TECHNICAL BULLETIN: ULTRASONIC WELDING IN PLASTICS

1 Introduction

When you talk about welding, you immediately think of metal. The welding in plastics it is not well known, even when it is used in many industries due to the necessity of a lot of manufacturers to join plastics parts, place inserts and repair pieces, among others. This joining technique is fast, effective, clean, and does not require the use of adhesive, solvents or external heat sources.

In many cases, the plastics cannot be joined using adhesives, so, what another mechanic method is available? The answer is ultrasonic welding. However, this technique it is not widely known by plastic transformers, which demand the necessity of knowledge in the correct selection of the required accessories and the use of the corresponding equipment. The plastic converters wonder where to start or what is needed for a plastic to be properly welded, as there are several considerations to make sure that the job is well done.

The present guide constitutes a quick reference tool, designed to facilitate the work of the plastic converters, with the diffusion of knowledge about welding techniques for finished plastics products.

Polinter, fulfilling the commitment acquired with its clients of service and continuous technical assistance, offers this guide to contribute with the knowledge of the process involved in the production, processing and use of plastics products in our daily life, with the aim of making an optimum use of it.

2 Welding in Plastics.

In plastics, neither the uses of adhesives nor solvents are the most appropriate options when it comes to joining plastics; a good bonding of pieces just is possible through the use of welding. However, selecting the right technique and equipment for welding plastics material can become a challenge. It is necessary to know the application to find the equipment that fit the welding requirements, being aware that not all tools are useful in certain kinds of materials.

3 Ultrasonic welding: conception

Welding plastics by ultrasound, occurs due to the rapid transmission of ultrasonic energy through a tool or "horn" which conduct this energy to a small interface area to the plastics to be joined. This energy creates mechanical vibrations, friction and heat to form a permanent seal between the parts in few seconds. To do this, it is important the selection of an appropriate combination frequency/energy.

Standard equipment uses the high frequency power, in order of 20 to 200 kHz; pieces of various sizes can be assembled with these frequency levels that are higher than the maximum audible by humans, and create the energy and the vibration amplitude necessary to melt most of the thermoplastics resins.

A system of 40 kHz is ideal for assembling plastics parts of small sizes which require soft and controlled ultrasonic vibration during the welding process. For a frequency of 40 kHz, the horn of the ultrasound equipment is 50% smaller than 20 kHz and lower vibration amplitude, which causes less stress on the parts to be welded.

Typical application requiring these types of welding include microelectronic components, circuit boards and medical equipment, among others.

With very low frequency machines (15 kHz), it is possible to weld many thermoplastics, especially those manufactured with engineering resins, which required of a high vibration amplitude for a successful assembly. This low frequency makes it possible to design large ultrasonic horns, which facilitates the welding of large parts. The uniformity of the amplitude through the horn increases the integrity of the welding.

4 Process parameters of ultrasonic welding

The mechanical resistance of welding union will depend on the conditions in which the welding is performed, the joining zone design or interface configuration of the materials to be joined, the horn design and the parameters used in the processes which are mentioned below:

4.1 Horn Vibration amplitude

A vibration of at least 40 µm on both sides is indispensable.

4.2 Pressure

The horn applies a pressure that bonds the parts to be joined. Compressed air pressures ranging from 0,1 MPa (1 bar) to 0,3 MPa (3 bar), and higher are usually used. A very high pressure may disturb the vibration of the horn, except in the case of fiberglass- reinforced plastics, for which a high pressure is required.

4.3 Welding time.

It depends on the type of plastic and the shape of the part. Generally, it is sufficient a 0.2 s of time for most thermoplastics. Very high times can cause a lot of melted material, resulting in flashing, bubbles and poor sealing.

4.4 Cooling time

Common times range from 0.1 to 0.2 s.

4.5 Lowering speed of the horn

Speeds of 50 mm/s are normally used.

4.6 Vibration start time

The vibration should be initiated at the time of contact between the parts. If it starts after exerting pressure on the pieces, the amplitude may be lost.

5 Consideration for plastics welding.

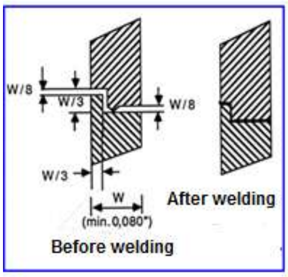
It is necessary to select the appropriate machine according to the shape and size of the workpiece to be welded.

The preparation of the surface is necessary and of vital importance. Each particle (release agent, dust, grease), trapped in the weld will affect its resistance. Also, not cleaning the surface favors oxidation. Hence the time invested in this surface preparation task is necessary to ensure a quality weld.

