

Welding of Plastics

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Introduction

Mechanical fasteners, adhesives, and welding processes can all be employed to form joints between engineering plastics. Mechanical fasteners can join two components quickly, but they do not provide leak tight joint, and the localized stresses may cause them to pull free of the polymeric material.

Adhesives can provide good properties and fully sound joints, but they are difficult to handle and slow to cure. Also joint preparation & surface cleanliness need to be given importance in adhesive bonding.

Welding can be used to produce bonded joints with mechanical properties that approach those of parent material. The plastic welding is confined to thermoplastic polymers because these materials can be softened by heat. Thermosetting polymers once hardened cannot be softened again on heating. The heat required for welding thermoplastic polymers is less than that required for metals.

Plastic welding processes can be divide into two groups: -

- a) Processes involving mechanical movement – ultrasonic welding, friction welding, vibration welding.
- b) Processes involving external heating – hot plate welding, hot gas welding and resistive and implant welding.

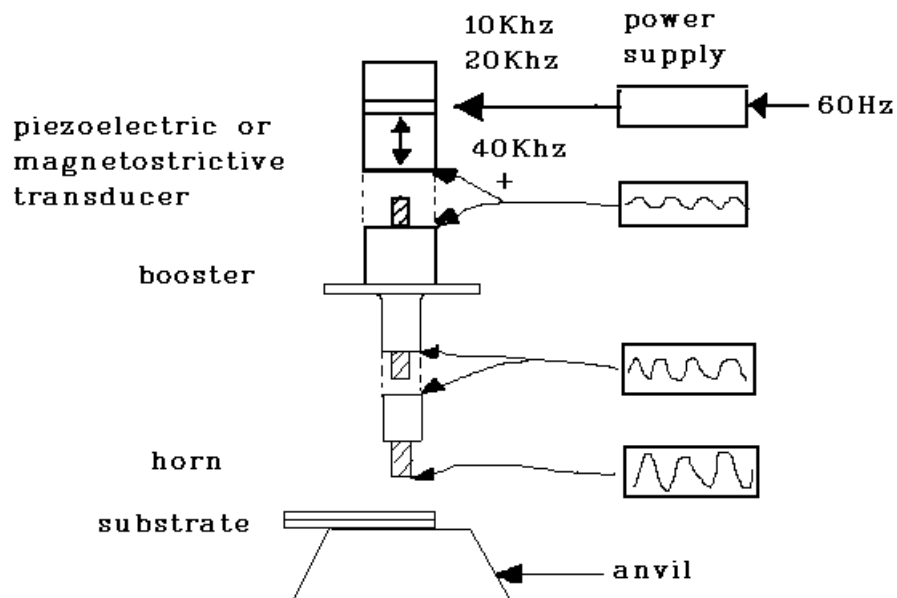
Processes

1) Ultrasonic welding

This method uses mechanical vibrations to form the joint. The vibrations are of high frequency. The parts to be assembled are held together under pressure between the oscillating horn and an immobile anvil and are subjected to ultrasonic vibrations of frequency 20 to 40 KHz at right angles to the contact area.

Alternating high frequency stresses generate heat at joint interface to produce a good quality weld. The tools for this process are quite expensive so that large volume production runs are preferred.

The welding is limited to small components with weld lengths not exceeding few centimeters. Applications range from valves and filters used in medical equipment, to cassette bodies, automotive components and vacuum cleaner bodies welded on multi-head machines.

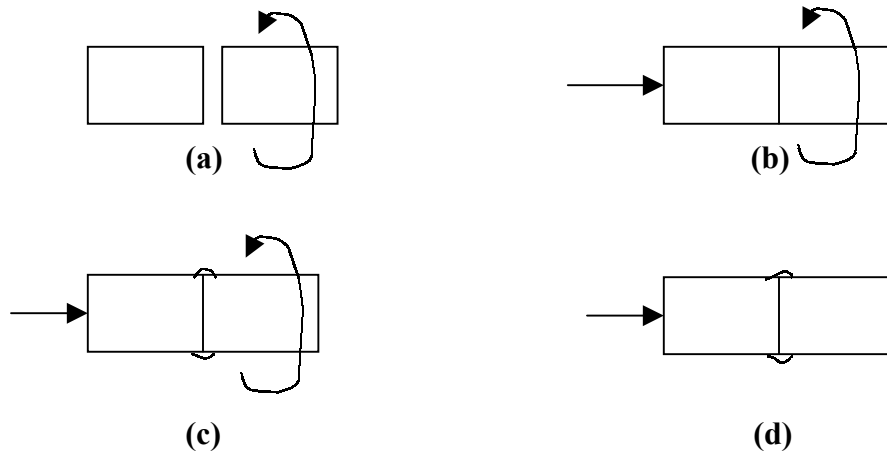


Ultrasonic Welding Device

2) Friction Welding

The friction welding of thermoplastic (also called spin welding) is based on the same principle as that employed for welding metals. In this process one of the substrates is fixed, while the other is rotated with a controlled angular velocity. When the parts are pressed together, frictional heat causes the polymer to melt and a weld is created on cooling. Major welding parameters include rotational speed, friction pressure, forge pressure, weld time and burn off length.

