ULTRASONIC
Welding and cutting technology

Ultrasonic Plastic Welding

Presenter

Bill Aurand - Sales Manager

Who is Rinco Ultrasonics?

- Rinco is a team of **<u>Ultrasonic Experts</u>** with a sole focus on ultrasonic welding.
- Established in Switzerland in 1976, Rinco employs about 150 people, worldwide.
- Rinco Ultrasonics' standard equipment is all manufactured at our headquarters in Romanshorn, Switzerland.

Who is The Crest Group?

THE CREST GROUP

Worldwide leader in ultrasonic technologies

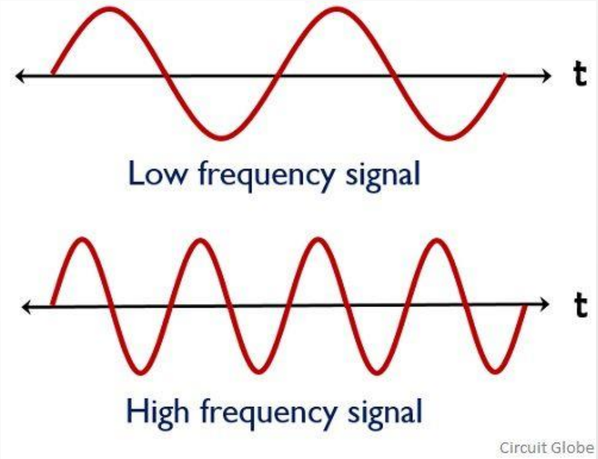
- The Crest Group is a global company with nearly 1000 employees and customers in more than 100 countries.
- Founded in 1961, Crest is an American Company with headquarters in Trenton, New Jersey.
- The Crest Group is the largest privately held company in the ultrasonic industry.

Basic Theory

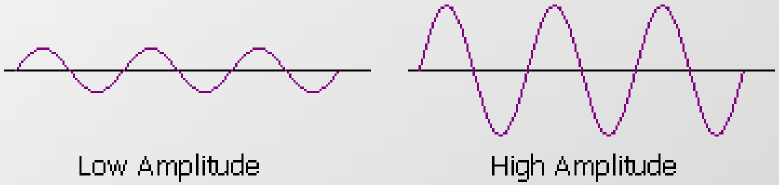
First – let's get clear on some industry terms

Process Terminology/Definitions

FREQUENCY:
Frequency is the rate at which the Converter/Booster/Horn assembly expands and contracts (35,000 vibrations per second for 35kHz or 20,000 vibrations per second for 20kHz)



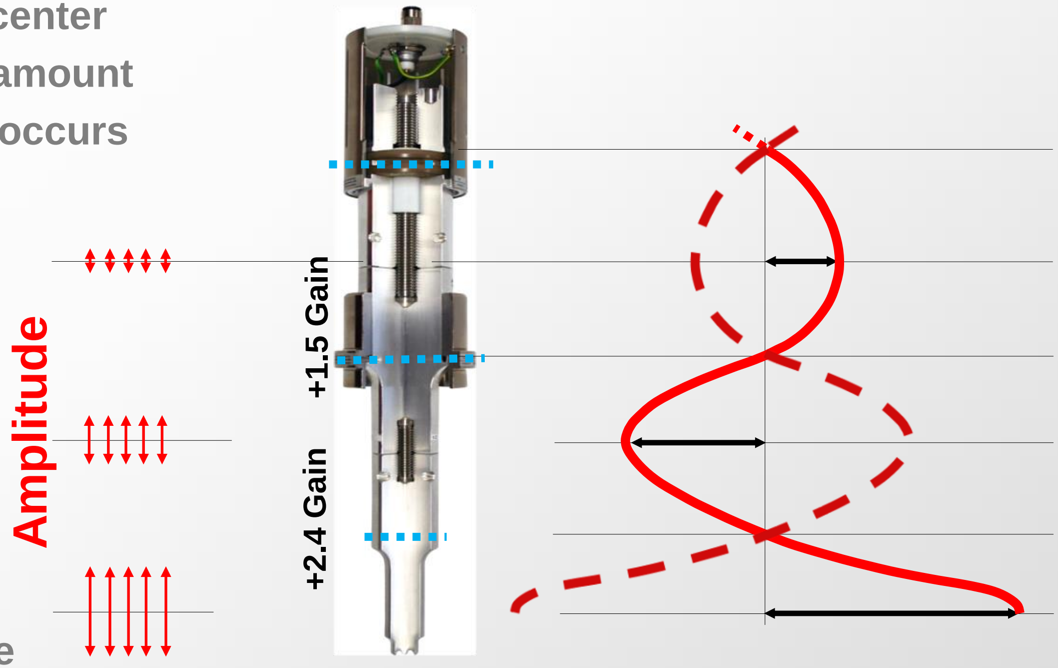
AMPLITUDE:
Amplitude refers to the specific distance that the face of a vibrating component travels during expansion and contraction. Typical welding amplitude requirements are between 30µm and 100µm (peak-to-peak) at the horn surface, depending upon the frequency and plastic material being bonded.



Process Terminology/Definitions

NODAL PLANE:

The Nodal Plane is the point near the center of each vibrating tool where the least amount of longitudinal expansion/contraction occurs and the greatest amount of radial expansion/contraction occurs.



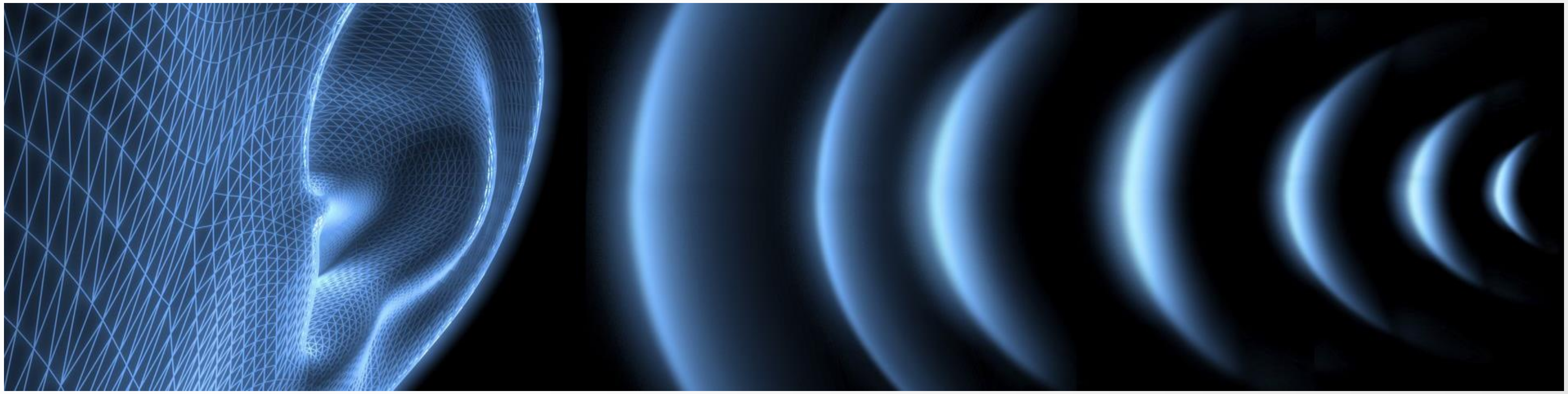
GAIN:

Gain is the term used to described the amplification factor of a booster or horn. Gain is determined by the mass ratio on opposing sides of the nodal plane.

What is Ultrasound

Definition: Ultrasound is accoustical vibration above the range of human hearing.

Most people can hear frequencies as low as 20Hz and as high as 20kHz.



Rinco utilizes the following frequencies for various ultrasonic welding applications: 20kHz, 30kHz, 35kHz, 40kHz and 70kHz

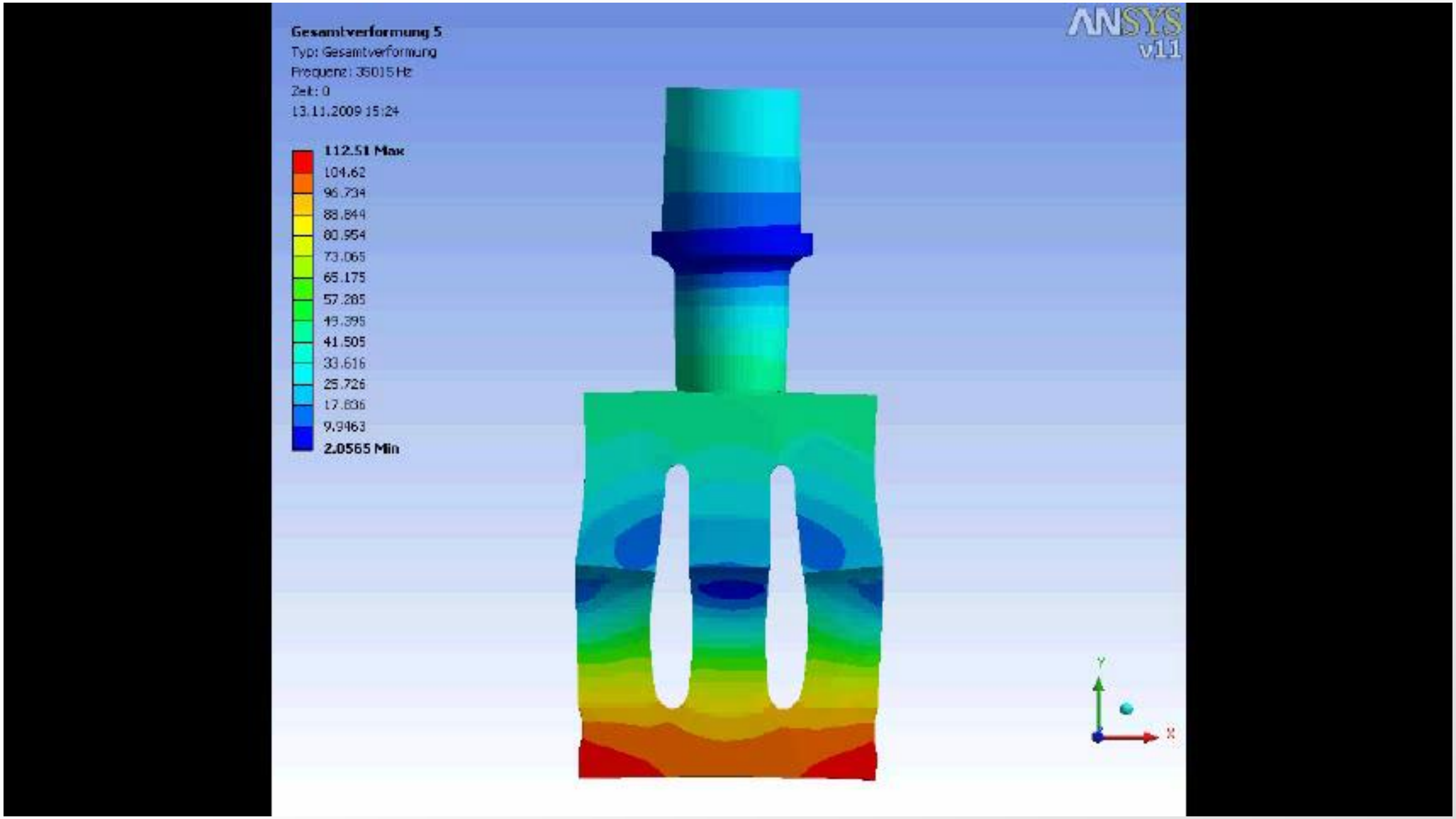
20kHz and 35kHz are the most commonly used frequencies, worldwide.

