

AN OVERVIEW OF
ULTRASONIC, VIBRATION
AND SPIN WELDING

Joint Design A Critical Factor In Strong Bonds

By Warren E. Kenney

Welding techniques for assembling parts molded in DuPont engineering thermoplastics conventionally require an input of energy that results in heat. This heat causes a brief melting of material at the interface of two parts to be joined. Simultaneous application of pressure produces a strong, homogenous bond.

Techniques range from simple hot plate welding to electromagnetic and induction heating processes used to join large or complex parts. Hot plate welding is seldom used with engineering plastics because of their higher melt temperatures and rapid solidification when heat is removed. Electromagnetic welding utilizes a magnetically “activated” thermoplastic in the joint interface which is heated by electromagnetic coils while under clamping pressure. (An induction welding variation uses metal inserts which are heated by the magnetic field.) Because of the specialized nature of these methods, designers should contact their DuPont representative for application assistance.

Ultrasonic, vibration and spin welding—the methods that will be covered in this overview—offer quick, precise and economical means of assembly. Each, however, calls for close attention to joint design, holding and alignment fixtures, and material moisture.

Ultrasonic Welding

Ultrasonic welding, a versatile technique for joining small parts, uses high frequency (20 kHz or 40 kHz) vibrations to develop the intermolecular heat that melts

interfacing surfaces. Vibrations are applied through a custom-designed tool, called a “horn”. Required welding intensity for a particular joint is developed by using different horn configurations and welding variables.

This technique is very fast (usually less than two seconds) and can be automated for high speed assembly operations. The resulting welds are homogenous joints with strength approaching that of the base material. Ultrasonic joints are particularly suitable where a hermetically sealed or structural joint is required.

Joint configuration is perhaps the most critical factor for good welding. Two basic designs are used:

- The Shear Joint (Figure 1), developed and recommended by DuPont for engineering plastics.
- The Energy Director (Figure 2), used primarily for amorphous plastics (e.g., acrylic, styrene etc.).

Shear joint welds are achieved by first melting the contacting edges, then continuing the melt along the vertical walls as the parts telescope together. Telescoping prevents exposing the weld region to air, which could cool it too rapidly, causing brittleness or oxidation. Weld strength, determined by the depth of telescoping, can be increased even beyond that of the adjacent wall by designing the depth at 1.5 to 2 times the wall thickness. For conservative calculations, assume



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joint strength efficiency to be approximately half of the base resin's strength. (Fillers and reinforcements contribute no strength to a welded joint).

Where flash is objectionable, flash containment traps (Figure 3) should be included in the design.

High moisture content can result in very weak or ineffective welds. For example, exposure of nylon parts to warm air 23°C (73°F) at 50 percent relative humidity for 24 hours can seriously degrade a weld. Preferably, parts should be welded in a dry-as-molded condition (0.2 percent moisture for 66 nylon).

Because of the multi-directional forces developed during welding, supporting fixtures to prevent wall movement are very important. Fixtures must provide solid support around and under the joint, and the horn must be as close to the interface as possible for maximum energy input. Energy-director joints should not be used with crystalline thermoplastics where a sealing or structural bond is required.

Vibration Welding

Vibration welding is basically friction welding. Upper and lower halves of a part to be welded are placed in form-fitting fixtures mounted on platens of the welder. The upper half then is reciprocated at high

speed (120 to 300 Hz) and pressure (1379 to 2758 kPa/200 to 400 psi) against a stationary lower half.

The major advantage of vibration welding is the ability to weld large, complex parts—to 0.61 x 0.46 m (2 x 1.5 ft)—in specially designed equipment. The weld area is not restricted to the periphery. Internal surfaces such as dividers or supports are easily welded with proper design and fixturing.

Joint and part design, however, must permit unrestricted relative motion in the direction of the reciprocating travel ±0.8 mm (±.030 in). If at all possible, the weld