The advantages of friction welding are high weld quality and the simplicity and reproducibility of the process. The drawback of this process is that, in its simplest form it is suitable only for applications in which at least one of the components is circular and requires no angular alignment.



Arrangement for rotary friction welding

- (a) Rotary member brought up to speed (b) Rotary member advanced into contact under axial load
 (c) Rotary contact pressure maintained for specified period.
 (d) Rotation stopped and pressure maintained or increased for specified period to produce weld.

3) Vibration Welding

This process is also called linear friction welding. Two thermoplastic parts are rubbed together under pressure and at a suitable frequency and amplitude, until enough heat is generated to melt the polymer. After vibration is stopped, the parts are aligned and the molten polymer is allowed to solidify creating the weld. The process is similar to spin welding, except the motion is linear rather than rotational. The process is rapid; the vibrations applied typically of 100 – 240 Hz, 1-5 mm amplitude.

The main advantage of this process is its ability to weld large complex linear joints at high production rates. Other advantages are the ability to weld a number of components simultaneously, simplicity of tooling and suitability for welding almost all thermoplastic materials. Vibration welding has found its principal applications in the automobile and domestic appliance industry.

Vibration welding can be applied to almost all thermoplastic materials, whether injected molded, extruded, blow moulded, thermoformed, foamed or stamped.

4) Hot Plate Welding

It is the simplest of the mass production techniques to join plastics. A heated plate is clamped between the surfaces to be joined until they soften. The plate is then withdrawn and the surfaces are brought together again under controlled pressure for a specific period. The fused surfaces are allowed to cool, forming a joint. The welding tool or heating element has built in electric heaters to prevent the plastics sticking to it.

Temperatures are generally between 180⁰ C and 230⁰ C depending on the thickness and type of the material to be welded. This process is commonly used to weld together the butt ends of plastic pipes used in gas and water distribution, sewage and effluent disposal and in chemical industries; attachment of filler tubes and connectors onto blow molded fuel tanks for automotive applications.

Many items of daily use are produced by this process – vacuum cleaner housings, components for washing machines and dishwashers, automotive parts such as brake fluid reservoirs, rear lights, indicator lights, etc. The drawback of this process is that it is relatively slow. Weld times range from 10 to 20 seconds for small items and to as much as 30 minutes for very large pipes. Hot plates for conventional type of welding (using temperature up to 300⁰ C) are made mainly of aluminium. Hot plates for high temperature welding mainly consist of aluminium copper alloy. The temperature of hot plates is controlled by electronic regulators, with the thermosensor located as close as possible to the working surface.

5) Hot Gas Welding

This is similar to oxy-acetylene welding of metals. The only difference is that the open flame of oxy-acetylene welding is replaced by a stream of hot gas. Compressed air, nitrogen, hydrogen, oxygen or carbon dioxide is heated by an electric coil as it passes through a welding gun.

Hot gas welding is a fabrication process for thermoplastic materials. The process, invented in the mid 20th century, uses a stream of heated gas, usually air, to heat and melt both the thermoplastic substrate material and the thermoplastic welding rod. The substrate and the rod fuse to produce a weld. To ensure welding takes place, adequate temperature and pressure must be applied to the rod, along with the use of the correct welding speed and gun position.

Typical applications include chemical storage vessels, ventilation ducting and repair of plastic moldings such as car bumpers. Nitrogen is used for oxygen sensitive plastics such as polyethylene while oxygen results in higher weld strengths. Compressed air is popular since it gives satisfactory results for many purposes and is cheap.



Hot Gas Welding

Plastics, which can be welded, are PVC, polyethylene, polycarbonates and nylons. The main advantage of this process is that large, complex fabrications can be constructed. This process is slow and the weld quality is entirely dependent on the skill of the welder.

6) Implant Welding

In this process, metal inserts are placed between the parts to be joined and are then heated by means of induction or resistance heating. The resistance method requires that wires be placed along the joint to carry current to the implants; this is not required for induction welding. The thermoplastic material melts around the implants and flows to form a joint. Implant welding has been applied to complicated joints in large components such as vehicle bumpers, electrically driven vehicles and sailing dinghy hulls.

New Methods

Laser welding is suitable for joining both sheet film and molded thermoplastics. It uses a laser beam to melt the plastic in the joint region. The laser generates an intense beam of radiation (usually in the infra red area of the electromagnetic spectrum) which is focussed onto the material to be joined. This excites a resonant frequency in the molecule, resulting in heating of the surrounding material.

Laser welding is a high volume production process with the advantage of creating no vibrations and generating minimum weld flash. The benefits of a laser system include; a controllable beam power, reducing the risk of distortion or damage to components; precise focussing of the laser beam allowing accurate joints to be formed; and a non contact process which is both clean and hygienic. Laser welding may be performed in a single-shot or continuous manner, but the materials to be joined require clamping. Weld speeds depend on polymer absorption.

References

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