Snap Fits and Press Fits

By Warren E. Kenney

The “ideal” plastic assembly would have all components joined right in the molding shop. Press or snap fitted together by operators at the machine, finished products would be ready for packaging and shipment.

While assembly operations in the automotive, machinery or appliance industries are usually a bit more complex, subassemblies frequently will employ snap and press fits—especially when adequate strength, stiffness and toughness are assured by the use of such engineering polymers as Rynite® thermoplastic polyester, Delrin® acetal, Zytel® nylon, and Hytrel® polyester elastomer.

Indeed, incorporating a press or snap fit into a design to take advantage of the speed and economies it allows labor reduction and elimination of assembly fixtures, equipment and/or inventories of separate fasteners—may be one of the more critical decision points in a successful product.

Snap Fits

All snap fits are variations of two basic designs, cylindrical (Fig. 1a) or cantilevered lug (Fig. 1b). Both provide strong, easily assembled joints.

Snap fits work by using an undercut in one piece and, on the other, a lip or hook which “snaps” into the undercut. Assembly requires temporary deformation of one or both pieces, but parts return to an unstressed state in the final assembled position, thus eliminating the problem of stress relaxation, an inherent difficulty with press fits (Fig. 2).

Although assembly costs are relatively low, mold costs for snap-fit parts may be somewhat high because of complicated cross-sections. This joint generally is not used when a pressure tight or hermetic seal is required. Incorporating an o-ring or gasket between the parts at assembly can provide a degree of sealing.

Cylindrical Snap Joints

Cylindrical snap joints can be designed to separate with ease, with difficulty or not at all, depending on the shaft lead and hub return angle (see Fig. 1a). A shallow return angle (30°) separates easily; a 90° angle is inseparable. An angle of 45° is
typical for most applications. Inseparable joints are not commonly used because of the more complicated mold construction required to provide access to both ends of the hub. Generally, a 30° lead-in bevel should be provided on the shaft to facilitate hub entry.

Suggested interference limits to snap fit a steel shaft into a hub of Zytel® nylon are given in Table 1. Terminology reference is in Fig. 1a.

Slotting the cylindrical shaft or hub surfaces is an excellent method to reduce assembly forces or stresses. Essentially the cylindrical snap-fit becomes a series of cantilevered lug snap-fits and the stresses and forces would be calculated using the cantilever formulas. A typical slotted shaft is shown in Fig. 3.

Applications requiring high retaining forces, such as the diaphragm valve cover in Fig. 4, can utilize the slot technique to good advantage. The segments are provided with 90 degree undercuts that lock on the periphery. Disassembly can be achieved by using a tool through access slots.

The permissible undercut (y in Fig. 1a) is determined by the maximum allowable material strain ($E_{\text{max}}$), expressed as the absolute value.

$$y_{\text{max}} = E_{\text{max}} D_s$$

The force required to assemble a cylindrical hub/shaft is a function of two elements: the force to expand the hub, and the frictional force of sliding the shaft into the hub. The forces are combined into one equation shown below the illustration in Fig. 1a.

**Cantilevered Lugs**

The retaining force of cantilevered lugs is essentially a function of bending stiffness.

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**Table 1. Snap-Fit Dimensions**

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<th>D (max) (mm)</th>
<th>D (max) (in)</th>
<th>y (in)</th>
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**Figure 1a. Cylindrical Snap-Fit Joint**

**Figure 1b. Cantilevered Lug**

**Figure 2. Effect of Time on Press and Snap Fits**

**Figure 3. Slotted Snap-Fit**

**Figure 4. Snap-Fitted Diaphragm Valve**

**Figure 5. Properly Sized Snap-Fit Lugs**

**Figure 6. Theoretical Interference Limits for Press Fitting**

Based on Yield Point and Elastic Modulus at Room Temperature and Average Moisture Conditions.
They are actually spring applications which are subjected to high bending stress during assembly. Under working conditions, the lugs are either completely unloaded for moving parts or partially loaded in order to achieve a tight assembly.

Like cylindrical snap fits, cantilevered lugs can be made to separate easily or not at all by adjusting the return angle (Fig. 1b). Undercuts of 90 degrees can be molded by using side cores or corresponding slots in the parts. In the split worm gear of Delrin® in the photo (on previous page), two identical parts snap together permanently with cantilevered lugs for increased stiffness. The halves are positioned by two studs fitting into mating holes.

Whenever possible, lugs should be designed so that the thickness (h) or width (b) tapers from the root along the length. This will distribute stresses uniformly and reduce the material required for a given load. Always allow sufficient bending length. If the bend length is too short, the root stresses rise rapidly, breaking the lug. Fig. 5 shows a properly sized lug.

Fig. 1b defines the basic strength and deflection equations which can be used for cantilevered snap lugs. A note of caution: If high assembly stress or strain is anticipated, the secant modulus should replace the more common flexure modulus (E) for more accurate design.

**Press Fits**

Press fitting can provide a high strength joint for metal-to-plastic parts at a minimum cost. The large latitude of interference allowance, due to the lower modulus of plastics, reduces tolerance requirements and results in increased production economies. However, as mentioned in the snap-fit discussion, the press-fit holding force will reduce with time due to stress relaxation (Fig. 2). This force reduction must be accounted for in the design calculations. Typical interference limits for Zytel® 101 nylon are shown in Fig. 6.

Press fits are normally used to obtain maximum pullout force. This is done by using the greatest allowable interference between parts. To avoid exceeding material strength, interference will vary in accordance with polymer properties, part geometry and environmental conditions.

*In the spring 1983 and spring 1985 issues of Engineering Design, the Design Corner reviewed self-tapping screws, metal inserts, and welding methods recommended for efficient and economical assembly of engineering plastics. In this issue, Warren E. Kenney, senior design specialist at the Chestnut Run Technical Services Laboratory, completes the series with a new look at press and snap fits. This article was originally published in the Summer 1985 issue of “Engineering Design” magazine.*