What is Ultrasonic Welding

What is Ultrasonic Sealing?

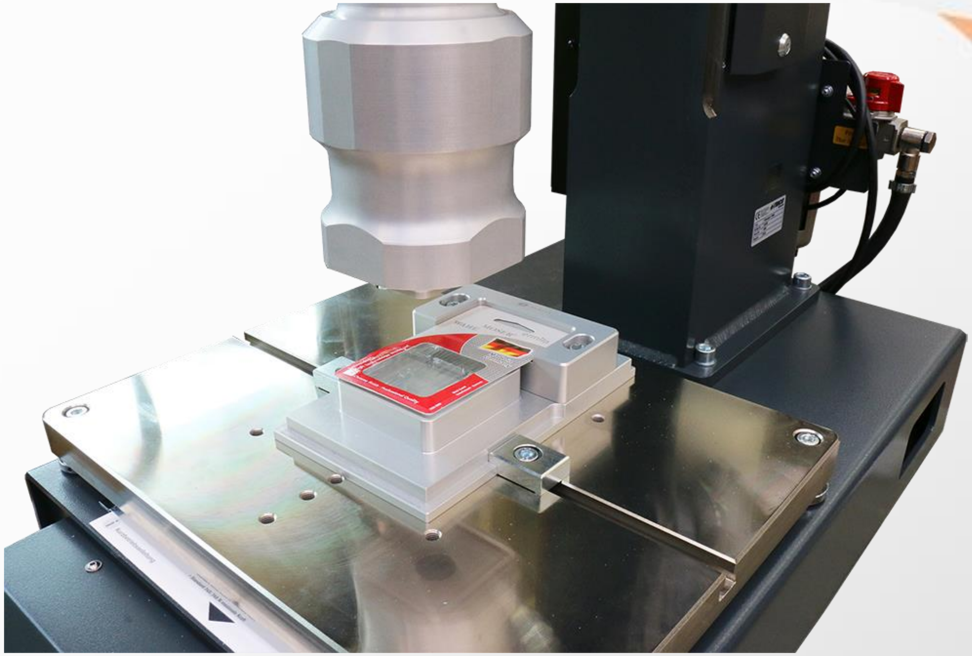
A secondary assembly process whereby high-frequency vibration (compression/decompression cycles) applied to thermoplastic materials create intermolecular frictional heat, resulting in a molecular bond.

Understanding The Vibration



The Basic Premise

Ultrasonic welding technology is based upon the physics of sound waves in solid bodies.



The upper (vibrating) tool, known as the horn, contacts the plastic parts and begins to develop force. Vibration begins when a trigger force is reached. The horn couples with the top plastic part (vibrating in phase), causing the plastic pieces to vibrate against one another (vibrating out of phase) at the joint zone. The energy generated by this vibration causes the material to melt, creating a molecular bond between the plastic pieces.

Sequence of Events

1. **Tool infeed (downstroke)**
   Downward stroke of the weld head until the horn makes contact with the object to be welded.

2. **Force buildup (trigger)**
   Increase of force applied to the part until a predetermined ultrasonic trigger force is reached.

3. **Inital melting (weld)**
   Vibration is initiated causing plastification of the polymer under force and vibration.

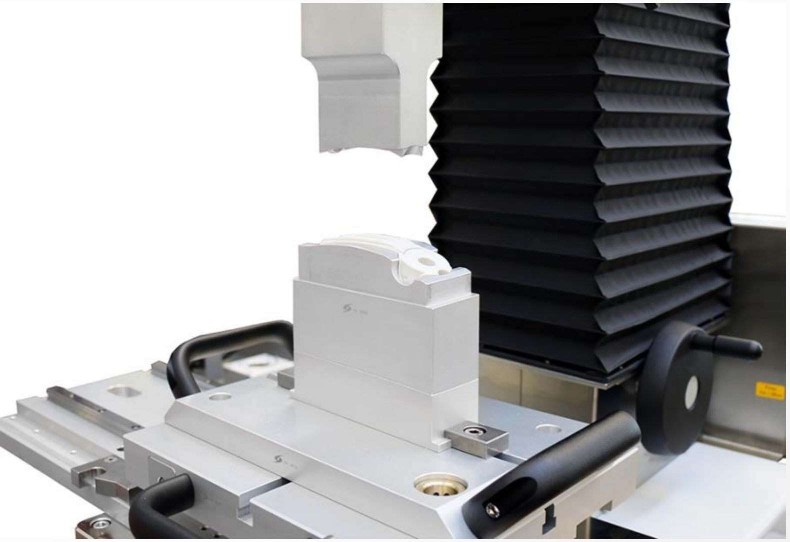
5. **Solidification (hold)**
   After vibration ceases, solidification of the molten plastic occurs while maintaining clamp force.

6. **Return stroke (upstroke)**
   Return of the horn to the home position.

Process Variables

The ultrasonic welding process is subject to three primary variables: **Weld Force**, **Weld Amplitude**, and **Weld Duration**.

- Weld Force – Clamping pressure supplied by an actuator
- Weld Amplitude – Distance of vibration at the horn face
- Weld *Duration **-** How long the horn vibrates on the part



***One primary weld parameter is chosen to determine the duration of vibration. Common weld parameters are:**

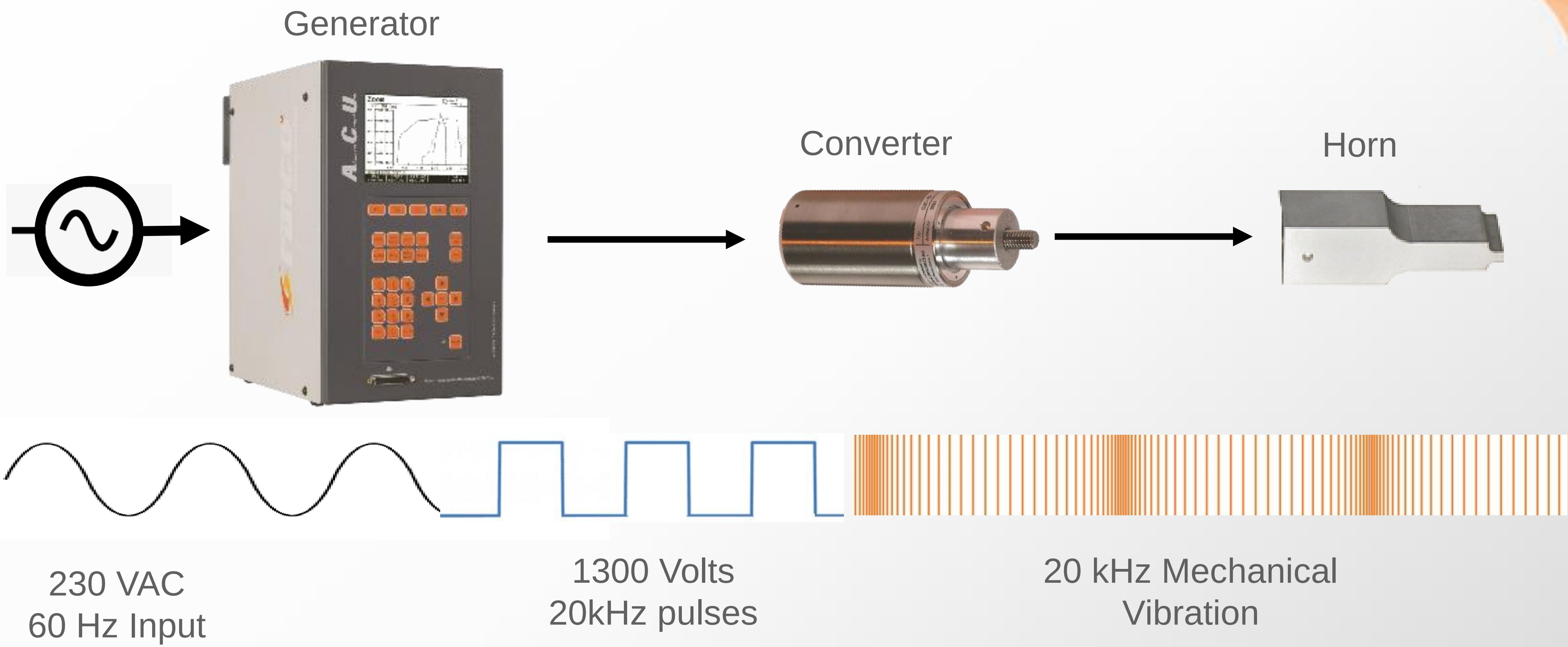
- Time
- Travel (welding depth)
- Energy

These parameters are often refered to as welding modes.

Questions about the Ultrasonic Welding Process?

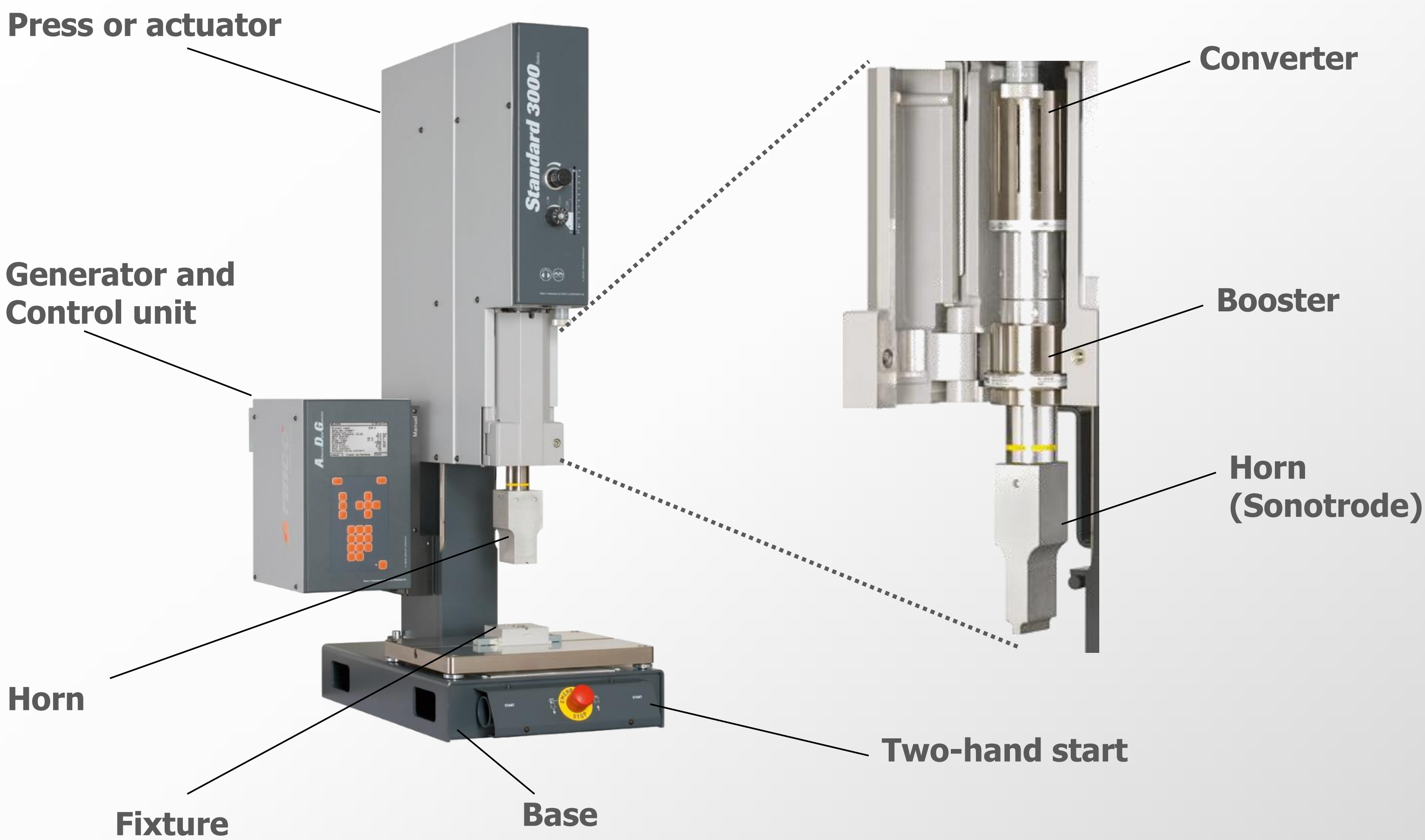
Components of an ultrasonic welding system

