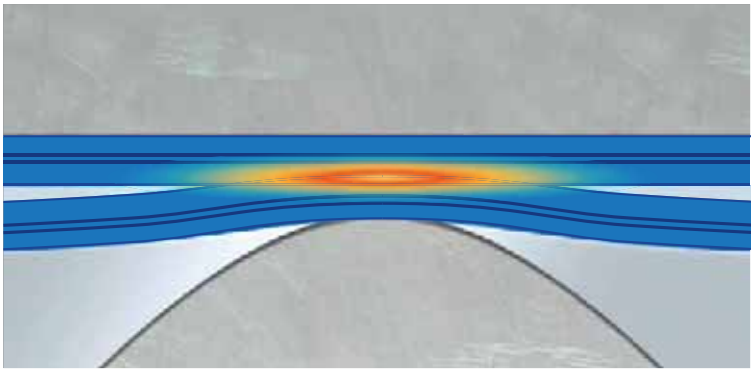


ULTRASONIC WELDING TECHNOLOGY

FUNDAMENTALS OF PACKAGING

Herrmann Ultraschall

Ultrasonic welding technology.
For packaging material with thermoplastic sealing layers.

Herrmann Ultraschall is a world-leading company in the field of ultrasonic welding. For our customers, we assume both the role consultants and application problem solvers with regards to the ultrasonic joining of packaging materials and package types. This brochure contains practical advice and introductory information for the welding of packaging materials and different packaging types by utilizing ultrasonics.

In addition to leading-technology products, we provide excellent application consulting to solve welding tasks, taking economic aspects into account. Please note that this brochure does not replace application-specific consulting that is personally provided by our experts. Contact us to make use of our expertise, benefit from our knowledge and experience and utilize our ultrasonic laboratory for the studying of your packaging materials.

Typical ultrasonic welding application examples of packaging materials from the food, medical, and consumer industries.
Detailed descriptions can be found in the Herrmann Ultraschall brochures for the respective industry.

Short weld times and repeatable weld seal results are typical of the ultrasonic welding of film, coated composite films, and packaging materials.

Ultrasonic welding is a reliable and economic alternative for typical thermal processes that ensures tight weld seals despite product contamination, repeatable and analyzable weld processes, the saving of packaging material due to smaller sealing lines, and increased OEE.

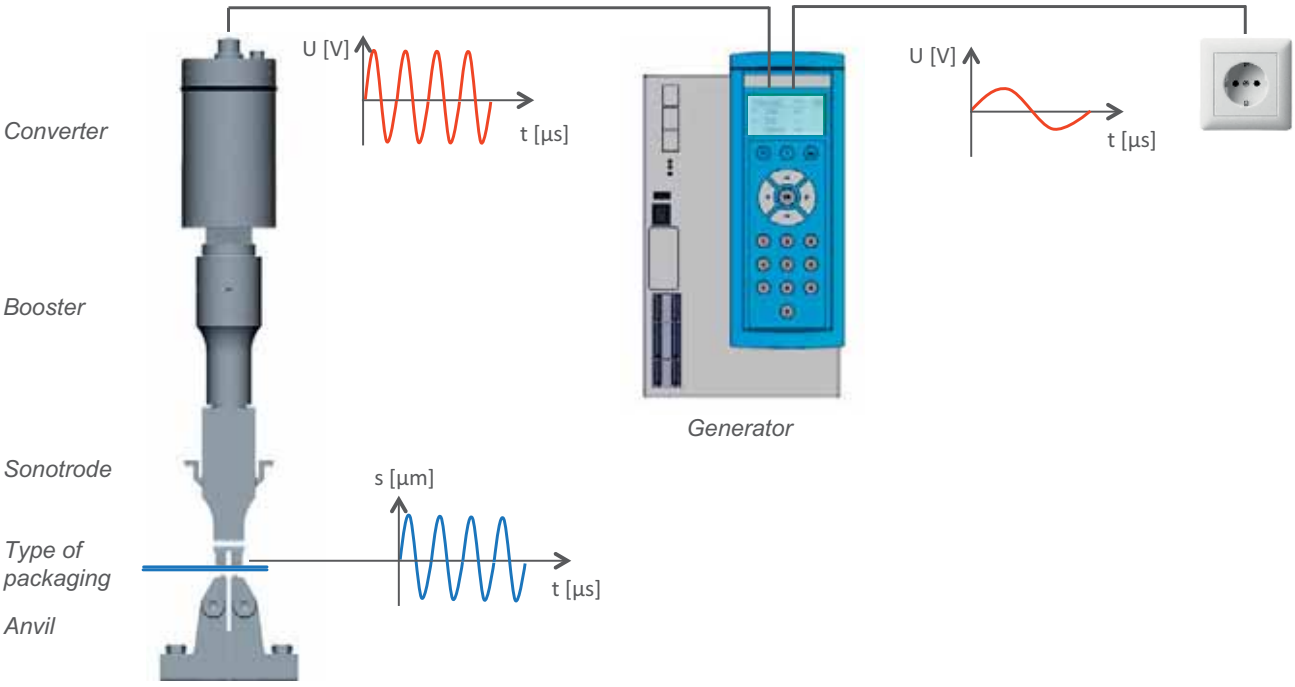
Ultrasonic welding technology is particularly well suited for packaging processes with high production rate requirements and applications with challenging process monitoring and validation requirements. Intelligent adjustment of welding parameters to ambient based or process related variations allows for consistent and uniform weld quality.

