BRANSON

Technical Information PW-4

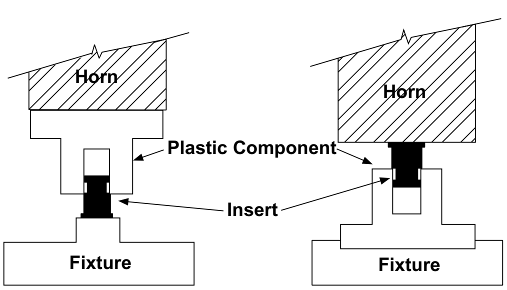
Ultrasonic Insertion

General Description

Ultrasonic insertion is the process of embedding or encapsulating a metal component in a thermoplastic part. This process replaces the costly, time-consuming, conventional method of injection molding plastic around the metal component (insert molding). An endless variety of part configurations can be inserted — flat, round, etc.; the most common is round, threaded inserts. This technical information sheet provides information on the fundamental principles of ultrasonic insertion, guidelines for insert and hole design, and basic rules for efficient use of the technique.

In ultrasonic insertion, a hole slightly smaller than the insert it is to receive is either molded or drilled into the plastic part. This hole provides a degree of interference (usually 0.015 to 0.020 inch diameter) and guides the insert into place. The metal insert is usually designed with exterior knurls, undercuts, or threads to resist loads imposed on the finished assembly.

Ultrasonic insertion can be accomplished either by driving the insert into the plastic or by driving the plastic component over the metal insert (see Figure 1). Ultrasonic vibrations travel through the driven component to the interface of the metal and plastic. Frictional heat is generated by the metal insert vibrating against the plastic, causing a momentary, localized melting of the plastic. As the insert is driven into place, the molten material flows into the serrations and undercuts of the insert. When ultrasonic energy ceases, the plastic resolidifies, locking it in place.



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In the majority of insertion applications the horn contacts the insert. However, there are several advantages to contacting the plastic part instead of the insert (inverse insertion). The horn wear problem encountered when the horn contacts the metal insert is alleviated, allowing the use of aluminum chrome-plated or titanium horns. Also, the noise level is reduced, and the power requirement is not as high.

Advantages of Ultrasonic Insertion

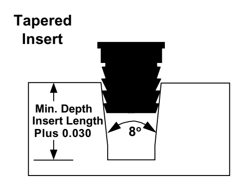
Ultrasonic insertion offers several advantages over the other insert assembly techniques including:

- Short cycle time—typically less than one second.
- Minimal induced stress around the metal insert, as with molding in or cold pressing.
- Elimination of possible mold damage and downtime should inserts fall into the mold during insert molding.
- Reduced molding cycle times.
- Multiple inserts can be driven at one time.
- Ideal for automated, high production operations.
- Repeatability, consistency, and control over the process.
- Can work with thermosets.
- More consistent results as compared with direct thermal processes.

Designing for Insertion*

The insert and hole designs are determined by the functional characteristics or requirements of an application. A sufficient volume of plastic must be displaced to fill the exterior undercuts, knurls, and/or threads of the insert to lock it in place, and produce the strength required for the application.

A typical threaded insert designed primarily for tensile (pullout) strength should have multiple undercuts to provide maximum resistance (Figure 2). Where maximum torque strength is required, the insert should have long axial (straight) knurls (Figure 3). Combination inserts are designed with both undercuts and knurls to provide pullout and torque strength.



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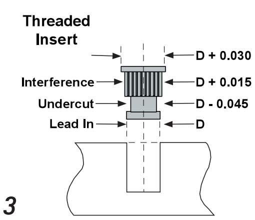

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The insert acceptance hole should be designed so a sufficient volume of material is present to be displaced by the insert. This material will fill the exterior undercuts, knurls, and/or threads of the insert to lock it in place and provide the strength required for the application. Additionally, the acceptance hole should be designed so the insert does not bottom out; the recommended minimum depth of the hole is the length of the insert plus 0.030" to provide a gap for forward-displaced material. This is especially important with threaded bore inserts, as it prevents material from being driven up through the bore, which could render the insert useless.

* Manufacturers of commercially available inserts should be contacted for design specifics relating to their products.

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The hole should also be of sufficient depth to prevent a threaded screw from bottoming out in the final assembly. This also can be prevented by specification of the proper screw length. The hole may be tapered, especially if it is to accept a tapered insert; this facilitates accurate positioning of the insert and usually reduces installation time.

When inserting into a blind hole, a vent along the insert or acceptance hole should be provided. This prevents a pressure buildup under the insert which could make it difficult to gain repeatable results and affect the appearance of the surface of the part around the insert.