Figure 1. Ultrasonic Welding • Shear Joint

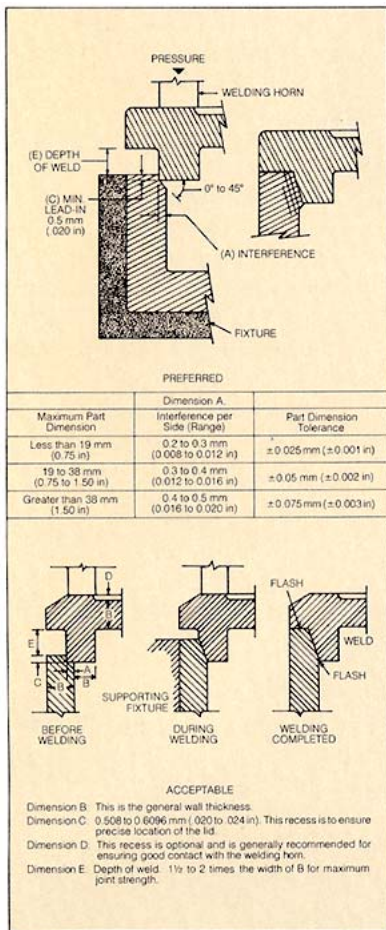


Figure 2. Ultrasonic Welding • Energy-Director Joint

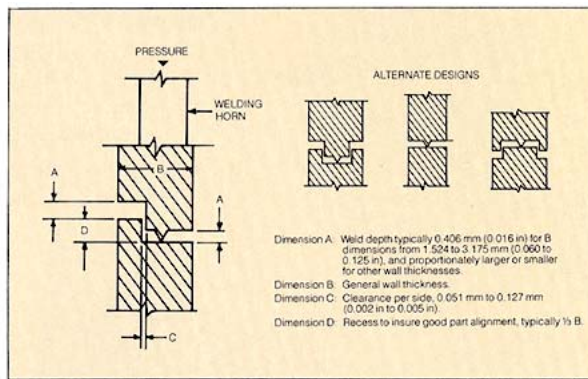


Figure 5. Joint Design for Basic Shapes

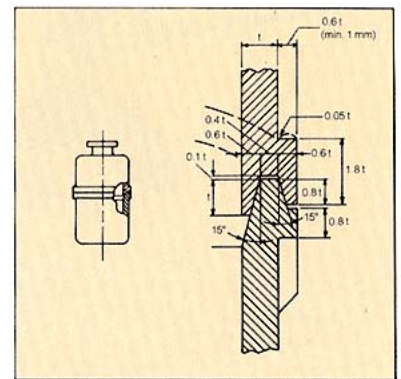


Figure 3. Flash Traps for Shear Joint

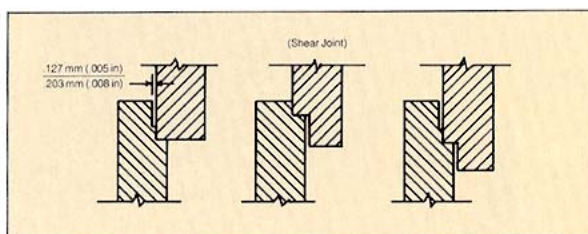


Figure 5. Joint Design for Caps or Bases

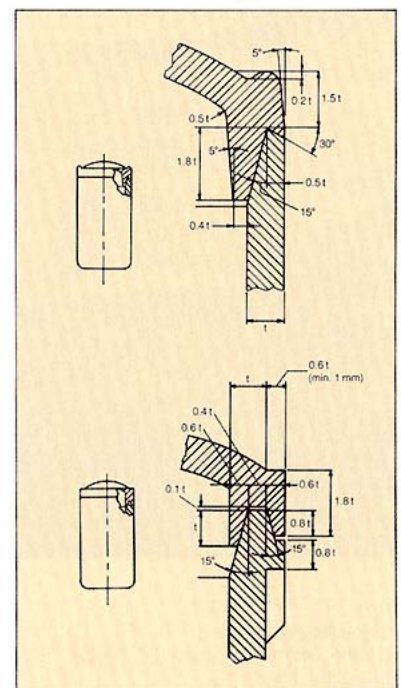
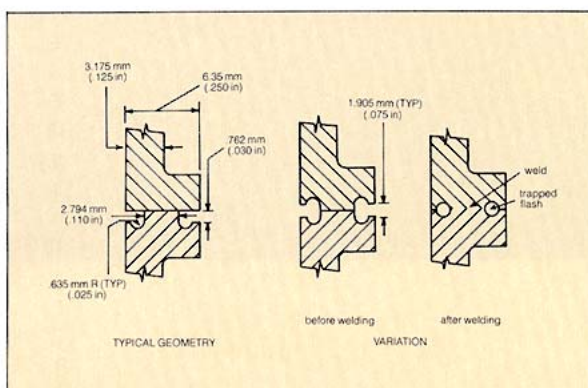


Figure 4. Typical Vibration Weld Joint with Flash Trap



Sample disc and contrasting color insert provide good view of tight joint achieved via ultrasonic welding.

joint should be in a single plane. Multi-plane parts can vary only in height—the joint plane must always be parallel to the plane of travel. Joints are normally two flat flanges approximately twice the wall thickness. If flash containment is desired, traps may be designed into the joint (Figure 4).

Properly designed holding fixtures are essential. Parts must be held in their relative position and the joint uniformly supported and aligned to assure that there is no loss of reciprocating action.

Spin Welding

The most efficient method for joining circular parts is spin welding. The equipment is simple (a drill press will suffice) and the speedy process—1-2 seconds—provides a strong, hermetically sealed bond. As in

vibration welding, this process produces a friction weld. One part is held stationary, while the other is rotated. For a proper weld, the rotating part must have a relative joint velocity of 3-12 meters per second (10-40 fps), with a joint pressure of approximately 3447 to 4826 kPa (500 to 700 psi). Weld time is typically 0.25-0.5 sec., followed by a hold time of 0.5 - 1 sec.

Joint design and firm fixturing, again, are keys to successful spin welding. Recommended joint designs are shown in Figures 5 and 6. Part size is generally limited by joint area—58 cm² (9 in²) is a typical upper limit, though larger parts have been done with special equipment. With proper dimensioning, internal and external joints can be welded simultaneously.

Because assembly economies, as well as the quality and integrity of an application, often depend on how expertly designers choose joining techniques, Design Corner frequently reviews recommended mechanical and welding assembly procedures. The author of the accompanying article, a senior technical specialist at Chestnut Run's Technical Services Laboratory, will cover press fit and snap fit designs in a forthcoming issue. Self-tapping screws and metal inserts were discussed in the spring 1983 issue of Engineering Design. This article was originally published in the Spring 1985 issue of "Engineering Design" magazine.