The best way of treat the surface is sanding the first layer of the area to be welded. It is important that this step does not leave dust in the surface. Solvents should be used carefully, because it is dangerous that penetrate the welding area and because they can affect the plastic material.

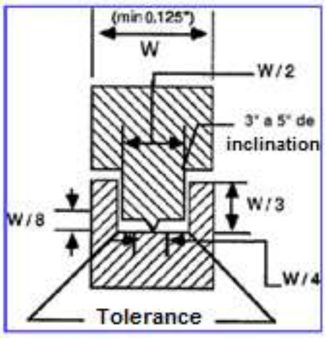
6 Design of the ultrasonic welding

Ultrasonic welding of two thermoplastics parts requires that the ultrasonic vibrations be transmitted through of the parts that need to be joined and traveling through the splicing or interface. The vibrating energy becomes in heat that melts and sold the plastic. When the vibrations stop, the heat transmission ceases and the plastic solidifies under the combined effect of the temperature (cooling) and the pressure, producing a welding in the interface.



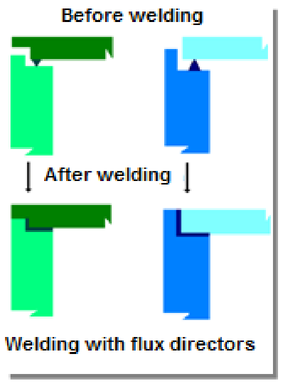
Ultrasonic Welding

The interface configuration, referred as "joint design", is very important for achieving optimal results. There are a variety of joint designs or welds, each with specific features and advantages. Its use depends on factors such as plastic type, part geometry and welding requirements, i.e., structural strength, airtight seal, etc.



Spline Joint

Energy directors (triangular or rectangular perturbations in one of the surfaces) are sometimes used to control the area where the energy is dissipated, making that the joining more efficient and thermal stress to decrease.



7 Insertion

The insertion is the process in placing a metal insert or filler and other material in a thermoplastic part. In ultrasonic insertion, a slightly smaller hole than the filler is molded into the plastic part. This hole provides a degree of interference and also serves to steer the filler in place. The metal filler is usually designed with knots and other irregularities to resist the loads imposed, once assembled in the plastic.

Ultrasonic vibrations travel through the drive component to the interface between metal filler and plastic. The heat generated by the metal filler that vibrates against the plastic, makes the plastics melts, allowing the filler to be led to its place. The flow of molten material into the recesses of the plastic and the metal part solidifies, fitting even more the metallic filler in its place.

In most cases, the plastic component is fixed and the filler is driven to the place. In others, the horn can come into contact with the plastic, driven on the filler and/or several fillers can be inserted simultaneously.

Because the tool that hold the insert is exposed to high wear (metal that comes in contact with another metal), is advisable to use a hardened steel tool. For low-volume applications, a titanium tool with replaceable tips is also a good option. The diameter of the tool must be at least twice the diameter of the filler.

8 Staking

It is the assembly method in which a plastics bolt is “formed” to catch or lock another component in place. This component is usually of a different material.

The appropriate design of this type of welding produces an optimal force, with a minimum generation of molten material (in excess). In addition, there are several configurations for bolt / cavity design. The use requirements and the physical size of the bolt determine the design to be used. The stacking principle is the same as other types of ultrasonic sealing: the initial contact area between the tool and the bolt should be set at a minimum value, thus concentrating the energy required to produce a fast melting of the plastic material.

The alignment between the tool and the bolt is not as critical as with the standard profile.

The knurled stacking is used in cases in which the appearance and strength are not critical. In this case, there is no special interest in the exact diameter of the alignment or bolt.

For ultrasonic stacking, in general, high vibration amplitudes and low pressures are required. Some materials of high melt temperature (as semi crystalline) tends to form a weak and fragile head bolt. The use of a standard profile, high amplitude and high shooter pressure can improve results. For cases where a sloping surface is required and the piece that will form the bolt is thick enough to be mechanized (chamfer shape, for example), the sloping stacking is ideal.

The tool must be lowered on the bolt at a slow and moderate speed that allow the melting of the material and at same time prevent the bolt to be malformed by the pressure. The best results are obtained when the ultrasonic vibrations are started before the tool is in contact with the bolt, using a trigger switch. This prevents "cold formation" and allows welding to proceed in a gradual way rather than with an interrupted movement. To obtain consistent results, the total travel distance of the tool must be mechanically limited by a positive stop

9 References

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