Electrical to Mechanical



The generator converts 230V AC input into a high frequency electrical signal. This is transmitted to the Piezo elements in the converter. These Piezo elements expand when voltage is applied, converting the electrical energy into mechanical motion. This produces a standing wave with maximum amplitude at the end face surfaces.

System Components

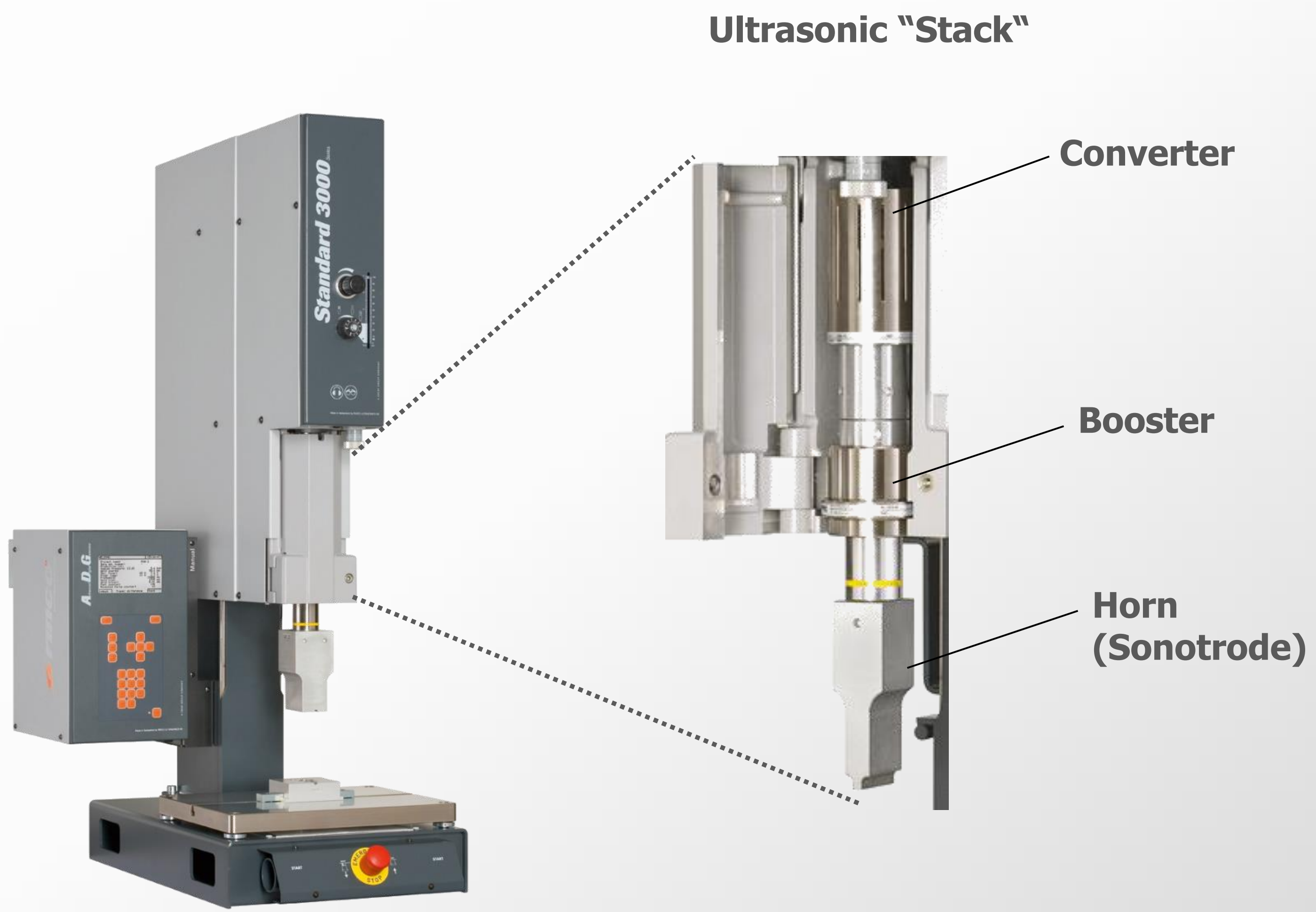


Generator

Ultrasonic generators convert 230VAC current into a high voltage, high frequency electrical signal that is delivered to the system via the RF cable.

Generators can be a part of a sophisticated process controller or as simple as a PC board.

System Components



Ultrasonic Stack

Converter

Booster (1:2)

Horn (1:2)

Converter

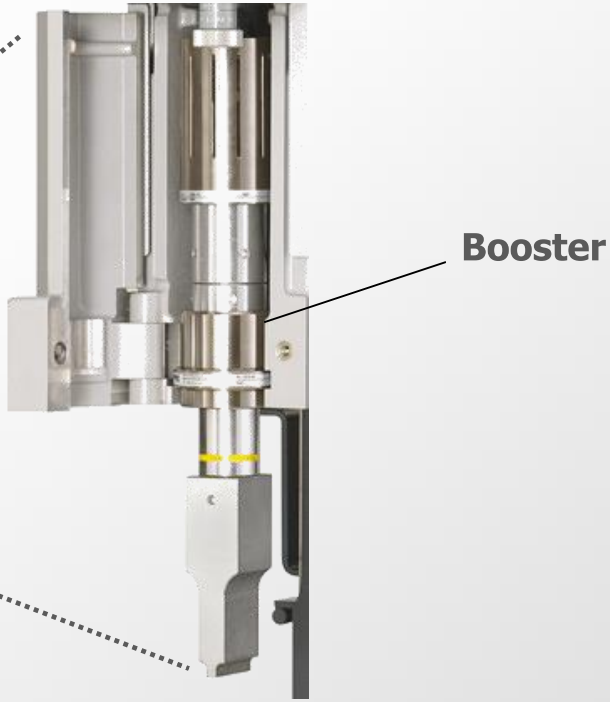
Within the converter, piezoelectric ceramic discs compressed between front and rear drivers expand when a high voltage pulse from the generator is applied, producing mechanical movement.

A typical 20kHz converter produces about 20 microns of amplitude.

A typical 35kHz converter produces about 12 microns of amplitude.

Note: A converter functions in both directions. For this reason, metal to metal contact should be avoided.

System Components



Ultrasonic Stack

The output amplitude supplied by the converter is too low to weld plastic parts and must be amplified.

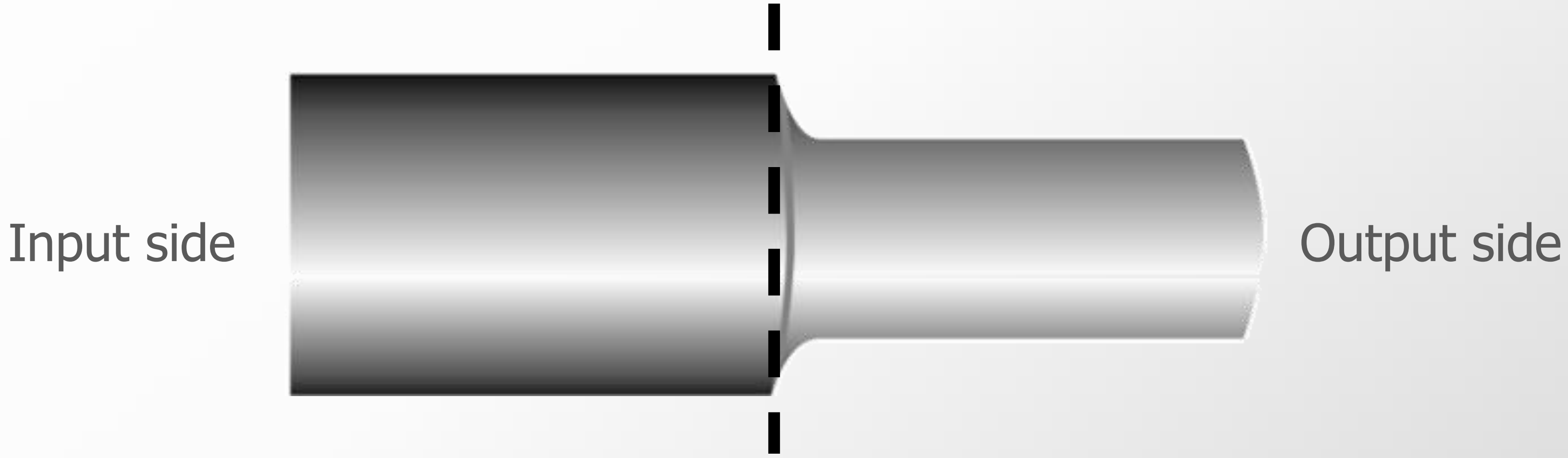
A booster contains no moving parts. Instead it functions based on its Geometry with respect to the node.

Booster:

Horn:

Ultrasonic Stack

The gain factor of an ultrasonic booster or horn is determined by the mass ratio on either side of the node. Greater mass on the input side of the node results in increased amplitude. Greater mass on the output side of the node results in decreased amplitude.



Boosters

In addition to adjusting the amplitude from the converter, boosters also provide the primary clamping point on the vibrating components (ultrasonic stack).

Note: Rinco generators are also capable of increasing or decreasing the process amplitude via a digital setting, eliminating the need for multiple boosters.

Competitive Boosters

Rigid-mount Rinco boosters and converters are designed to be disassembled using the press as a clamp.

It is important to note that competitive stacks **MUST** be removed from the press for disassembly.