Generation of ultrasonic vibration

The ultrasonic generator converts the supply voltage into a high frequency voltage of between 20 and 35 kHz. This electrical signal is converted into mechanical vibrations by the converter using the inverse piezoelectric effect. The generated mechanical vibrations are transferred, while increasing the overall amplitude, to the materials to be welded by means of the booster and sonotrode. The sonotrode, which is the active weld tool, introduces the longitudinal vibrations into the sealing area under a defined force.

An ultrasonic frequency of 30 kHz, for example, means 30,000 cycles per second at an amplitude from 10 to 30 µm!

The anvil is the passive counterpart to the sonotrode and provides the rigid surface required for welding. The applied force and mechanical vibration create frictional heat in the plastic material and between the contact surfaces of the packaging material, which in turn causes the material to melt.



Ultrasonic welding technology.
Small movements, great effects.

The operating principle

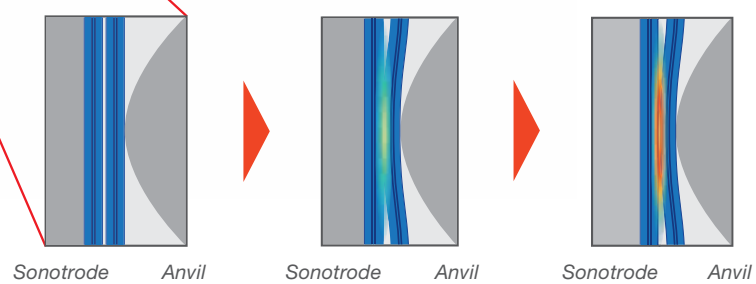
Equal to thermal processes, ultrasonic welding also generates material melts to achieve molecular bonding of the layers. The major difference is that heat is generated internally in the packaging material itself rather than by conduction from the external layers to the inside sealing surfaces.

During the ultrasonic welding process, the mechanical vibrations are transferred into the packaging material by the sonotrode. This takes place at a specific frequency, with a defined force and corresponding amplitude, for a specific period of time. The deformation resulting from ultrasonic vibrations causes friction among the molecular chains and the surfaces of the layers of the packaging material.

Focusing of the energy by means of tool design or component-integrated energy directors (see page 6) causes the material to melt in the required locations. The initial melt increases the absorption of energy, which in turn leads to acceleration of melting.

The cold ultrasonic tools quickly dissipate the generated heat so that the produced seal is very strong and stable, immediately after welding. Consequently, thermal loads affecting the packaging materials and the packed products are very low.

Sequence of melt generation in the packaging material:
Heat develops from the inside to the outside.



Plastics for packaging materials and packaging types. Material selection – great range of options.

Weldable plastics

All thermoplastic materials can be welded using ultrasonics. Homogeneous, molecular bonds can be achieved with plastics of equal types. For heterogeneous plastics, form-fit joints can be created by means of mechanical embedding.

