Molded-In Inserts: Precautions and Guidelines

By Alan C. Miller

When end use considerations preclude complete utilization of the multifunctional design capabilities of DuPont engineering plastics, components can be joined through a variety of relatively quick and inexpensive assembly techniques. Among them: press and snap fits, cold heading cementing self-tapping screws, heat staking and spin, vibration and sonic welding. There is still another method of joining engineering plastic components to a final assembly that can solve critical problems. Molding metal inserts into a part, often considered a last resort because of the difficulties associated with it, may pay off in some outstanding advantages when adequate safeguards are taken in the design stage. It is the purpose of this article to suggest some of those precautions and some guidelines for successful insert molding. The three principal reasons for using metal inserts are:

1.) To provide threads that will be serviceable under continuous stress or permit frequent part disassembly.
2.) To meet close tolerances on female threads.
3.) To provide a permanent means of attaching two high-load-bearing parts, such as a gear to a shaft.

In most cases, it should prove possible to secure the insert in a pre-molded part via press or snap fitting or ultrasonic insertion. These and other options, as well as the possible disadvantages of insert molding listed below, should be carefully considered before the final design decision is made.

Disadvantages
- Inserts can “float” or be dislocated in the mold, or cause damage to it.
- Plastic may flash internal threads of an insert and require cleaning.
- Inserts are often difficult to load and can prolong the molding cycle.
- Inserts require preheating to expand them.
- Inserts in rejected parts are costly to salvage.
- When plastic shrinks around the insert, hoop stress is molded into the part and cracking may result.

Windshield wiper valve in Delrin® 500 F has threaded brass fitting (arrow) in place when it emerges from mold.

Stamped steel link attachment is secured to instrument gauge sector gear of Rynite® 545 via insert molding.
Of all the complaints associated with molding inserts, delayed cracking of the surrounding plastic because of molded-in hoop stress is the most common. In order to estimate hoop stress, assume that the strain in the material surrounding the insert is equivalent to the mold shrinkage. An indication of the stress can be gained by checking a stress-strain chart for the specific material. If that data is not readily available, multiply the mold shrinkage by the flexural modulus of the material (shrinkage x modulus = stress).

All DuPont engineering plastics can be used in insert molding, as evidenced by the accompanying photos of some current applications in Delrin® acetal resin, Zytel® nylon resin, Minlon® mineral-reinforced nylon resin, and Rynite® thermoplastic polyester resin. A quick comparison of shrinkage rates for these materials, however, puts things in better perspective. Were Zytel® 101 nylon resin, with a mold shrinkage rate of 0.016 mm per mm (in per in), and Delrin® 500 acetal resin, with a mold shrinkage rate of 0.025 mm per mm, otherwise equally well suited for an application requiring a molded-in insert, Zytel® 101 would have a clear advantage.

The higher shrinkage for Delrin® yields a stress of approximately 52.4 MPA (7600 psi), which is about 75 percent of the ultimate tensile strength of the material. The thickness of the boss material surrounding an insert must be adequate to withstand this stress, however, and as thickness is increased, mold shrinkage goes up. If we assume part life of 100,000 hours, the 52.4 MPA stress will relax to approximately 14.8 MPA (2150 psi). Not bad, but long term creep rupture data (derived from data for plastic pipe, a natural example of hoop stress) suggests the possibility that a constant stress of 17.9 MPA (2,600 psi) for 100,000 hours will lead to a creep rupture failure. A part exposed to elevated temperatures, additional stress, stress risers, or an adverse environment could easily fracture under such conditions.

Where such outstanding properties as stiffness, low coefficient of friction or spring-like attributes make Delrin® a clear choice over other materials, designers would do well to consider Delrin® 100, the toughest acetal resin yet commercialized.

The higher elongation of Delrin® 100 and its resistance to notches have made it superior to other grades for use in a variety of gears.

As previously indicated, unreinforced Zytel® 101 nylon is a very “forgiving” resin due to its lower mold shrinkage and high elongation. Its many successful gear type applications include the automotive cam shaft drive sprocket shown.

"Show and tell" version of tractor instrument cluster gives inside view of brass circuitry insert molded in actual component of Minlon 10B-40 at left.

This automotive camshaft gear of Zytel® 101 nylon, molded over a steel support ring, racked up 51,752 miles before being removed for evaluation.
Because glass- and mineral-reinforced resins have the advantage of even lower mold shrinkages than their base resins, they too have been used with success. Their lower elongation is offset by a typical mold shrinkage range of from 0.005 to 0.010 mm per mm (in per in).

Though weld lines of heavily loaded glass or mineral resins may have only 60 percent of the strength of the unreinforced material, addition of a rib at that point can substantially increase the support provided by the insert boss. (Fig.1).

**Guidelines for Molded Inserts**

- Inserts should be rounded or have rounded knurling and there should be no sharp corners. An undercut should be provided for pull out strength (Fig. 2).
- The insert should protrude at least 0.4 mm (0.016 in) into the mold cavity. Depth of molding beneath it should equal at least one sixth of the insert’s diameter to avoid sink marks (again, Fig. 2).
- Boss diameter (Fig.1) should be 1.5 times the insert diameter except for inserts with a diameter greater than 12.9 mm (0.5 in). For the latter, the boss wall should be derived with the overall part thickness and specific grade of material in mind. Keep the metal insert small relative to the plastic surrounding it.
- Toughened grades of resin should be considered (e.g., Delrin® 100, Zytel® ST-801, Zytel® 80G-33, Minlon® 12T, Rynite® 4004 and Rynite® 4005). These 6 have higher elongation than standard grades and a greater resistance to cracking.
- Inserts should be preheated before molding (200 ° F for Delrin®, 250° F for Zytel®, Minlon® and Rynite®). This minimizes post mold shrinkage, pre-expands the insert and improves the weld line strength.
- Conduct a thorough end-use test program to detect problems in the prototype stage of your development. Testing should include temperature cycling over the range to which the application may be exposed.

If you need additional assistance in establishing parameters for a successful insert molding application, contact a DuPont representative at the sales office nearest you (locations on page 2) or write to: The Editor, Engineering Design Magazine, Room N-2533, DuPont Co., Wilmington, DE 19898.

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