System Components

Horn

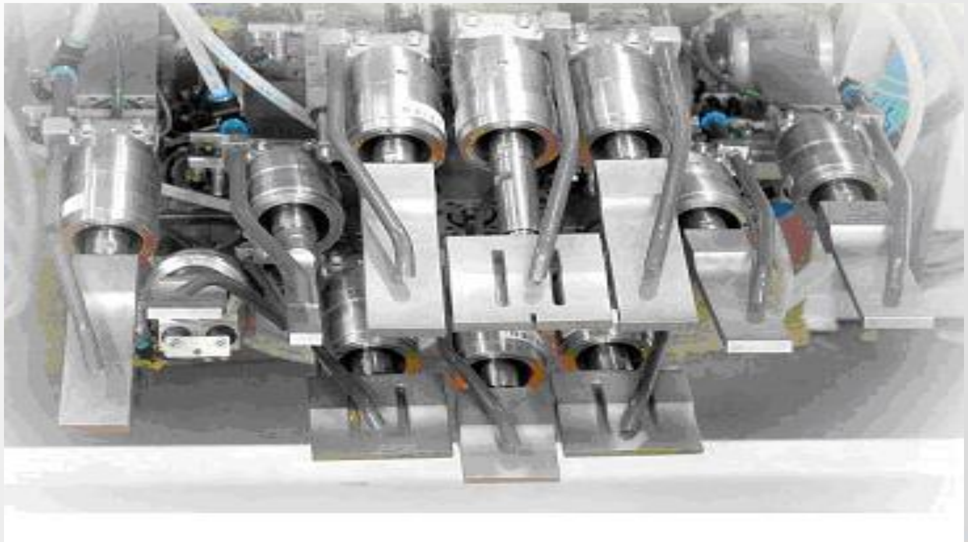
Horn (Sonotrode)

Ultrasonic Horns

Ultrasonic Horns are acoustical tools, custom-designed and tuned for each application.

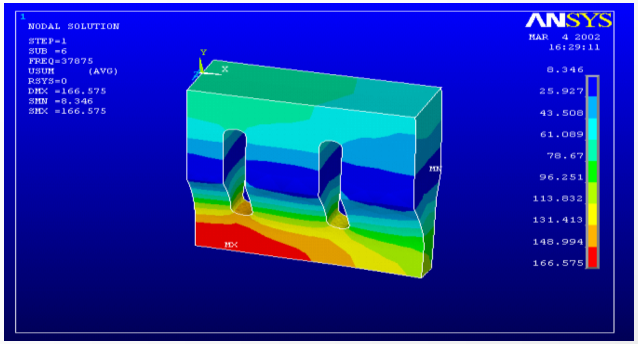
Horns transfer the ultrasonic vibration to the parts under a controlled amount of force provided by some sort of actuator.

Horns are usually designed with a specific gain in order to produce the proper amplitude for the application.



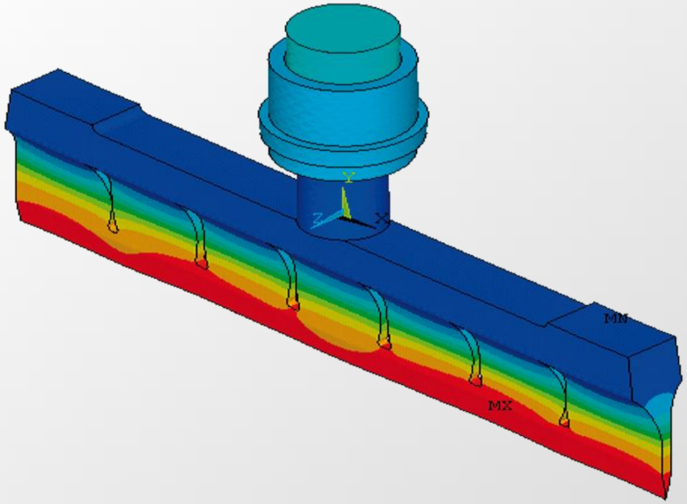
Ultrasonic Horns

Finite Element Analysis (FEA) computer modeling systems are used for state-of-the-art horn design.



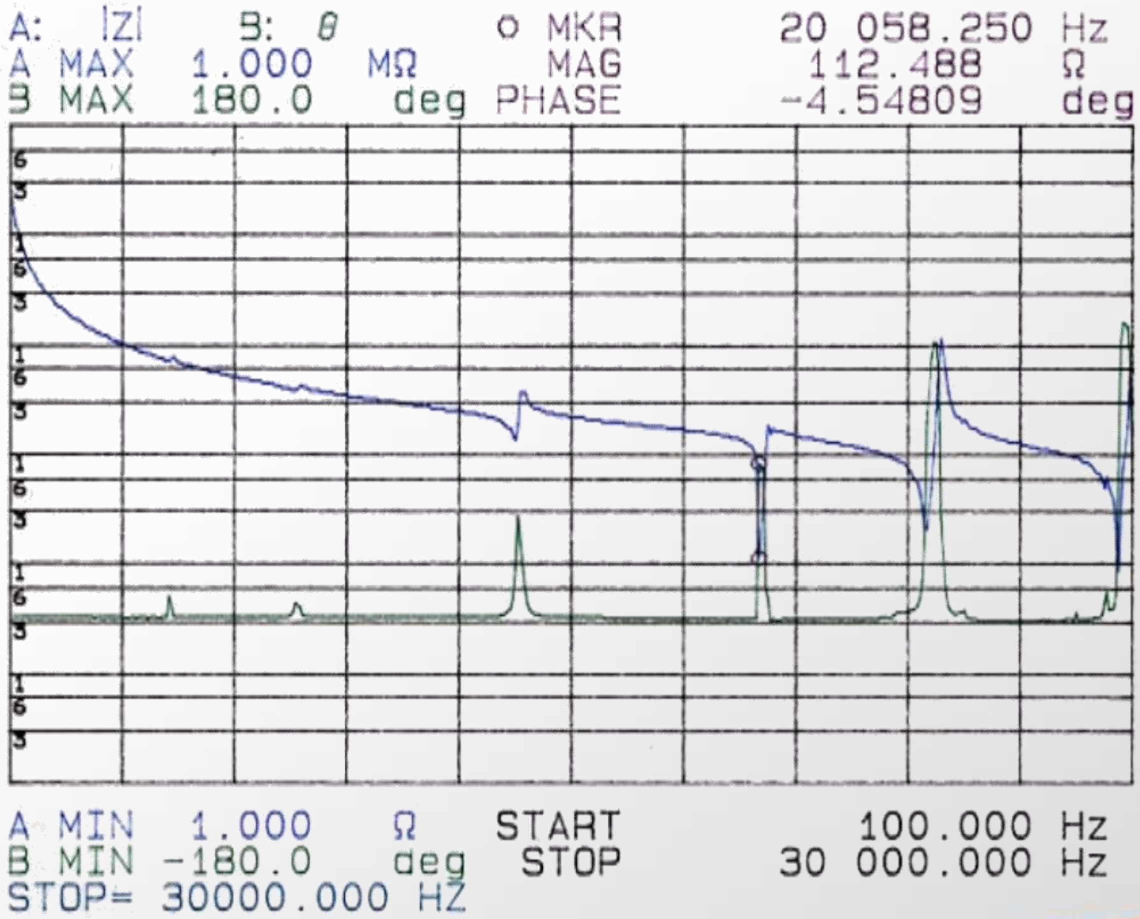
FEA allows us to:

- Minimize the mechanical stress in the horn, providing longer tool life.
- Create horns with even amplitude distribution throughout the entire weld surface.
- Optimize the resonance of a horn by eliminating secondary frequencies that would cause the horn to vibrate in an unproductive mode.



Ultrasonic Horns

Rinco horns are analyzed using sophisticated measurement technology to confirm their functional capability.



