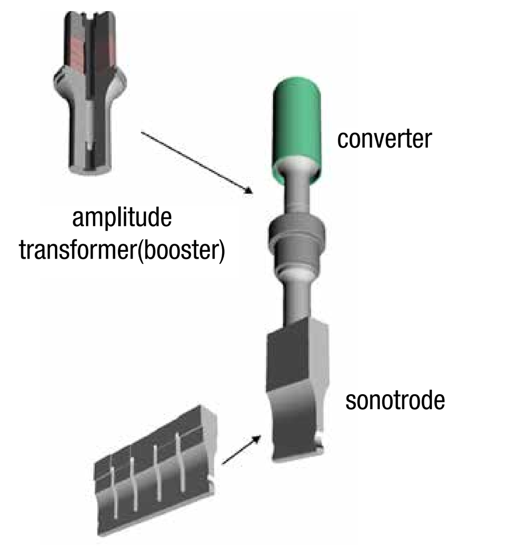
DVS MEDIA

Series welding processes for plastic components

Ultrasonic welding

Process description

In the case of ultrasonic welding, the high-frequency energy produced in a generator is transformed into high-frequency mechanical oscillations by a sound transducer (converter) and is transmitted to the component by the welding tool (sonotrode). In this respect, the entire oscillation system (consisting of the converter, the transformation piece and the sonotrode) works in resonance. In the case of ultrasonic welding, the working frequency is typically between 20,000 Hz and 40,000 Hz. The heat needed for the welding is produced by the dissipation of the mechanical oscillation energy in the joining zone. In this respect, the high-frequency oscillations are absorbed and lead to molecular and interfacial friction and, as a consequence of this, to the plastification of the plastic. In the case of ultrasonic welding, a special joining zone geometry in the form of an energy director (ED) is necessary for targeted energy input and for weld formation appropriate for the application. The parameters which are particularly relevant to the process are the working frequency of the ultrasonic welding machine, the oscillation amplitude, the joining pressure or the joining pressure profile and the hold time. The welding process can be carried out with displacement control, time control or energy regulation.



Advantages	Disadvantages
very short process times	special joining face design (ED)
high degree of automation possible	high material and geometry dependence
energy-efficient and resource-conserving	oscillation input into the component
low investment costs	particle abrasion
shortest process times needed	

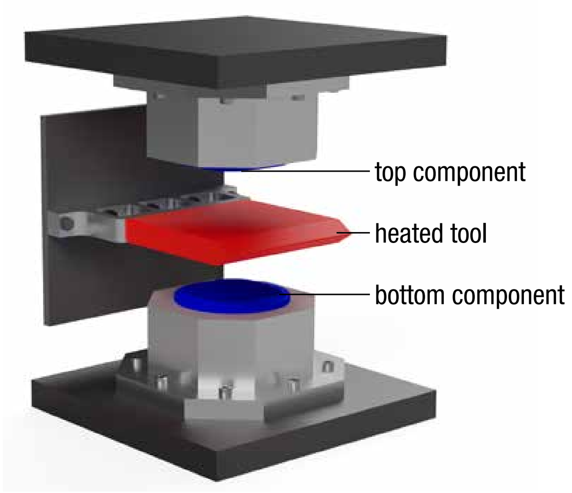
Areas of application

Typical areas of application are the automobile, packaging and electronics industries as well as medical technology. Because of the very short process times, ultrasonic welding is outstandingly suitable for utilisation in series production. As a consequence of the size restriction on the welding tool, the procedure is suitable particularly for small to medium-sized components made of thermoplastics as well as for the welding of films and non-woven materials.

Heated tool welding

Process description

In the case of hot tool welding, the joining faces of the mouldings or the semi-finished products are heated by the direct contact to the tempered heated tool and are subsequently welded under pressure. Because the heating and joining operations are carried out at different times, heated tool welding constitutes a multistage procedure. The process is divided into five process phases: alignment, heating, changeover, joining and cooling. During the alignment, the joining faces come into complete contact with the heated tool. Subsequently, a melt layer forms with nearly pressureless heating. Thereafter, the heated tool is removed (changeover) and the components are welded under pressure. After the needed joining path has been covered and the melt has thus been pressed out, the cooling operation takes place under pressure and the melt solidifies. The welding process can be carried out with pressure regulation or displacement control. The characteristic process parameters include the heated tool temperature, the heating time, the joining pressure and the cooling time.