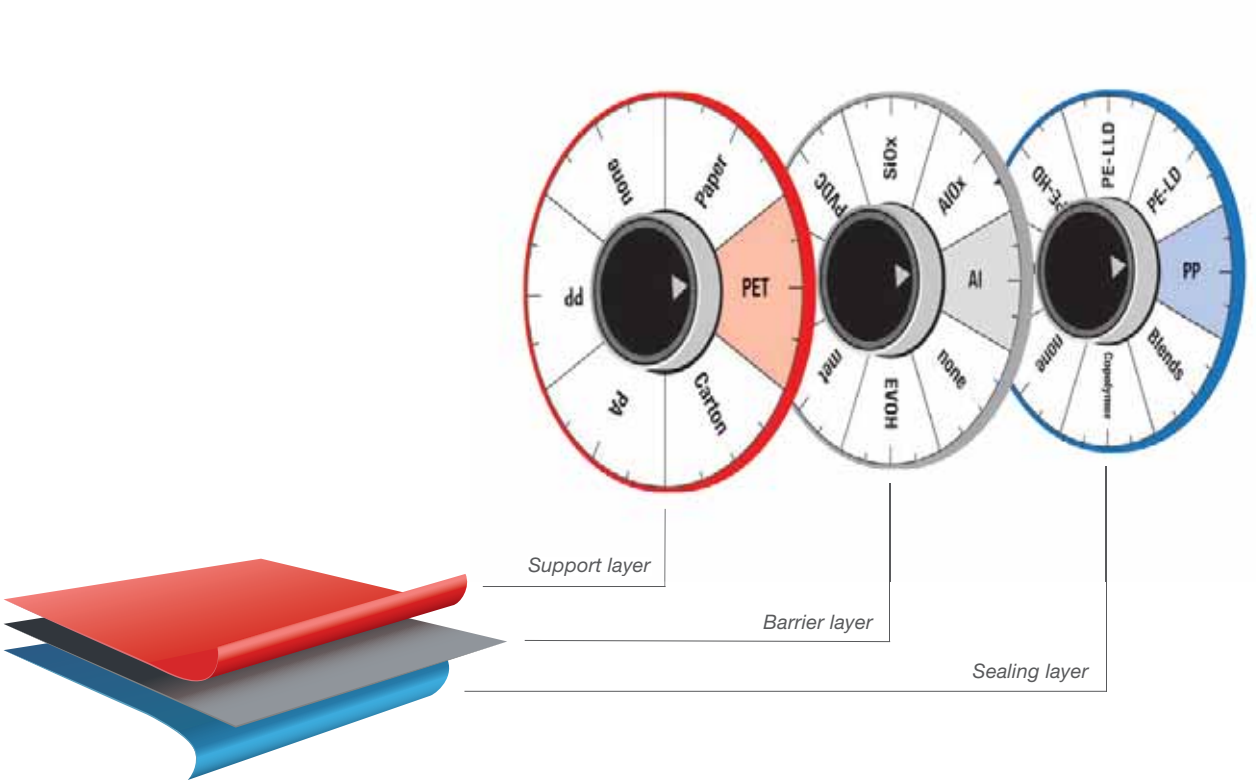
Due to the vast range of functional requirements for packaging, it is common for the materials to be sealed to include multiple layers, each having different properties. A typical multi-layer structure may include a support layer, a barrier layer, and a sealing layer, for example. The sealing layer is typically made of a plastic material from the group of polyolefins, e.g. PE or PP.

The respective layers may each be composed of different sub-layers. In combination with a large number of different types of plastics, this results in a great variety of packaging materials. Ultrasonics can also be used to produce peelable seals, e.g. based on cohesive peel systems.

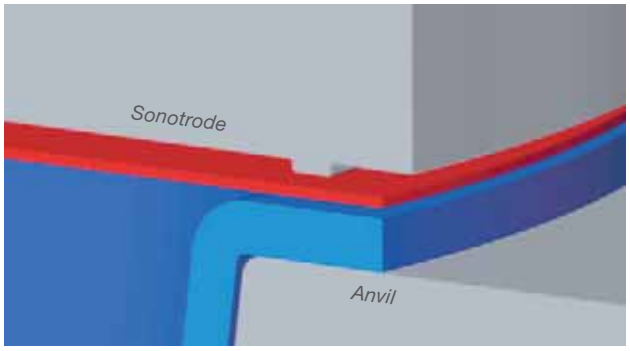
Examples for packaging types with good ultrasonic weldability:

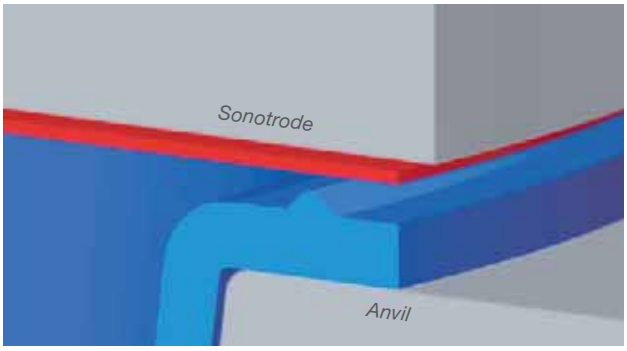
- Stand-up pouch for autoclaving: PET/ALU/cPP
- Stand-up pouch without autoclaving properties: PET/ALU/PE
- Pillow bag for salad: BoPP or oPP/PE
- Pillow bag for cheese: oPA/PE
- Carton packaging: PE/Carton/PE/Alu/PE
- Blister pack: PET or PET/Polyolefin
- Coffee capsules: PP/EVOH/PP

Due to the large number of variants and options, different application purposes and packaging requirements, Herrmann Ultraschall offers comprehensive consulting within the scope of ULTRASONIC ENGINEERING. It includes initial inspection of weldability through to common process development in our ultrasonic laboratory for packaging material with its versatile equipment.



Focusing of energy.
Local energy input.





Focusing tool design

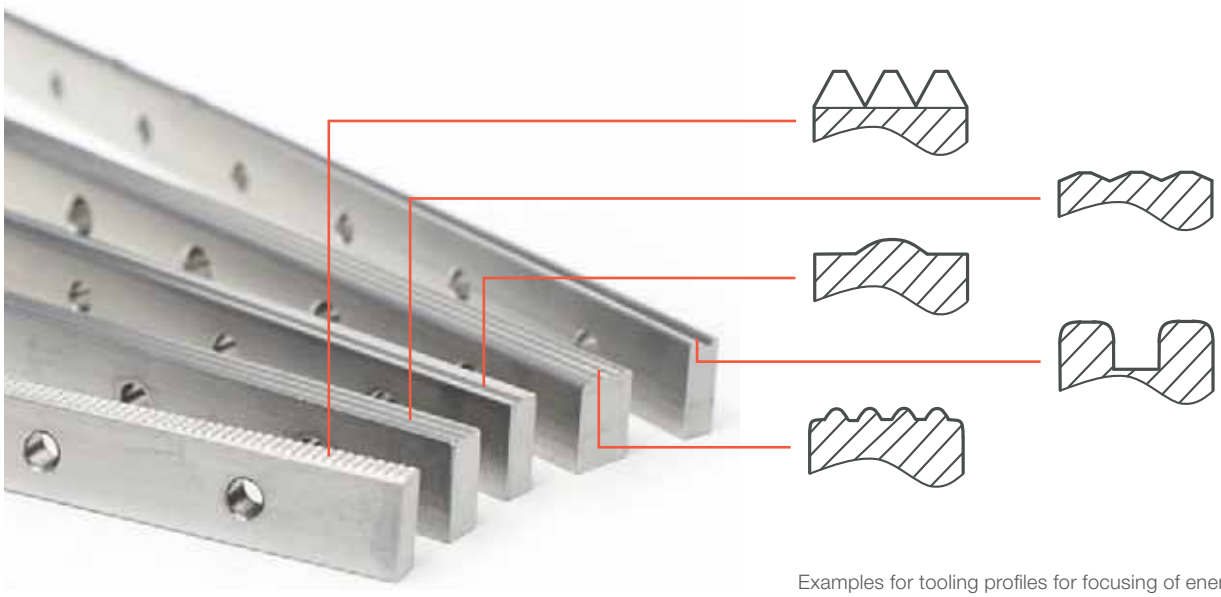
To initialize the melt formation, it is required for the introduced vibration energy to be focused. With film and other flexible packaging materials, this is achieved through appropriate tool design. Also referred to as anvil and/or sonotrode profiles, these often are in the form of radii or small plateaus. The tooling profile defines the location of energy input.

To obtain wider visual seal shapes, several lines may be arranged next to one another or many small dots in the form of truncated pyramids may be distributed as required. Each of these elevated contact points serves as an initiation of melt formation through energy focusing.