A lead-in designed into the insert or the acceptance hole that allows 20% of the insert to be located in the hole prior to insertion is suggested. This provides easier handling of the parts and prevents the insert from moving out of the hole when initially contacted by the horn or during indexing in automation.

A small flange can be used on the top of an insert to create a larger horn contact area and also push material that may have been displaced up the sides of the insert back down around the sides. Should a hermetic seal be desired, a specially designed insert that incorporates a gasket or "O" ring is required to achieve consistent results.

The majority of inserting applications involve the installation of standard threaded bore inserts; however, other metal components can be inserted, including eyeglass hinges, machine screws, threaded rods, metal bezels, roll pins, metal shafts, metal mesh or screens, decorative trim, electrical contacts, terminal connectors, fabrics, and higher melt-temperature plastics.

Equipment Requirements

To ensure an efficient ultrasonic operation, these basic rules concerning equipment should be followed:

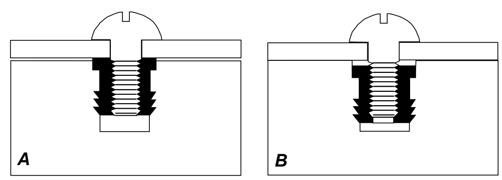
1. Power requirement (minimum):
   - Insert O.D. less than 1/4": 1000 watts
   - Insert O.D. less than 1/2": 2000 watts
   - Insert O.D. greater than 1/2": 2000-3000 watts (or more)
   - Multiple inserts: 2000 watts or more
2. Due to the high wear situation encountered in applications in which the horn contacts the insert, the horn should be made of hardened steel or carbide-faced titanium for minimum wear of the horn face.
3. The horn face should be three to four times the diameter of the insert when possible, to minimize the effect of coupling the horn to the insert.
4. When the horn contacts the insert, a converter protection circuit should be installed in the welder. (The circuit is built into 900 and 2000 Series equipment.) This prevents possible damage to the converter and associated wiring and connectors from electrical feedback caused by reverse piezoelectric effect resulting from metal-to-metal mechanical shock.
5. To maintain an accurate depth of insertion, the total distance the horn travels should be either mechanically limited by a positive stop or lower limit switch, or electronically controlled by a linear optical encoder (measures meltdown or final distance).
6. A pretrigger switch is recommended. With very small inserts (#2 or #4), pretriggering prevents cold-pressing the insert in place; for larger (greater than 1/2-20) or multiple inserts, pretriggering prevents the high starting loads that could cause overloading.
7. The component to be fixtured should be rigidly supported under the insert acceptance hole. This prevents deflection of the part under load and ensures the dissipation of energy at the interface.

Process Parameter Guidelines

The following basic guidelines for ultrasonic insertion should be considered when using the process:

- Low to medium amplitude - the total gain of the horn/booster combination should be between 1.5 to 2.5 (30 to 50 microns amplitude).
- Low to medium pressure - 15 to 40 psig (100 to 280 kPa) with pressure increased accordingly for large or multiple inserts.
- Pretrigger
- Slow stroke speed, or downspeed of the carriage assembly, to allow melting to occur and to prevent cold pressing the insert in place.
- Rigid fixturing

In addition, after seating, the top of the insert should be flush or slightly above the surface of the part for maximum pullout strength and torque resistance (Figure 4A). This will also prevent the possibly of a "jack-out" condition.



4 Preferred Undesirable

Characteristics of Thermoplastic Resins for Insertion

The codes in the following table indicate relative ease of insertion for the more common thermoplastic polymers. Use the table as a **guide only**, since variations in resins may produce slightly different results.
Note: The ratings below do not relate to the strength of the final assembly. Refer to Technical Information Sheet PW-1 for detailed polymer information. For more information, contact the insert manufacturer.

Amorphous Polymers

Material	Ease of Insertion
ABS	1
ABS/polycarbonate alloy	2
Acrylic	2
Acrylic multipolymer	2
Butadiene-styrene	2
Phenylene-oxide based resins	1
Polycarbonate	2
Polystyrene (general purpose)	2
Polystyrene (rubber modified)	1
Polysulfone	2
PVC (rigid)	1
SAN-NAS-ASA	2
Xenoy (PBT/polycarbonate alloy)	2

Semi-Crystalline Polymers

Material	Ease of Insertion
Acetal	2
Cellulosics	2
Polyethylene	2
Polymethylpentene	1
Polyphenylene sulfide	2
Polypropylene	2

Code: 1 = easiest, 5 = most difficult

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