Advantages	Disadvantages
high degree of automation possible	complicated tools for 3D structures
high degree of maturity	long cycle times
homogeneous welding bead (particle-free)	material adhesion to the heated tool possible
tolerant in the case of material differences	high running costs (energy)
medium to long process times needed	

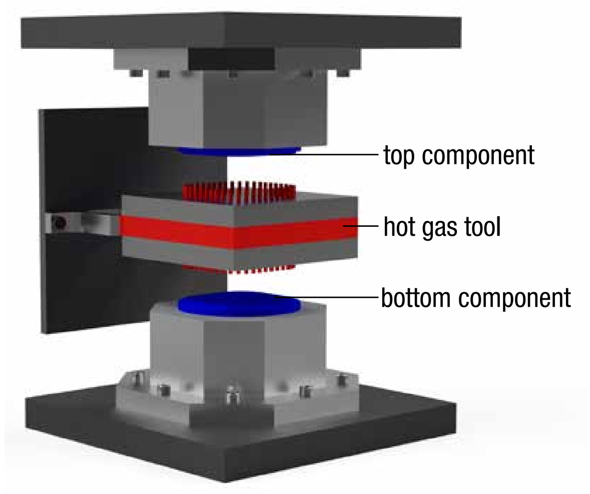
Areas of application

Heated tool welding is one of the dominant joining technologies in the series fabrication of semi-finished products and mouldings made of thermoplastics. This procedure is characterised by the particular suitability for complex three-dimensional joining faces and the applicability to a large number of plastics. The heated tool butt and socket welding procedures are extremely significant for welding in the pipe and apparatus construction sectors.

Hot gas butt welding

Process description

In the case of hot gas butt welding, the heat is input by means of convection and heat conduction. In this respect, the joining faces are plastified by a hot gas jet which emerges from a hot gas nozzle system adapted to the joining part. The process gas can be chosen freely but is selected depending on the oxidation susceptibility of the plastic to be welded. The gas temperature substantially above the melting temperature may lead to thermal or thermal-oxidative damage to the plastic. As in the case of heated tool and infrared welding, the heating and joining phases are carried out separately from each other. After the desired melt layer has been produced, the hot gas tool is removed from between the components which are welded under pressure. The characteristic process parameters are the gas temperature, the volumetric gas flow, the distance between the nozzles and the component surface, the heating time, the joining pressure and the cooling time. The joining process can be carried out with displacement control or force regulation.



Advantages	Disadvantages
contactless heating	thermal / thermal-oxidative damage to the plastic possible
homogeneous welding bead (particle-free)	energy input outside the joining zone possible
suitability for complex component geometries	few scientific foundations
suitability for high-temperature plastics	high operating costs
medium to long process times needed	

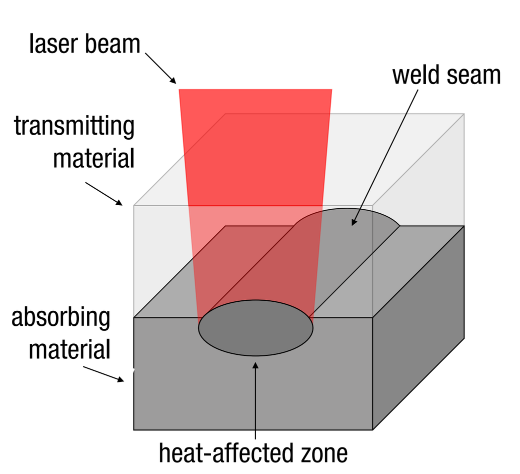
Areas of application

Hot gas butt welding is a fully automatable welding procedure which is basically suitable for all thermoplastic mouldings. It offers the possibility of reliably welding three-dimensional joining faces. Above all, automobile construction components with which complete freedom from particles is demanded are regarded as examples of applications. It is possible to join not only intake and charge air pipes and fuel and hydraulic oil tanks but also headlights.

Laser transmission welding

Process description

The joining zone is heated and plastified because the electromagnetic energy of the infrared laser radiation is absorbed by the plastic. In the case of laser transmission welding, the joining parts are brought into contact before the welding and the laser beam penetrates the joining part transparent for it and is transformed into heat in the absorbing joining part. The laser-beam-transparent joining part is also heated by heat conduction. Thus, the weld is manufactured by applying a joining pressure. In the case of laser transmission welding, it is possible to bridge only very small moulding tolerances since a gap prevents the heat conduction into the transparent component. A distinction is made between contour welding, simultaneous welding, quasi-simultaneous welding as well as mask welding. The relevant process parameters include the type of laser beam source, the wavelength, the energy per unit length as well as the properties of the spot.



Advantages	Disadvantages
small, easily controllable heat-affected zone	limited possibililty of gap bridging in order to compensate for fabrication tolerances
optically high-quality welds (no squeeze flow in the case of contour welding)	cost-intensive installation technology
short cycle times	complicated protective measures
usable for very small and precise components	as a rule, the laser beam must be able to pass through one joining member
short process times needed	

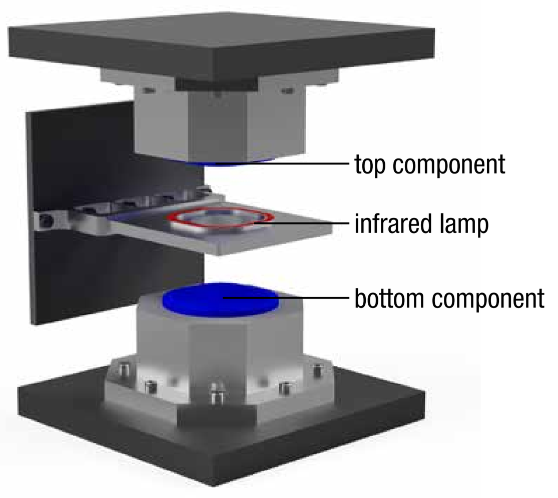
Areas of application

The main utilisation fields can be found in the electronics industry, medical technology and the automobile industry. Apart from identical plastics, different plastic types can also be welded with each other in so far as their melting temperature ranges coincide sufficiently and both materials are chemically and physically compatible.