Component-integrated focusing

For joining injection molded, blow molded, or thermoformed packaging types with one another or with film, elements referred to as energy directors (ED) are integrated in solid or rigid types of packaging. That allows for the focusing of the energy. The defined geometry of energy directors ensures targeted and repeatable melting and an even distribution of the melt. Production related tolerances in the component may be compensated for through melting of the ED.

In order to prevent cutting of film under the effect of ultrasonic vibrations, the ED tips should be designed in the form of radii or plateaus.



Examples for tooling profiles for focusing of energy.

Packaging applications.
One process, many solutions.

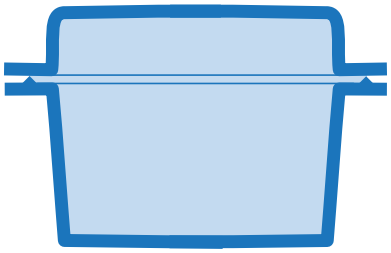
Flexible types of packaging

For welding flexible types of packaging, focusing of the energy is achieved by utilizing appropriate tool designs. This application variant is also intended for thin walled thermoformed parts, such as blister packs. In addition to welding, simultaneous cutting is also possible. In doing so, a cut weld seam can be produced in the same operation.

Bags/carton packaging, thin walled deep drawing components

Rigid types of packaging

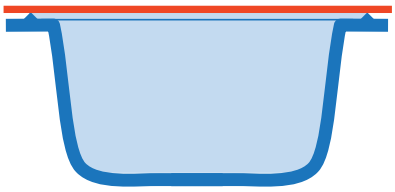
Rigid types of packaging are thicker or more stiff than flexible types of packaging, so focusing of the energy by means of tool design is not possible. For this reason, energy directors must be integrated into the components. Thoroughly thought out seal design ensures production of high-strength and tight ultrasonic seals.



Capsules, cups, trays, etc. with rigid closures

Flexible and rigid types of packaging

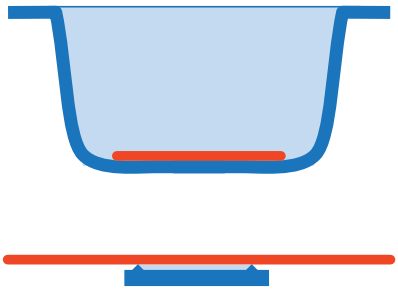
For welding of a rigid container to flexible packaging material, positioning of the energy director at the rigid component is recommended. This ensures process safety and reproducibility. As an alternative, an energy focusing profile can be incorporated into the tool that is on the side of the flexible packaging material.



Capsules, cups, trays, cans, etc. with flexible closures

Flexible and rigid types of auxiliary packaging components

For welding of flexible auxiliary packaging components, such as filter materials or zippers, implementation of a focusing profile on the tool is possible. This also makes it possible to seal different types of packaging materials through embedding. Hermetic and high-strength seals are achieved by means of molecular bonding through energy directors integrated in the rigid component. Reforming of auxiliary packaging components is also possible, i.e. crushing of zipper ends.



Filters, pads, valves, spouts, adapters, hanging aids, zippers, and many more

Precise parameterization.
For customized weld processes.

Process parameters

The benefits of the ultrasonic welding process are the result of the large variety of parameters that may be used for precise setting of the process, evaluation, and quality control. Through precise parameterization, the following can be achieved:

- Optimum melting speed for tight, strong, and visually attractive weld seals
- Easy reproducibility of the weld process quality

The major parameters of the ultrasonic welding process are:

