Virtually all thermoplastic polymers can be welded to themselves utilizing the vibration welding technique. Vibration welding also offers the largest range of welding of dissimilar materials, as well as the ability to weld different molding grades (injection molded, extruded, etc.) to each other. Since it uses mechanical friction to weld, the process puts as much energy as required at the interface to melt the plastic. As long as the parts are able to be vibrated relative to each other in the plane of the joint, the process may be used.

This method of assembly, when compared with ultrasonic assembly, is particularly advantageous for semi-crystalline resins such as acetal, nylon, thermoplastic polyester, polyethylene, and polypropylene, as well as PVC, cellulosics, thermoplastic rubber, and elastomers, filled and reinforced resins, and those exhibiting hygroscopic properties. Fillers such as glass, minerals, talc, and mica do not present a problem for the process, as long as the percentage is kept under 40%. Different grades of a material can be welded to each other.

Vibration welding replaces ultrasonic welding in many troublesome applications, since the ultrasonic process relies on transmitting energy through the part to the joint interface. For example, the ability to transmit weld energy is dependent upon the grade of material, as well as part shape and size, the percentage of regrind, the heat history of the plastic, as well as the color additives, melt flow index and filler content. Vibration welding is not subject to the same constraints, since energy is not transmitted through the part, but rather it is generated directly at the interface.

Equipment Configurations

Branson vibration welders are available for part sizes up to 70” x 36” and larger. The smallest vibration welder has a footprint of 36” by 38”. The modular component design allows components to be integrated into automated production lines. Multiple control levels are available, and many units are capable of remote monitoring and diagnostics.
Vibration Welding

Vibration welding uses the frictional heat generated at the joint interface of two parts to be welded to melt the plastic. Branson offers both linear and orbital vibration welders. Linear welding moves one section in a back-and-forth, single axis motion against the mating piece. In orbital welding, the upper section is vibrated using constant velocity orbital motion – circular motion in all directions. Vibration Technology is an option for linear vibration welding that applies IR preheat to the plastic parts and attains virtually particulate free “clean” joints.

Vibration Welding: How It Works

Vibration welding is a velocity process; in order to melt plastic, the parts must be made to move relative to one another. Motion is produced and controlled by alternating energy to opposed electromechanical coils for linear motion or the sequencing of energy through three coils for orbital motion. The high frequency vibrational motion required for welding is applied through a spring mass system. The vibrating mass (springs, laminations, and tool) is tuned to run at its resonant frequency. A digital power supply is used to set and maintain the resonant frequency using a controlled feedback loop.

Linear & Orbital Vibration Welding

Branson offers two types of vibration welding: linear vibration and orbital vibration. Linear vibration welding - in production for over 25 years - uses transverse, reciprocating motion; the vibration occurs in only one axis. Two frequencies are available with linear welding: 100 Hz and 240 Hz. The frequency used is based on the application: high frequency has more flexibility in part design, especially parts with internal components; the lower frequency is better with dissimilar materials. Orbital vibration welding uses constant velocity motion, a non-rotating circular motion in all directions at 240 Hz. The vibration motion occurs equally in both the x and y axes and all axes in between.

Vibration Welding Process Advantages

The vibration welding process eliminates the need for solvents, adhesives, mechanical fasteners, and other consumables.

Additional advantages and benefits of the vibration welding process include:

- Fast, clean, energy efficient
- Suitable for large parts (up to 70” x 36” and larger) and irregularly-shaped parts
- No need for elaborate ventilation systems to remove fumes or heat
- High productivity with lower cost than many alternate assembly methods
- Ease of interface with automated assembly line production
- Can weld multiple smaller parts at one time.

Clean Vibration Welding with IR Preheat Option

One of Branson’s Clean Joining Technologies is Clean Vibration (CVT). This is a vibration weld process with non-contact heating and plasticization of the joint planes by means of broad-band metal-foil emitters (see picture). A subsequent vibration welding process of the molten layers of plastic follows (no solid friction, no local melt zones, uniform material flow).

The result is a “clean” vibration joint (compact weld bead, no ‘angel hair’ by-product) with excellent mechanical properties. (Contact Branson for information on this and other Clean Joining Technologies such as Laser Welding and IR Welding).

Part Configuration

It is a common misconception that vibration welding joints must be in a flat plane. Many parts are welded with all types of joint shapes. As long as there remains one axis of motion, the parts are candidates for linear vibration welding. As an example, refer to the automotive air intake manifold (shown in Figure 4), where the vibration motion is left to right.

Small angles in the direction of vibration (shown in Figure 5) can also be welded.

Designing for Vibration Welding

Three basic requirements must be met when designing parts for assembly using vibration welding:

- There must be enough relative motion (0.080”[2.032 mm]) between the mating parts to ensure that the proper amplitude can be utilized.
- The parts must be capable of being held rigidly in their respective fixtures. Walls must be designed to minimize or eliminate flexing. A uniform clamp force must be able to be applied to the joint.
- The amount of relative motion and the design features required to prevent wall flexure during the process vary depending upon the polymer being welded and the type of weld required. Several typical joint and part design details are listed below:

- **BU TT JOINT**
  The simplest joint design, the butt joint can be used on short walls or walls that are parallel to the vibration motion. No flash containment is included in this design.

- **BU TT JOINT WITH GRIP TAB DETAIL**
  This design also uses a flange with a grip tab or reverse flange detail to eliminate wall flexure and part warpage. It allows the clamp force to be applied directly over the weld area on parts that have tall walls.

- **TONGUE AND GROOVE WITH GRIP TABS**
  This joint provides pre-welding part alignment and also incorporates a design which will contain and hide the weld flash. This joint design will produce the “cleanest” finished appearance.

There are infinite variations to these three basic joint designs. Refer to Branson’s joint design specification sheet for typical dimensions and other joint and part design information.