Ultrasonic Horns

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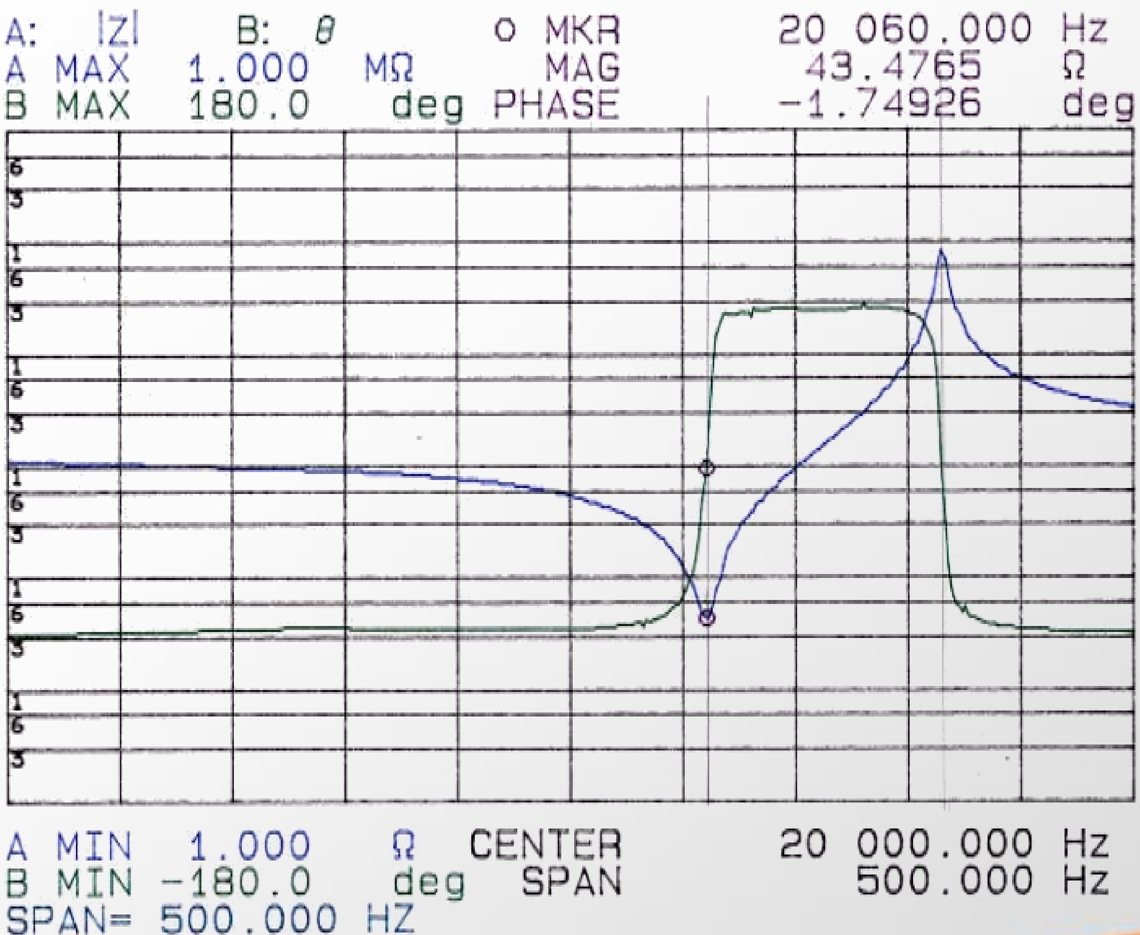
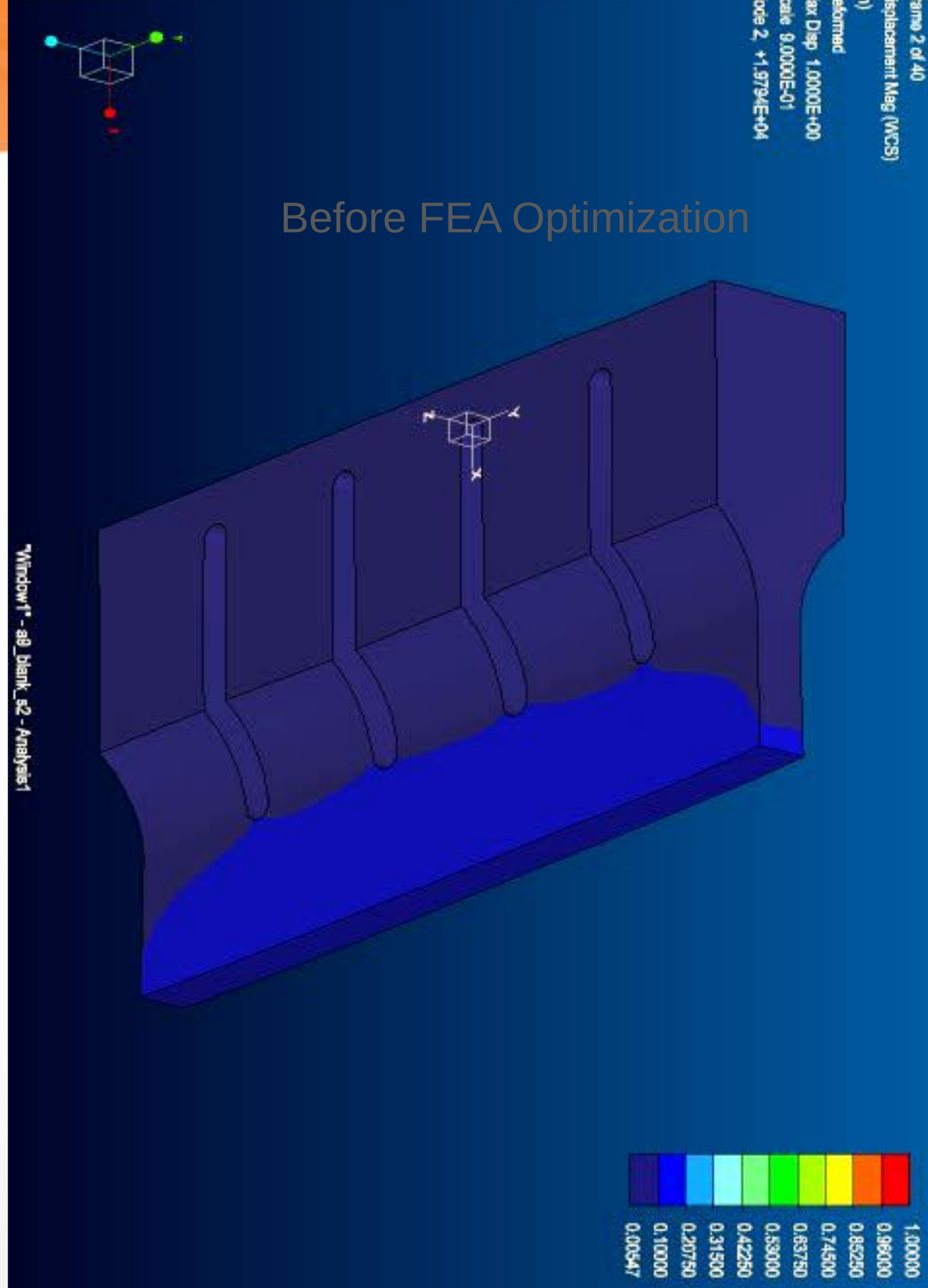
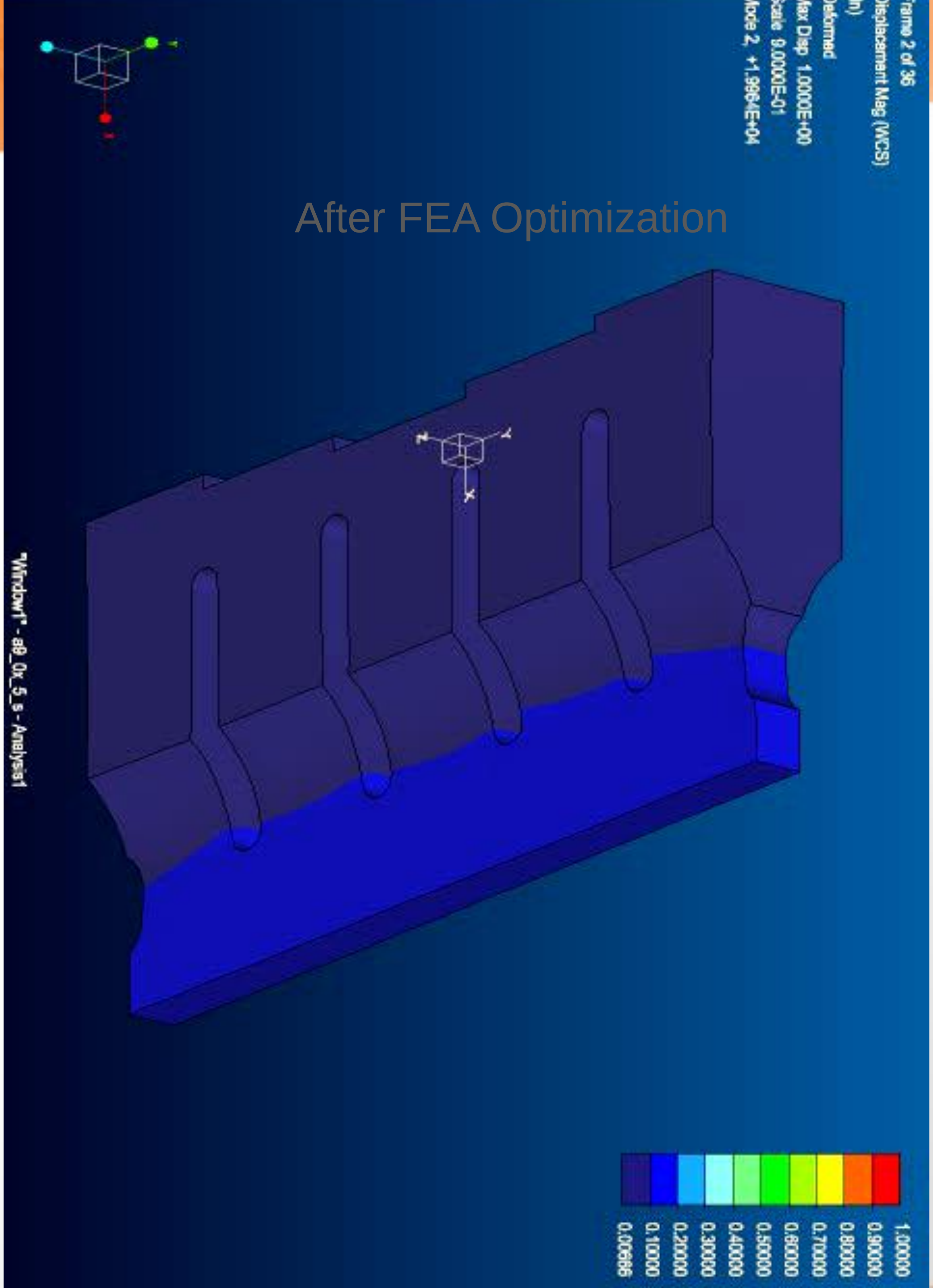
- Optimized Resonance Frequency (elimination of secondary frequencies)



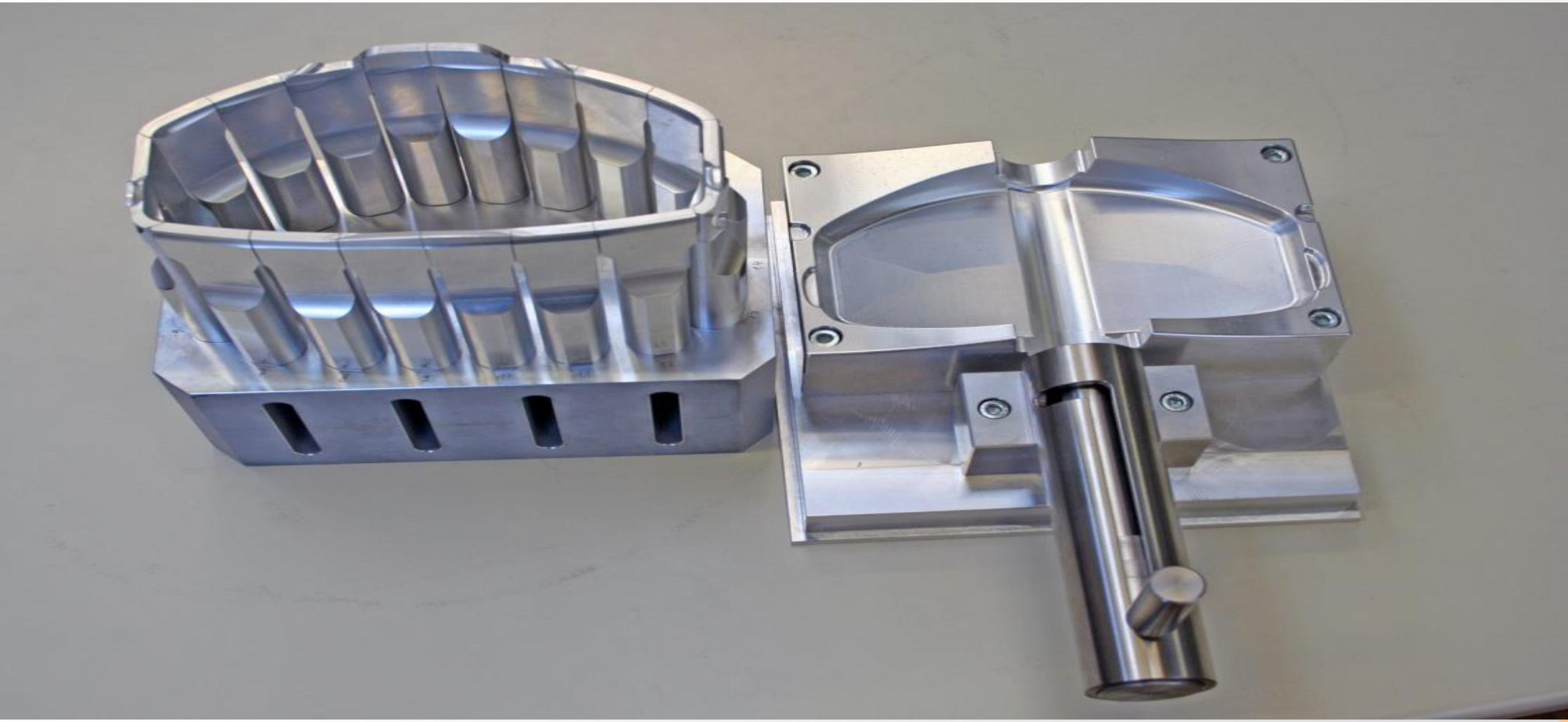
Before FEA Optimization



After FEA Optimization



Ultrasonic Horns



Ultrasonic Applications

Ultrasonic technology is utilized wherever thermoplastic products exist and even some applications without thermoplastics.