Infrared welding

Process description

In the case of infrared welding, the heat is input by means of heat radiation. The radiation emitted by the infrared radiator is absorbed by the plastic to be welded. As a rule, the short-wave (0.78 - 1.4 µm) and medium-wave (1.4 - 3 µm) infrared radiation ranges of the light spectrum are applied in this respect. In order to achieve a high efficiency, the emission spectrum of the radiator should be coordinated with the absorption spectrum of the plastic. It must be borne in mind that any filler materials (e.g. carbon black or colour pigments) alter the absorption capacity. A distinction must be made between volume and surface absorption. When short-wave infrared radiators with mostly higher area capacities are used, attention must be paid to any possible thermal damage to the component surface. The process management in the case of infrared welding is similar to that in the case of heated tool welding. After the contactless heating, the infrared radiator is removed from between the components which are subsequently welded under pressure. The parameters characteristic of the process include the radiator type and power, the radiation exposure duration, the radiator distance and the cooling time. The welding process can be carried out with pressure regulation or displacement control.



Advantages	Disadvantages
contactless heating	complex radiator/ material dependence
high design freedom of the joining faces and the infrared radiator	coordination of the emission and absorption behaviour
homogeneous welding bead (particle-free)	energy input outside the joining zone possible
low-stress joints	possibly complex radiator construction
medium to long process times needed	

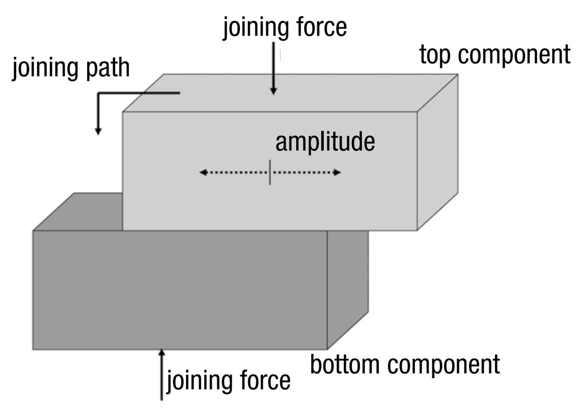
Areas of application

Infrared welding is utilised across different sectors. Typical applications are the welding of pipes and large-volume tanks as well as series fabrication in automobile construction. Infrared welding is extremely suitable not only for applications with stringent purity requirements but also for the joining of high-temperature thermoplastics with and without fibre reinforcement (no danger of adhesion or abrasion). Depending on the utilised radiator system, it is possible to weld complex 3D geometries too. Moreover, the infrared technology can be combined with other welding procedures. One typical application is vibration welding in combination with infrared preheating in order to reduce the particle formation.

Vibration welding

Process description

In the case of vibration welding, the plastic is heated by the dissipation of friction. With the effect of a joining force, the joining parts are moved relative to each other with an amplitude in the horizontal direction. In this respect, electromagnetic spring systems initiate horizontal oscillations in the top table. The interface between the joining parts is plastified by the transformation of friction energy into heat. This results in a melt layer which is exposed to alternating shear loads by the vibration movement. This gives rise to an additional energy input. Due to the applied joining pressure, melt is pressed into the bead at the same time. Consequently, this constitutes a single-stage welding procedure. With regard to the process management in the case of vibration welding, a distinction is made between the linear/longitudinal and linear/transverse oscillation directions (longitudinal and transverse to the main expansion direction of the joining parts respectively). The characteristic process variables are the oscillation frequency, the oscillation amplitude, the joining force, the joining path and the cooling time. The welding process can be carried out with time or displacement control. In addition, there is the possibility of another substantial reduction in the process time in the case of vibration welding using the process management strategy of the so-called high-pressure approach.



Advantages	Disadvantages
short cycle times	plane weld contours required
high weld quality	limited suitability for components with integrated electronic components
robust installation technology	particle abrasion (fluffing)
tolerant to contaminations	limited suitability for flexible components
short process times needed	

Areas of application

Vibration welding is suitable for the welding of injection-moulded, extruded or blow-moulded components in series fabrication. It is also possible to weld different materials with each other (e.g. plastic with elastomers, textile fibres or wood materials). The main areas of application are the automobile and household appliance industries.

The poster contents were compiled by employees of the Professorship of Plastics of the Technical University Chemnitz and employees of the KTP (Kunststofftechnik Paderborn) of the University Paderborn.