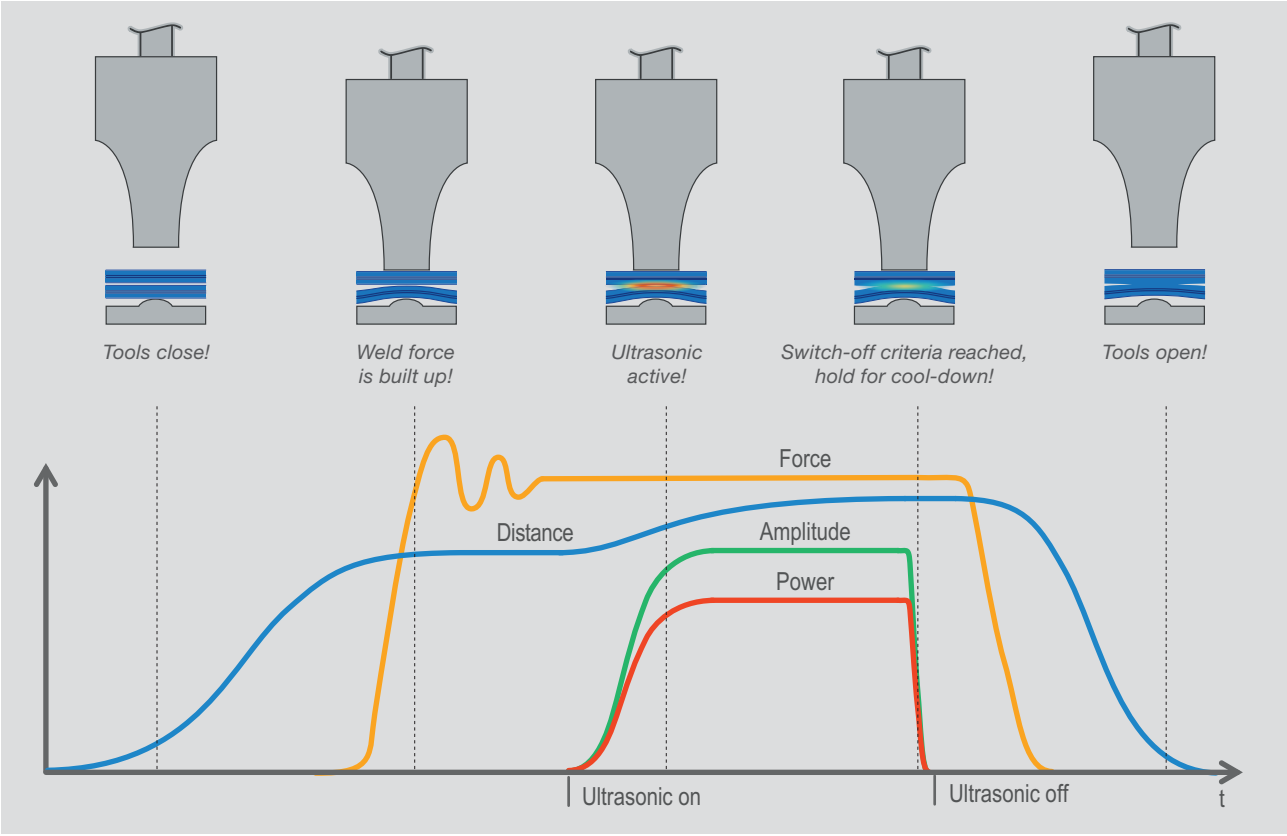
- Frequency
- Amplitude
- Weld force
- Switch-off criteria

The switch-off criteria is the parameter that defines the duty cycle of ultrasonic vibration. Depending on the type and application of the packaging, one of the following ultrasonic parameters is used for the switch-off criteria:

- Time
- Energy
- Weld depth, relative
- Weld depth, absolute

Build-up of weld force, travel of the weld tools, and the process sequence are functions of the packaging machine. The conditions for good welds include the appropriate closing time and stable forces throughout the entire weld process.

Weld process sequence



Optimum process control.
For reproducible quality.

Process monitoring

For uniform and robust weld process quality, Herrmann Ultraschall relies on intelligent measuring and control technologies that are integrated into the generator. For process monitoring and assessment of the weld, data obtained from connected sensors and measured values recorded directly in the generator may be used. Analysis of all measured values and signals is performed in the generator for every created weld cycle. This information is then communicated to the machine controller.