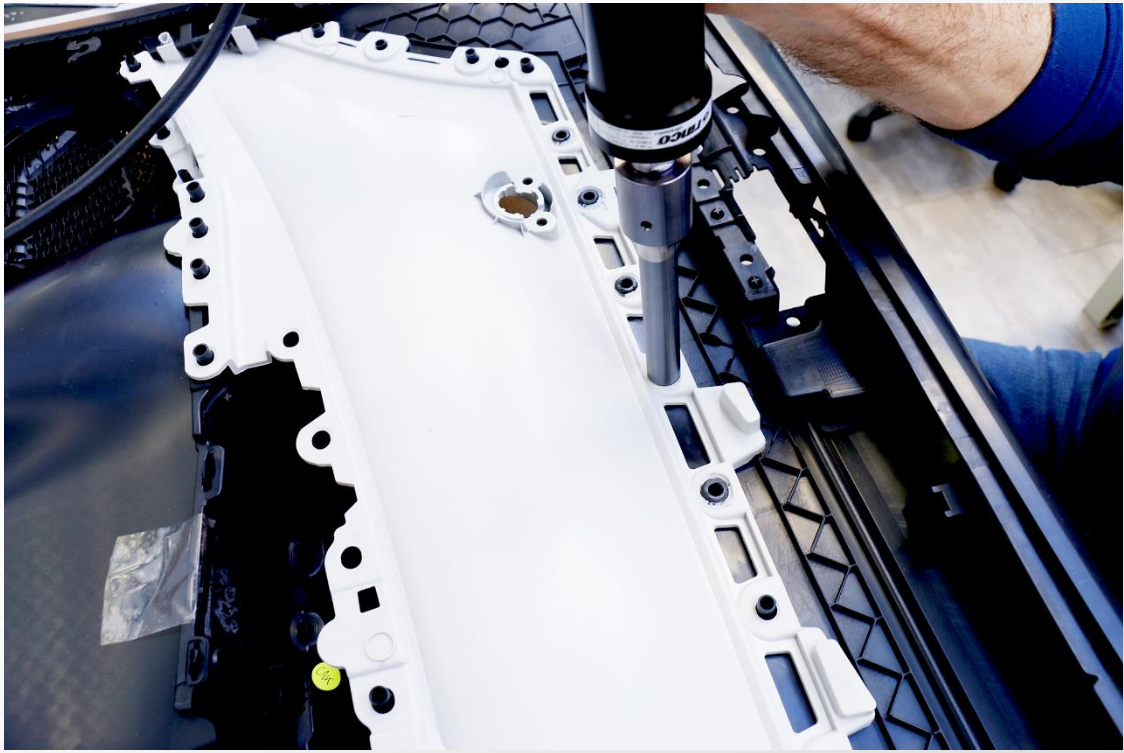
Ultrasonic Applications

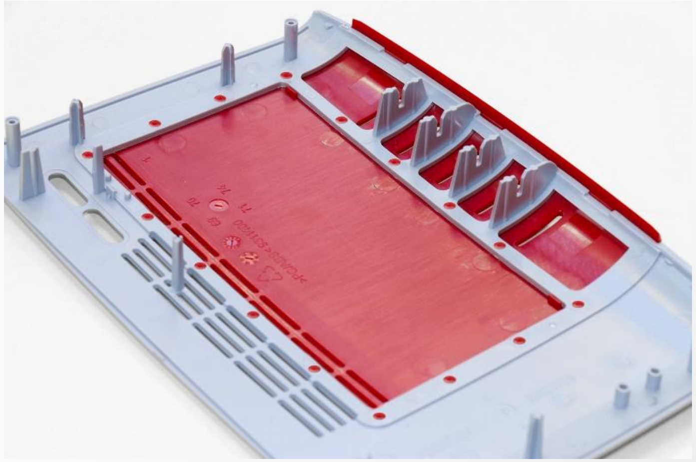
rinco ultrasonics

Rigid Part Welding

Ultrasonic Applications

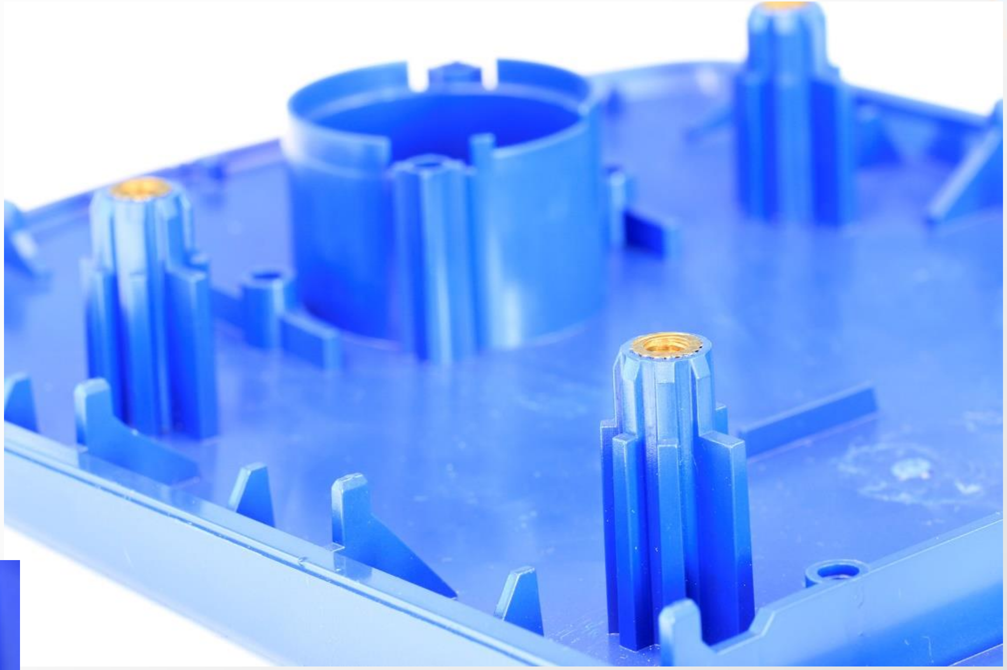
Assembling dissimilar plastic parts

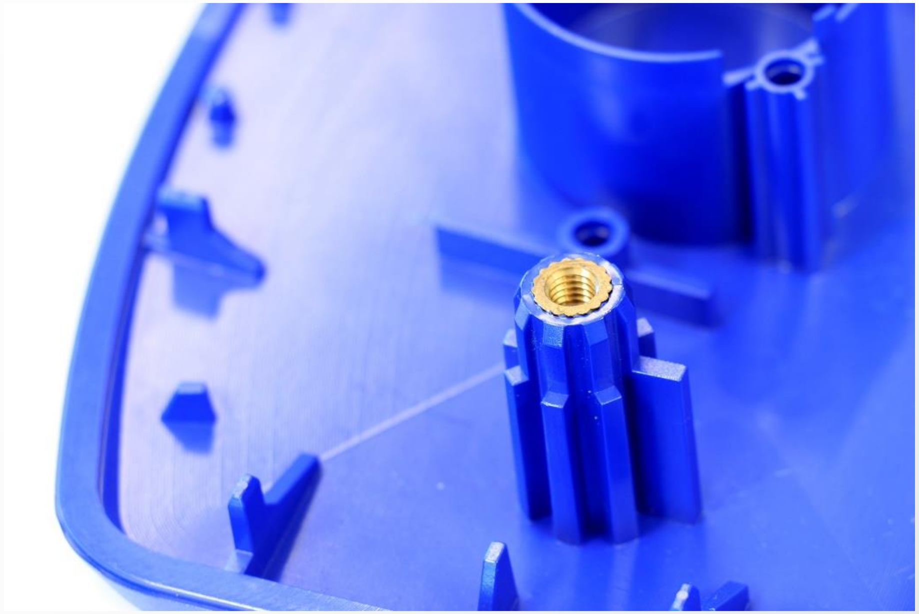




Ultrasonic Applications

Driving metal inserts



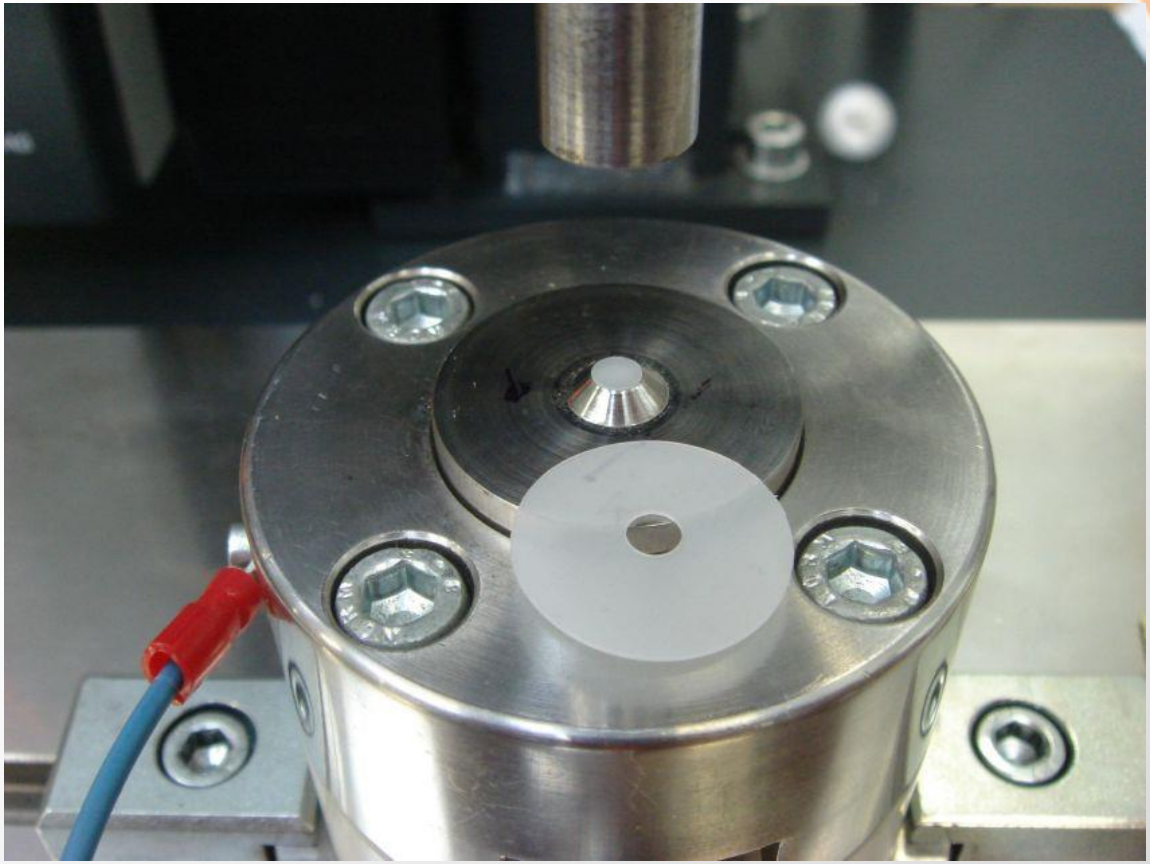


Ultrasonic Applications

Textile bonding and slitting

Ultrasonic Applications

Hole punching

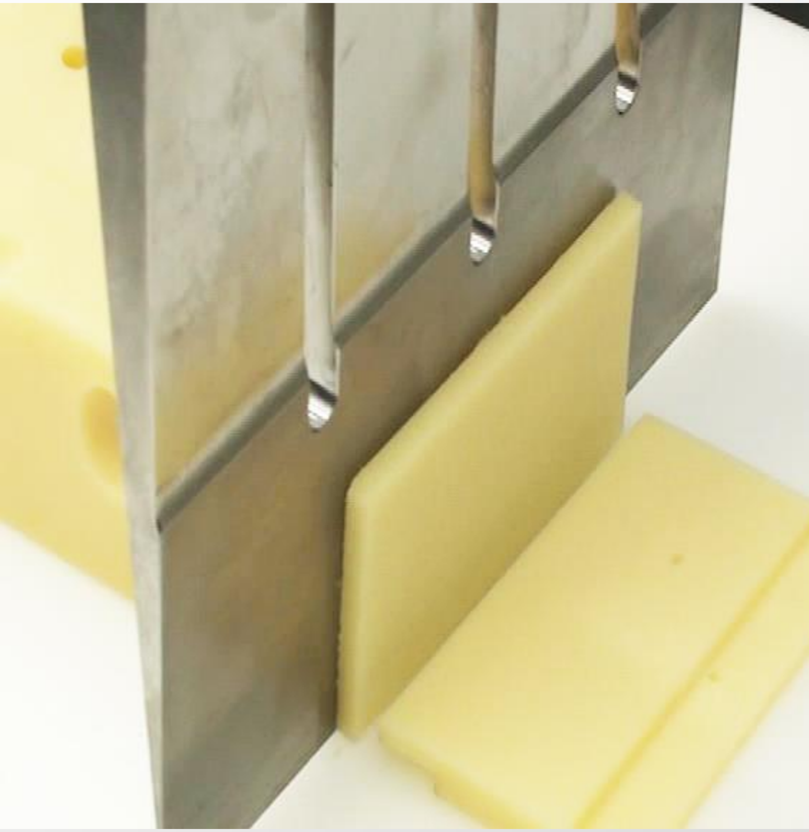


Ultrasonic Applications

Film sealing

Ultrasonic Applications

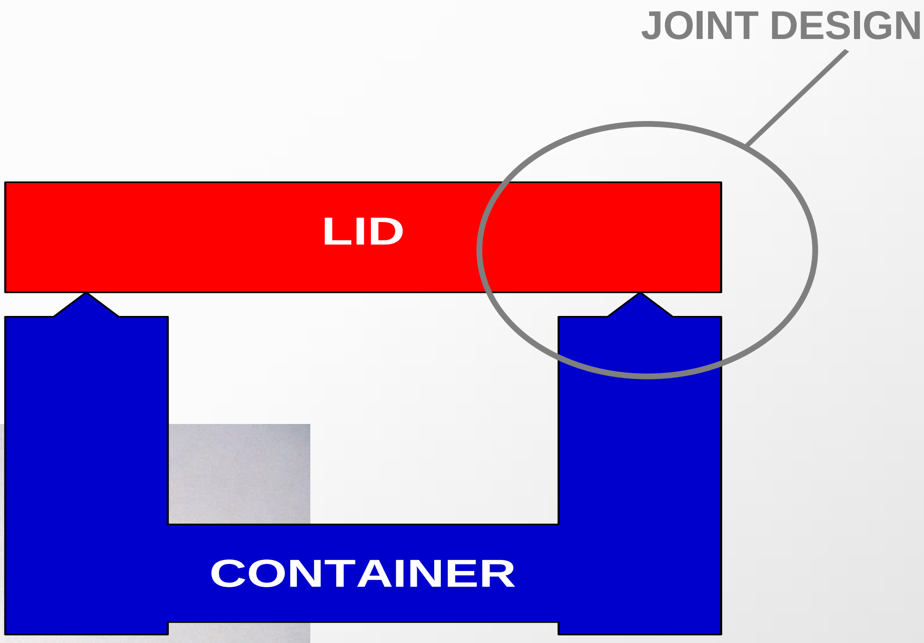
Food slicing

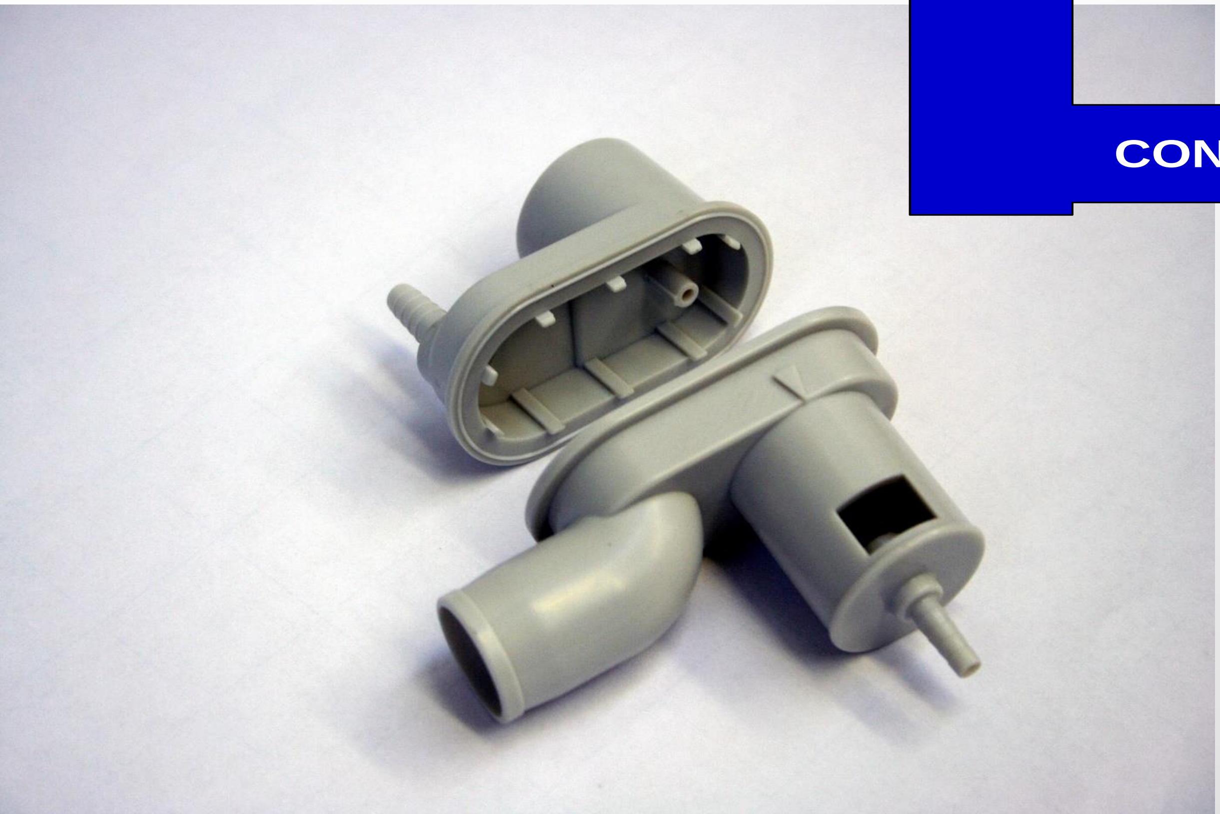


Why Use Ultrasonics?

- **Fast and Efficient -** Typical manual weld cycle times are in the 3-5 second range. Automated cycle times are usually much faster.
