EWI Advanced Ultrasonics

Capabilities Overview

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Overview

- Introduction to High Power Ultrasonics (HPU)
- Materials joining applications
- Allied Technologies
- Wrap Up
- Lab tour - demonstrations
High-Power Ultrasonics (HPU)

- HPU ... application of intense (i.e., high-power), high-frequency (i.e., ultrasonic) acoustic energy to create change in materials and processes.
- Transducer – is the engine/heart of HPU

Ultrasonic energy causes change in Material or Process
US Transducer (Converter)

- Transducer is responsible for converting electrical energy into intense acoustical energy
- Typical frequency ranges of 15- to 60-kHz
- Power ranges of 500-W to 5-kW
- Output displacement between 5- and 45-µm
Transmitting Acoustical Energy

- **Ultrasonic Stack**
  - Means of introducing vibrations to the material/process
    - Transducer – produces vibrations at small displacements
    - Booster – provides means of holding and amplification
    - Sonotrode – delivers vibrations to material or process, but also allows for amplification as well
Controlling the Process

- **Transducer** = heart of system
  - Power Supply = brains of system
  - Controls frequency
    - Transducer establishes Fq, and can’t be changed
  - Controls amplitude
  - Process control methods
    - Continuous
    - Time
    - Energy
    - Distance / Collapse
Some Applications of HPU

- Agglomeration, coagulation of particulates
- Atomization – combustion, humidification
- Biological – cell disruption, …
- Casting (see metal processing, molten)
- Chemical/sonochemical processing
- Cleaning
- Communion
- Compaction, consolidation
- Cutting, drilling, machining
- Defoaming
- Drying
- Emulsification/dispersion
- Filtering, sieving, separation, flow enhancement
- Food processing – cutting, drying, …
- Forming of materials (see also metals)
- Joining-welding, soldering
- Liquid processing (non chemical)
- Medical – surgical, therapeutic
- Metal processing – molten metals
  - Melt degassing
  - Solidification
  - Crystal growth
  - Composites
  - Atomization (powdered metals)
- Metal processing – solid metals
  - Forming
  - Heat treatment, annealing
  - Surface hardening
- Mineral processing
  - Flotation, emulsification
  - Disintegration of minerals, surface films
  - Defrothing, dehydration of ores
  - Hydrometallurgy
- Mixing
- Motors, ultrasonic
- Stress relief
- Surface treatment, cladding, plating
- Testing – erosion, fatigue, hardness
- Transport/positioning – uses of levitation
Materials Joining Applications

- High Power Ultrasonics at EWI

UPW

UMJ

US/B

UAM

UMW
UMW

- Solid-state bond, low heat input
- Common applications: Al, Cu, & Ni
- Electronics, aerospace, automotive
- Thick-thin & multiple layer
- Dissimilar materials
- Welds through contaminants & oxides
UMW Welding Equipment

Lateral Drive System

Wedge- Reed System
Additional UMW Processes

_Torsion Welder_

_Torsional Motion_

_Parts_

_Anvil_

_Seam Welder_

_Rotating Transducer_

_Parts_

_Anvil_

_Vibration_
Introduction to UPW

- **A process in which**
  
  ...Low amplitude, high frequency mechanical vibrations are introduced to components to locally heat via intermolecular friction to encourage melt flow at the weld interface

- **Equipment**
  - Press configuration, but very similar to UMW equipment

- **Benefits / Advantages**
  - Very fast process
  - Advanced, modern equipment with sophisticated control and monitoring features
  - Ideal for small to medium size parts
  - Versatility
  - Can be automated
Sample Applications
EWI’s Competitive Value

- We don’t build equipment, sell equipment, or service equipment
- We do process development, tooling development, and weldability / test programs
- Industrial applications are seldom designed around available equipment, but rather value provided to consumer through the end product
- Strengths – metallurgy, modeling, design, controls, access to wide range of equipment, testing, collaboration with integrators
Introduction to UAM

- a new technology – “UAM” uses solid state ultrasonic metal welding (UMW) to create net-shape solid metal parts
Process, Operation

CAD Model → Machine Code → Fabrication
Applications

- Range of emerging applications: rapid prototyping, low volume tooling, direct parts manufacture, tailored materials, MMC, embedded fibers, smart materials, sensors, cladding, armor, thermal management

- Embedded Ni Tape
  - 0.003" Diameter NiTi Wire (400X)
Ultrasonic soldering is the process of pretinning or metallizing the surface of almost any given material using an ultrasonic sonotrode instead of flux.

EWI has patented an active solder alloy, SonicSolder™, to work in conjunction with the ultrasonic soldering process.
EWI patented Sn-based soldering alloy for difficult-to-wet material
- Lead free
- Solders difficult-to-wet materials
- Eliminates need for corrosive fluxes and resulting fumes
- Selectively solders complex shapes with greater process control
- Can cover very large or small areas
- Process can be automated to achieve repeatability

- Ti 6-4
- Al 2219
- 25-mm SiC to Ti-6-4 or Al
- Carbon Fiber Tinning
- Glass-to-Metal Joint
- Heavily Oxidized Metals
HPU ... application of intense, high-frequency acoustic energy to change materials, processes.
Development of UM Systems

- Drill head
- Knee mill
- Dukane 20kHz, 5kW power supply
- Laptop for control of drives, US, and data collection
Prototype units fabricated
- Tested against design criteria
  - Frequency = 20kHz
  - Amplitude = 7-15µm
  - Driving power = 50 watts
- Confirmation of driving mode
- Vibration characteristics
  - Effects of transmitting vibration throughout the body and attachment mechanism

Patent Pending
Research conducted for enhancing forming/forging processes

- Objective – reduce forces required to pull plates stock through dies through use of acoustic vibrations
Series of test conducted with various forces, amplitude, velocity, and temperature ranges
Allied Technologies - UWD

- Center Draw Transducer
- Rigid Mount Booster
- Coupler
- Sonotrode/Die System
UWD - Results

- Typical results – major force reductions
The use of HPU has been extended to every market through a diverse range of applications.

While the processes may be drastically different, every system relies on the transducer, power supply, and some form of transmission line.

What makes the ultrasonic team at EWI unique:
- Strong foundation of technical knowledge
- Strength in process development
- Broad application experience
- Complimented by excellent engineering staff
- Maintain focus on providing innovative solutions for challenging applications
- Our solutions are not limited by what has already been done or exists
Since the early 1980s, EWI has helped manufacturers in the energy, defense, transportation, construction, and consumer goods industries improve their productivity, time to market, and profitability through innovative materials joining and allied technologies. Today, we also operate a variety of centers and consortia to advance U.S. manufacturing through public/private cooperation.