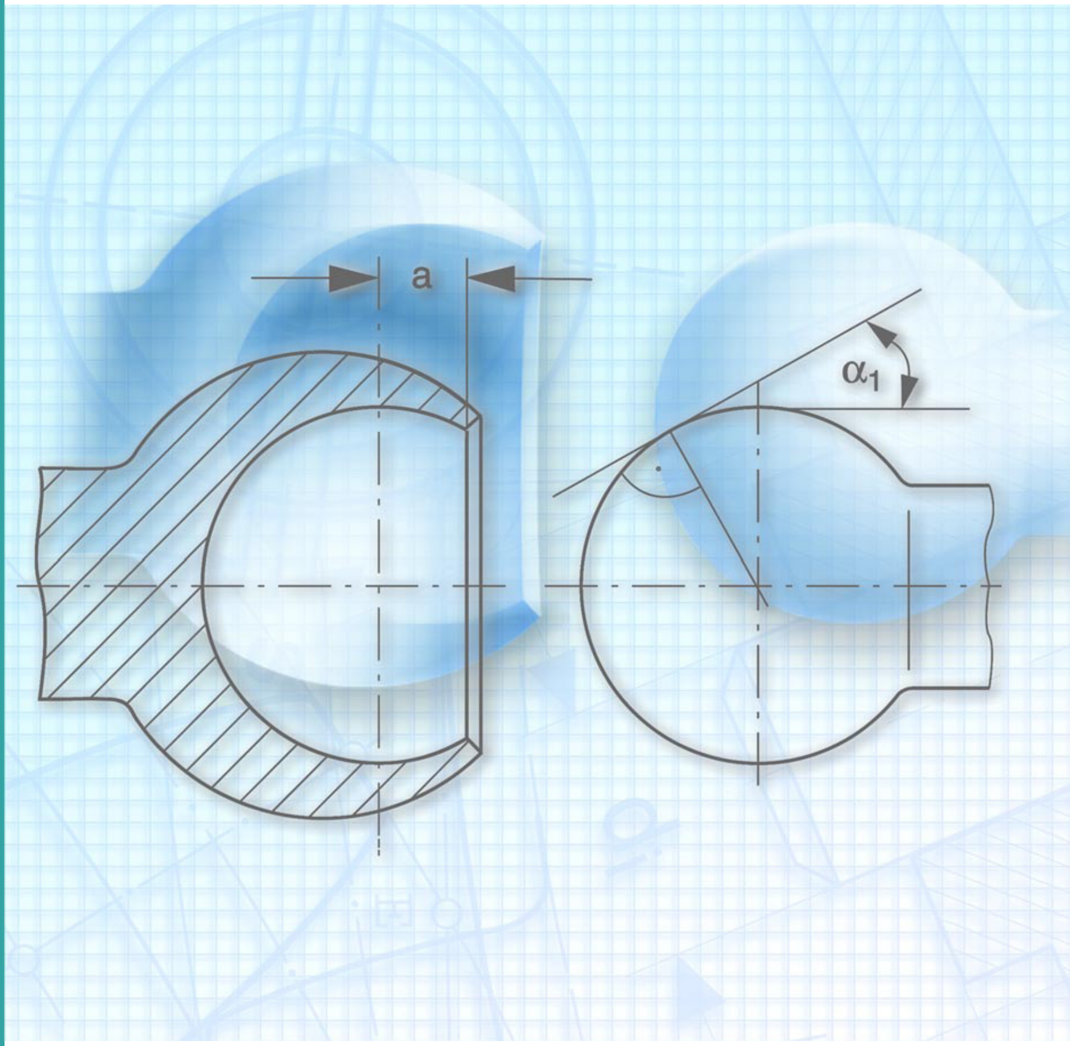
CALCULATIONS · DESIGN · APPLICATIONS B.3.1

Design calculations for snap fit joints in plastic parts



Ticona

Performance Driven Solutions™

Contents

1. *Introduction*

Snap-fits are formfitting joints which permit great design flexibility. All these joints basically involve a projecting lip, thicker section, lugs or barbed legs moulded on one part which engage in a corresponding hole, recess or undercut in the other. During assembly, the parts are elastically deformed. Joints may be non-detachable or detachable, depending on design (figs. 4 and 5). Non-detachable joints can withstand permanent loading even at high temperatures. With detachable joints, it is necessary to test in each individual case the permanent load deformation which can be permitted in the joint. In the unloaded state, snap-fit joints are under little or no stress and are therefore not usually leaktight. By incorporating sealing elements, e.g. O-rings, or by using an adhesive, leaktight joints can also be obtained.