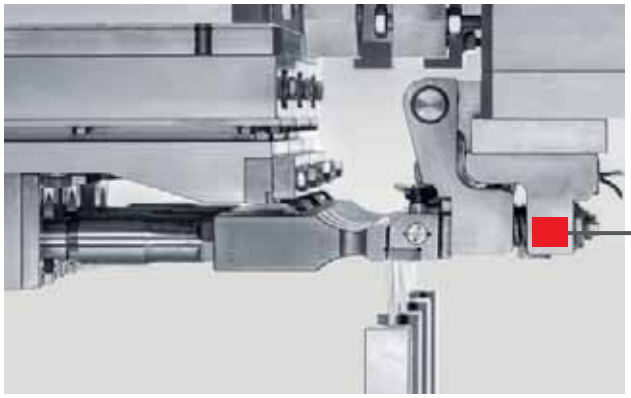
In upstream process monitoring, the following criteria may be checked in the weld position:

- Detection of the presence of the packaging material
- Fault conditions

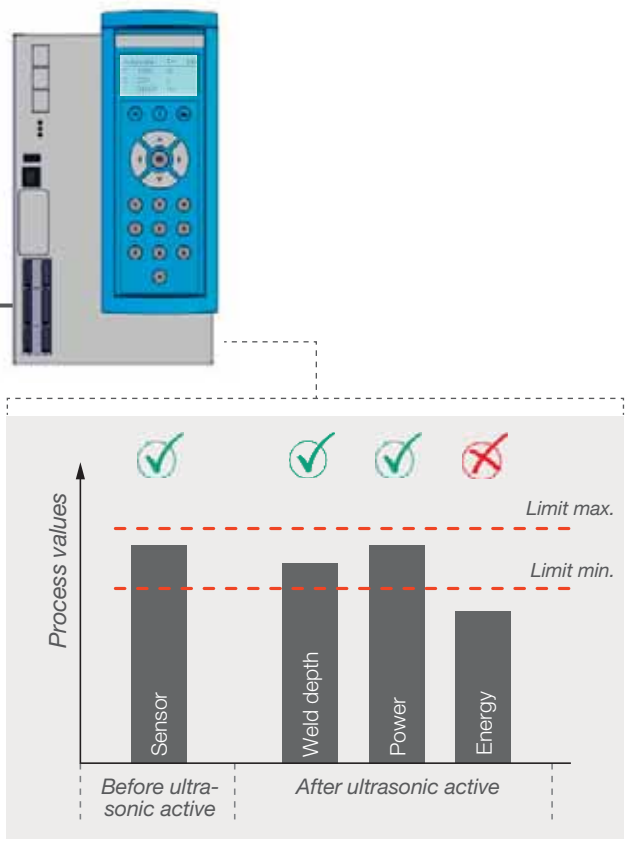
Based on that information, appropriate actions may be defined in the packaging machine, e.g. to prevent damaging metal contact of the tools or to reject faulty packaging.

The integrated process monitoring system is used for assessing the results of the process during and upon completion of the weld. Process parameters that are not classified as switch-off criteria may be used for assessment of the weld process. Limits for quality control may be defined for the following process variables:

- Weld depth
- Weld time
- Power (peak, average, end)
- Energy



Integrated sensors



Schematic diagram of process monitoring by the ultrasonic generator during a weld using time as the switch-off criteria

Saving costs in the long run.
Sustainability, efficiency, and safety.

The advantages at a glance

One of the great advantages of ultrasonic welding is the displacement of product particles from the seal area. Tight and strong weld seals can be achieved even for products that are difficult to dose as well as significantly reducing reject rates.