- **Economical** – Low investment costs and a long equipment life expectancy.
- **Wide range of applications –** Ultrasonic sealing and cutting is well suited for use with a large variety of plastic materials, part sizes and industries.
- **Very accurate welding technique -** Precision process control and micro-adjustable actuators make ultrasonic assembly a highly repeatable process.
- **Green Process** – Ultrasonic sealing is environmentaly friendly, using no additives and very low energy consumption.

Ultrasonic Joint Design





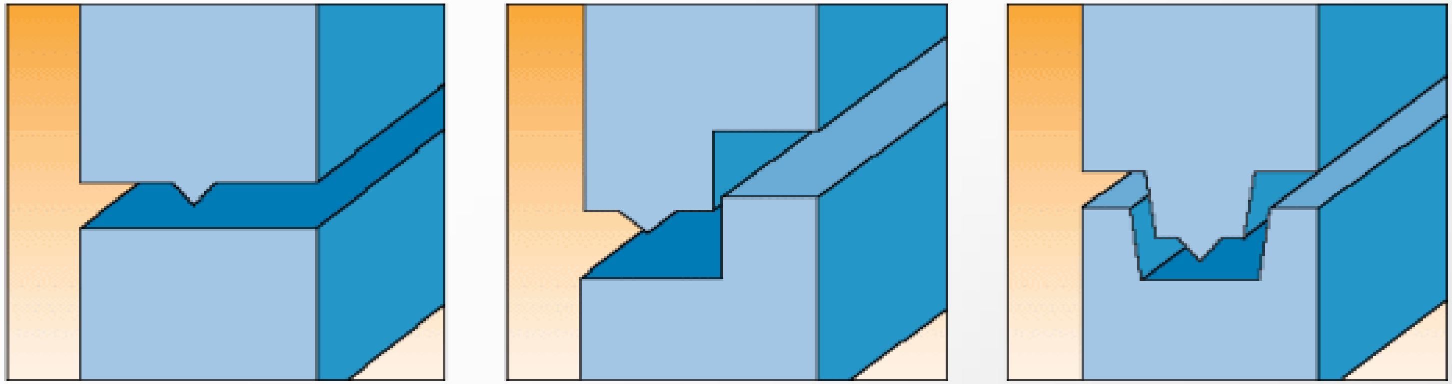
Ultrasonic Joint Design

Five requirements of an Ultrasonic Joint

- Point contact to ensure rapid melt initiation
- Robust design to support high trigger force in order to ensure complete perimeter contact
- Flash containment
- Alignment features between the plastic part halves
- Effective contact points for the horn and fixture