Snap-fits are one of the cheapest methods of joining plastic parts because they are easy to assemble and no additional fastening elements are required.

2. *Requirements for snap-fit joints*

Snap-fits are used to fix two parts together in a certain position. In some cases, it is important to exclude play between the assembled parts (e.g. rattle-free joints for automotive applications). The axial forces to be transmitted are relatively small. In the majority of applications, the joints are not subject to permanent loads (e.g. from internal pressure).

Special fasteners such as rivets and clips also work on the snap-fit principle. They should be easy to insert, suitable for blind fastening, require low assembly force and be able to bridge the tolerances of the mounting hole.

®Hostaform
Acetal copolymer (POM)

®Hostacom
Reinforced polypropylene (PP)

®Celanex
Polybutylene terephthalate (PBT)

®Vandar
Impact-modified
polybutylene terephthalate (PBT-HI)

®Impet
Polyethylene terephthalate (PET)

® = registered trademark

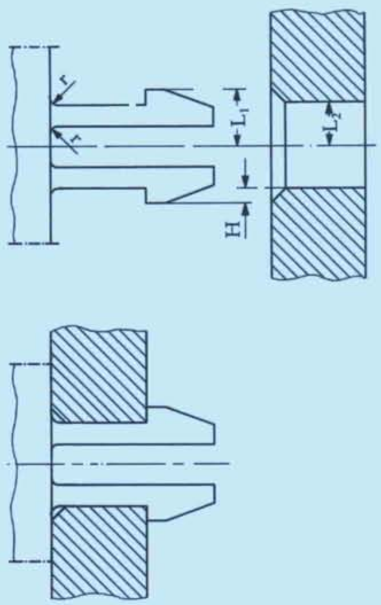
3. *Basic types of snap-fit joint*

The parts with an undercut can be cylindrical, spherical or barbed. There are three corresponding types of snap-fit joint:

1. Barbed leg snap-fit
2. Cylindrical snap-fit
3. Ball and socket snap-fit

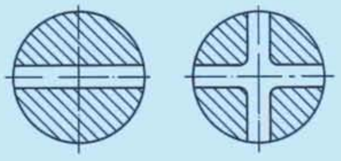
3.1 *Barbed leg snap-fit*

Fig. 1



Barbed legs are spring elements supported on one or both sides and usually pressed through holes in the mating part (fig. 1). The hole can be rectangular, circular or a slot. The cross-section of the barbed leg is usually rectangular, but shapes based on round cross-sections are also used. Here, the originally cylindrical snap-fit is divided by one or several slots to reduce dimensional rigidity and hence assembly force (fig. 2).

Fig.2



The undercut depth H is the difference between the outside edge of the barb and the inside edge of the hole (fig. 1):

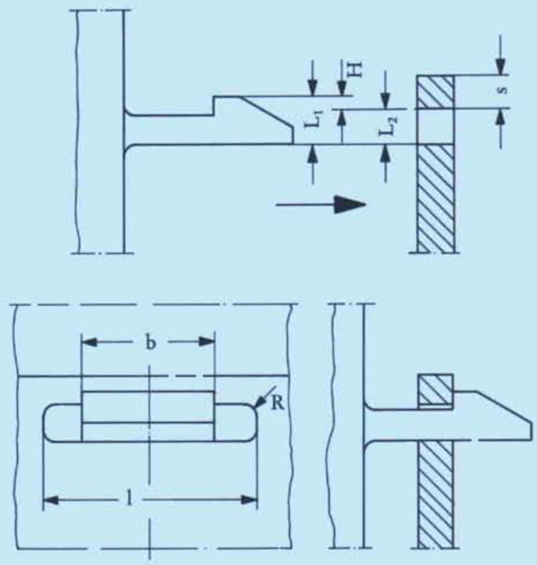
$$\text{undercut depth } H = L_1 - L_2 \qquad (1)$$

The leg is deflected by this amount during assembly.