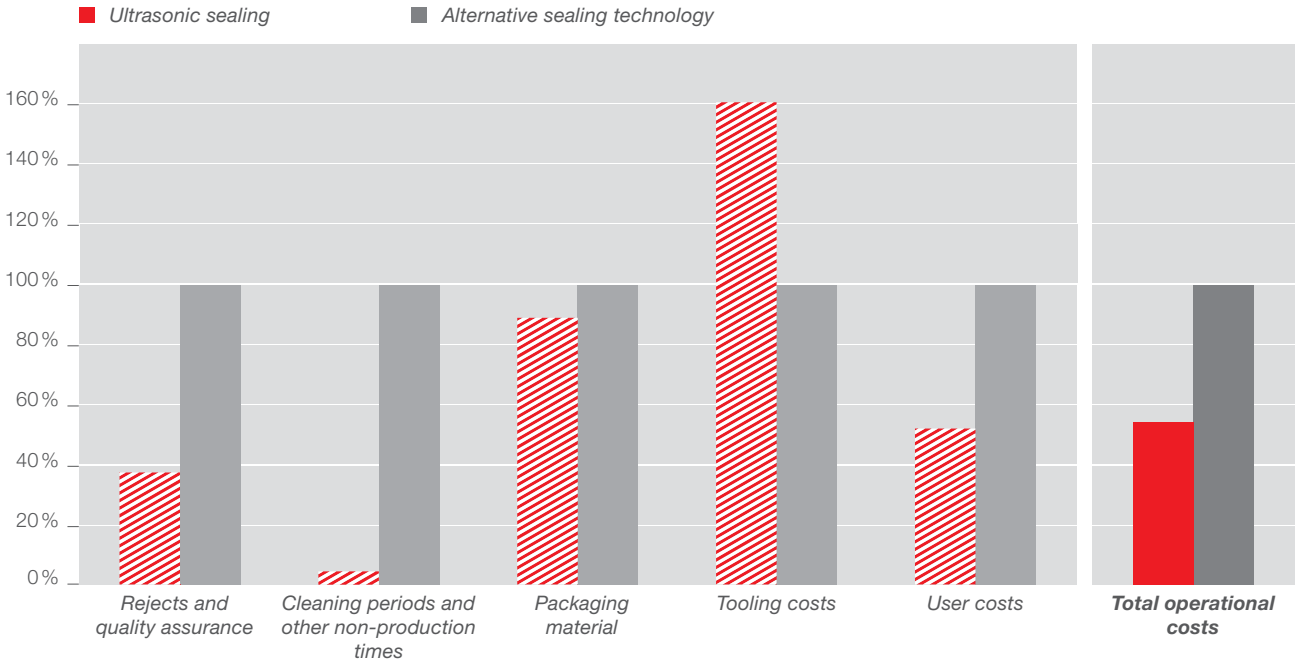
Since heat is generated internally in the seal and does not have to be transmitted through the packaging material, the thermal loads acting on the packaging material and packaged goods are very low. Film shrinkage can be ruled out completely. The cold weld tools ensure fast cooling and thus increased stability of the seal. Prolonged heating and cool-down phases, as well as burning hazards for machine operators, do not occur. The cleaning effort and maintenance time caused by product residues sticking to the tools is significantly decreased. This also considerably reduces non-production times.

Precise focusing of the ultrasonic energy results in smaller sealing lines, which saves packaging material. The ultrasonic seal strength is comparable to conventional welding technologies but offers additional benefits such as increased efficiency and overall packaging material savings.

The process control integrated in the generator increases the process safety and reduces expenditure for additional quality monitoring. In combination with short weld times, reject rates can be drastically reduced and the production performance of the machine can be sustainably increased.

Although the investment for ultrasonic technology is comparatively higher in most cases, the significantly reduced operational costs and the increase of productivity in the long run, have proven to render faster ROI and achievement of the break-even point.

Important components of the total operational cost



Continuous support from the beginning.
ULTRASONIC ENGINEERING.

The expert teams at Herrmann Ultraschall will support during every phase of a project. This includes packaging material tests, production-related trials in the application laboratories, on-site assistance during start of production, as well as after-sales and training services. The cost-effectiveness of the processes is always the number one focus.

Ultrasonic laboratory packaging

Verification of weldability
- Activation of the material through ultrasonics
- Inspection of seal tightness through penetration substances and pressure tests
- Cost estimation and initial pricing

Seal design consulting
- Form design of seal contours
- Customized weld seals based on customer requirements
- Concept consulting on new packaging shapes and designs

Weld process development
- Preparation of the weld concept
- Development and manufacturing of application-specific ultrasonic weld tools
- Identification of the process frame

Test rigs
- Design and configuration of application-specific test rigs
- Statements on tool layout and drive concept
- Inspection of the weld process

Prototype production
- Small series production
- Quality control and/or consumer tests
- Release by marketing
- Validations by the final customer

Machine integration
- Feasibility and risk analysis
- FEM-supported tool calculations
- Mechanical and electrical interface definition
- Development of integration concepts

TCO analysis
- Identification of the break-even point
- Return rate in comparison with alternative joining processes

Training
- Individual and hands-on user training
- Training on-site with the packaging machine

Start-up and in-production optimization on-site
- Support beyond actual start-up
- Adjustment of the process frame to production conditions
- Validation of results at the packaging machine

Immediate support and spare parts
- Fast self-help option, with hotline support
- Reduction of standstill time
- Competent error diagnostics and troubleshooting
- Availability of original spare parts

Service package tool management
- Tool overhaul for service life optimization
- Tool change with extremely short standstill times

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