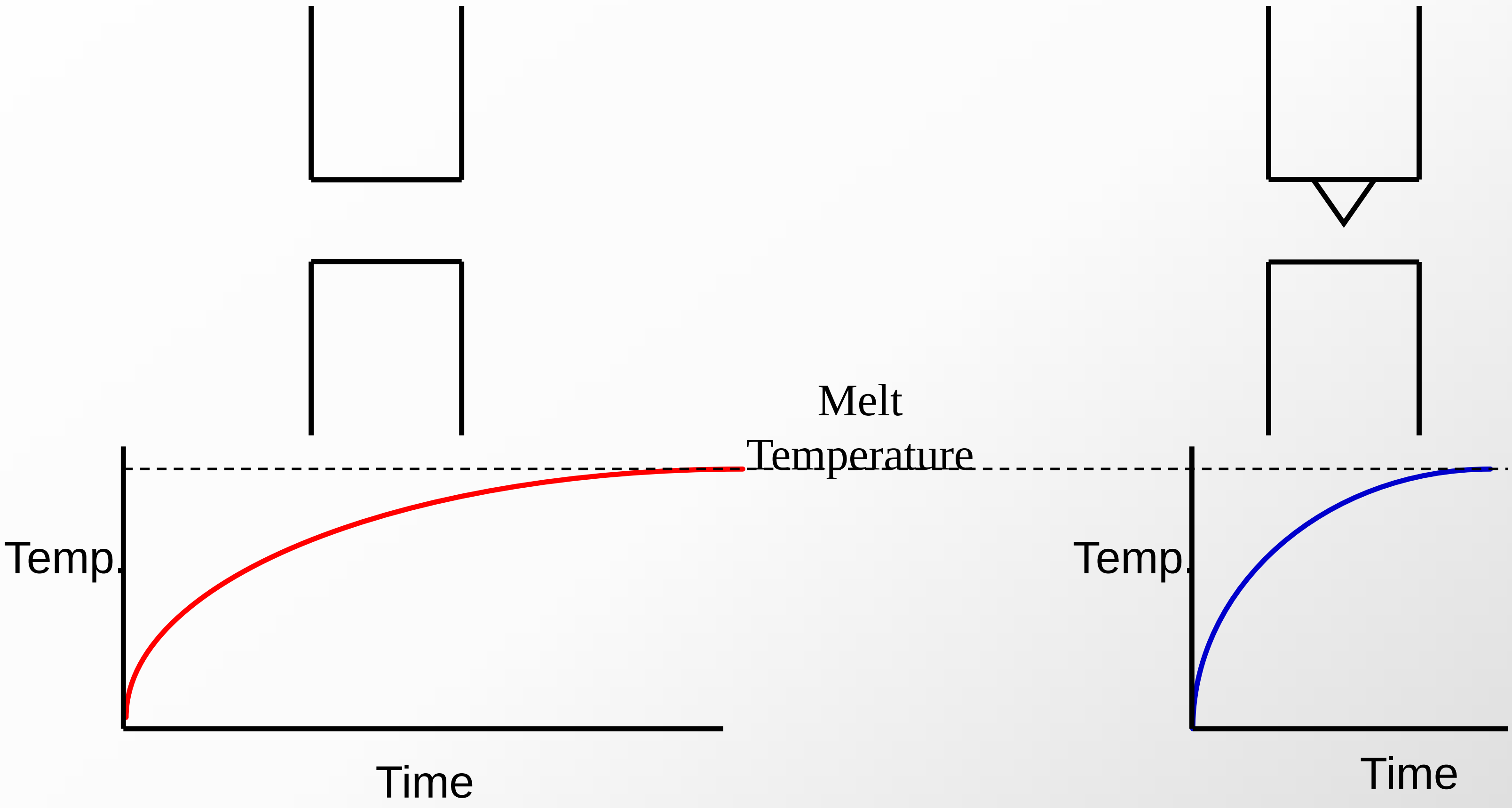
Ultrasonic Joint Design

An Energy Director is a triangular, sacrificial bead that enables rapid melt initiation by providing a focal point for the frictional energy.



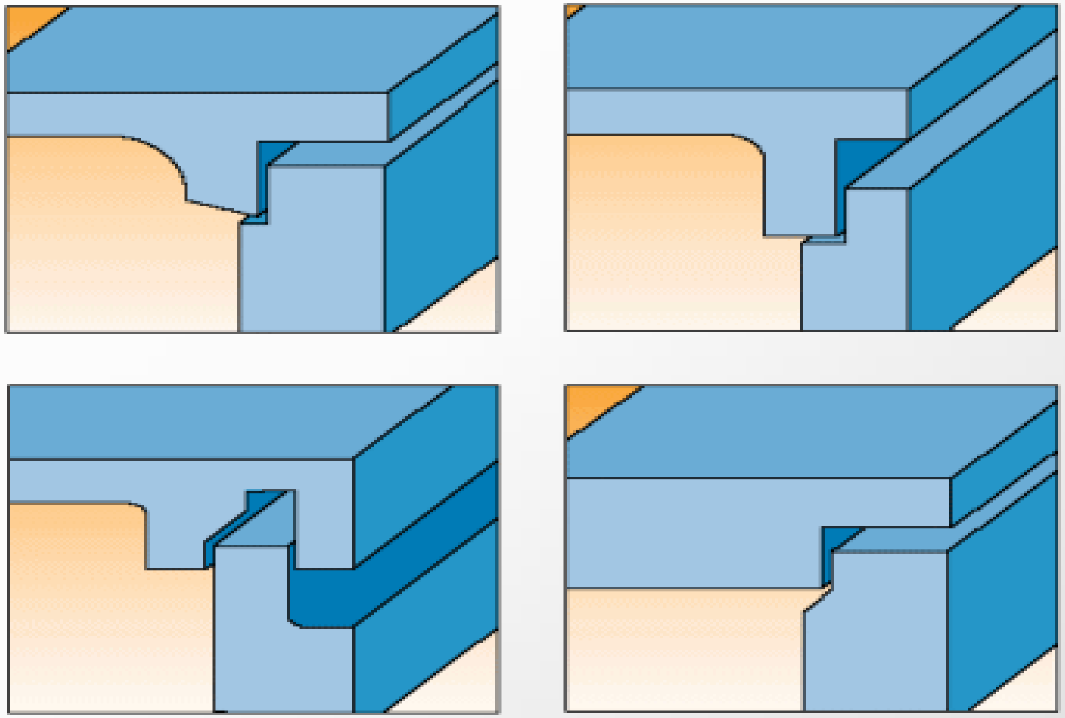
Ultrasonic Joint Design

Point Contact = Energy Director



Ultrasonic Joint Design

A Shear Joint is preferred when using semi-crystalline materials.



What’s new

New innovations in rigid plastic welding

Ultrasonic Welding Parameters

The ultrasonic welding process is subject to three primary parameters: **Weld Force**, **Weld Amplitude**, and **Weld Duration**.

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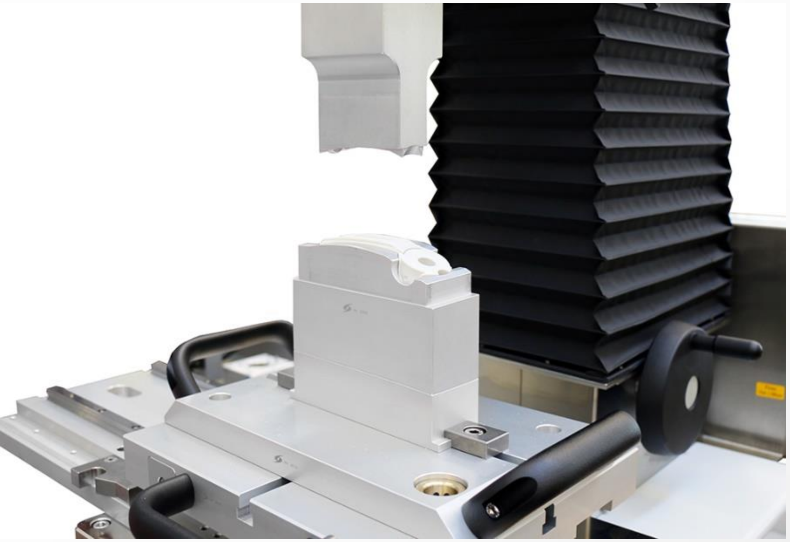
- Weld Amplitude – Distance of vibration at the horn face
- Weld Duration **-** How long the horn vibrates on the part



One primary weld parameter is chosen to determine the duration of vibration. Weld parameters are:

- Time
- Travel (welding depth)
- Energy

These parameters are often refered to as welding modes.

Servo Versus Pneumatic

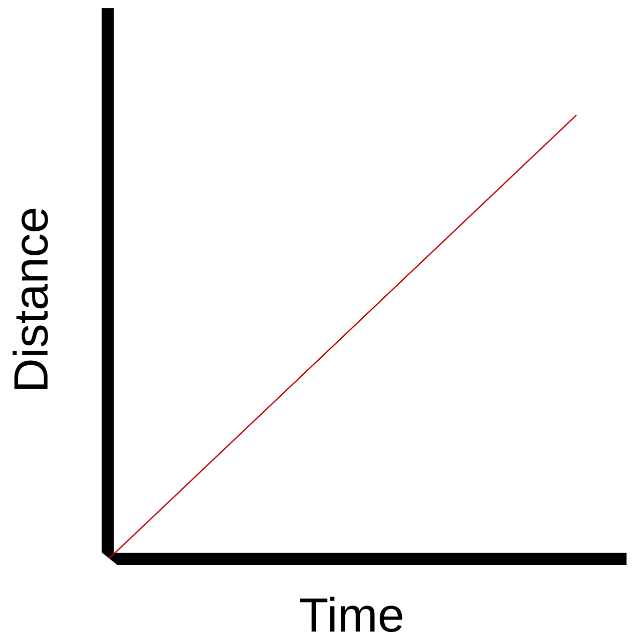
New technology servo welding systems enable a shift in the way the ultrasonic welding variables are managed. In fact, the servo drive allows the force variable to be approached in a completely different way.

- Force
  - Joining velocity versus force

Joining Velocity vs Force

Recent studies have proven that more important than the force being applied during a weld, is the joining velocity or the speed at which the part collapses.

So, rather than programming the clamp force and allow the joining velocity to fluctuate, servo welders can control the joining velocity and allow the force to fluctuate as a byproduct of the programmed collapse velocity.



Servo Versus Pneumatic

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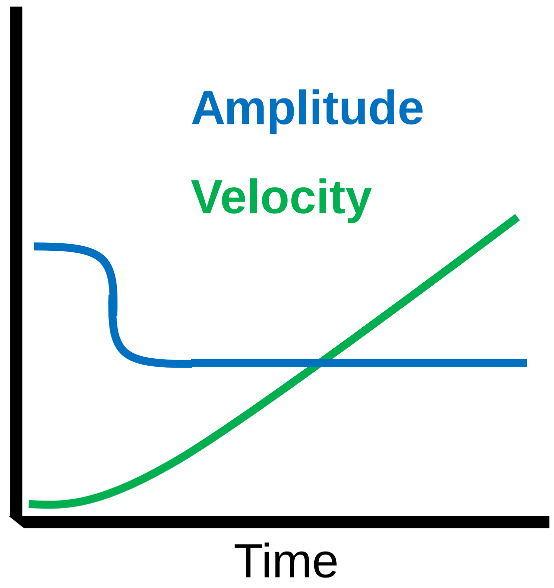
- Force
    - Joining velocity versus force
- Amplitude and Force
    - Dynamic adjustment

Joining Velocity vs Force

Due to the nearly instantaneous response of servo drive mechanisms, usable manipulation of the clamp force can now provide benefits, even on the fastest of weld cycles.



In addition to force manipulation, amplitude adjustments can also be made on the fly for complete control of the entire weld process.

Typically, high initial amplitude at low joining velocity progressing to lower amplitude and increased velocity will produce the strongest welds while simultaneously maintaining the best control of flash.

High Speed Dynamic Welding

Dynamic weld example

- Maximum speed downward stroke (50mm)
- Deceleration .2mm prior to contact
- Force buildup to 80 Newton trigger force
- Initial weld stage
  - 100% amplitude
  - 1mm/sec joining velocity
  - .1mm collapse depth
- Secondary weld stage
  - 70% amplitude
  - 2.5mm/sec joining velocity
  - .16mm collapse depth
- Solidification
  - 200ms hold time
- Maximum speed upward stroke
- Total cycle time <u>650ms</u>

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Thank You!

For additional information, contact us at:

info@rinco-usa.com