Designs





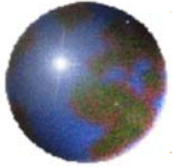
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System Components

New Atomizing Plate Design





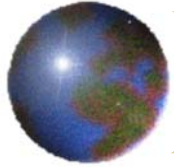
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System Components

New Atomizing Plate Design





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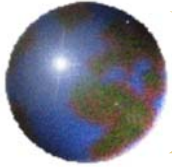
New Atomizing Options

MMM Pipe-Clamp Technology

- ❑ High Volume Powder Production
- ❑ Non-Specific Size
- ❑ Low Cost Sonotrode

(2 inch Pipe Shown)



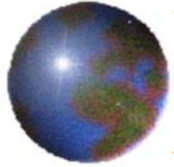


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New Atomizing Options MMM Pipe-Clamp Technology





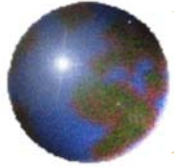
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New Atomizing Options MMM Pipe-Clamp Technology

- ❑ High Temperature Ceramic Alloy
- ❑ Material Rated up to 1200° C





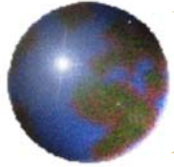
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New Atomizing Options High Temperature Sonotrode

- ❑ High Temperature Alloy
- ❑ Material Rated up to 1200° C





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New Atomizing Options

MMM Pipe-Clamp Technology

- ❑ High Volume Solder Powder Production
- ❑ Non-Specific Size
- ❑ Low Cost Sonotrode

(2 inch Pipe Shown)