In designing a barbed leg, care should be taken to prevent overstressing at the vulnerable point of support because of the notch effect. The radius r (fig. 1) should therefore be as large as possible.

3.2 *Barbed leg snap-fit supported on both sides*

Fig. 3



This joint employs a barbed spring element supported on both sides. The undercut depth H is the difference between the outside edge of the barb and the width of the receiving hole (fig. 3). Hence as in formula (1) we obtain:

$$\text{undercut depth } H = L_1 - L_2 \qquad (1a)$$

This snap-joint may be detachable or non-detachable depending on the design of the retaining angle.

3.3 *Cylindrical snap-fit*

Cylindrical snap-fits consist of cylindrical parts with a moulded lip or thick section which engage in a corresponding groove, or sometimes just a simple hole in the mating part.

Fig. 4: Non-detachable joint

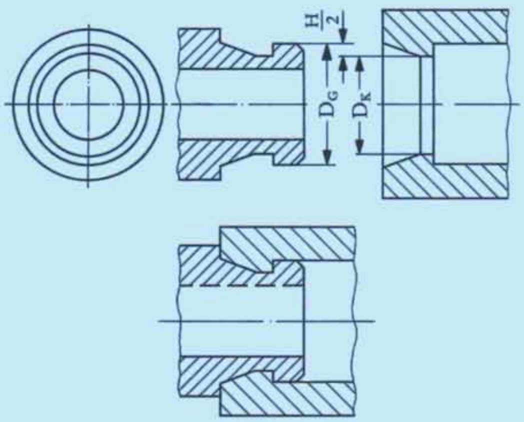
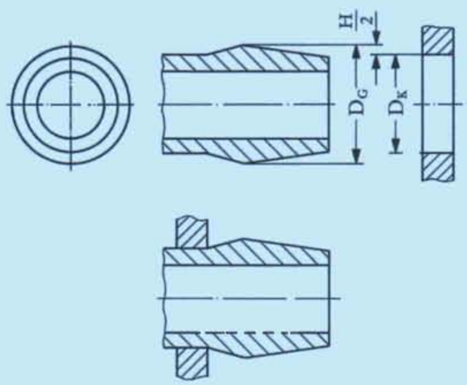


Fig. 5: Detachable joint



The difference between the largest diameter of the shaft D_G and the smallest diameter of the hub D_K is the undercut depth H.

$$\text{undercut depth } H = D_G - D_K \qquad (2)$$

D_G largest diameter of the shaft [mm]
D_K smallest diameter of the hub [mm]

The parts are deformed by the amount of this undercut depth during assembly. The diameter of the shaft is reduced by $-\Delta D_G$, and the diameter of the hub increased by $+\Delta D_K$.

So the undercut depth can also be described as

$$H = \Delta D_G + \Delta D_K \qquad (3)$$

As a result of these diameter changes, the shaft and hub are deformed as follows:

compression (−) of the shaft

$$\varepsilon_1 = -\frac{\Delta D_G}{D_G} \cdot 100\,\% \qquad (4)$$

elongation (+) of the hub

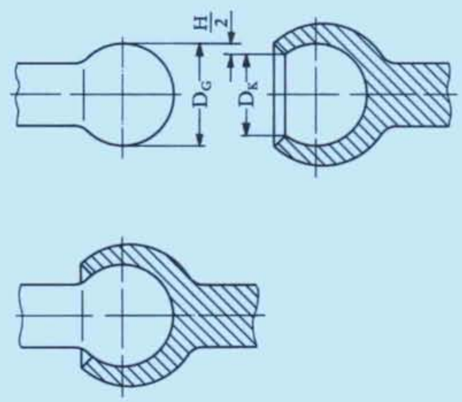
$$\varepsilon_2 = +\frac{\Delta D_K}{D_K} \cdot 100\,\% \qquad (5)$$

As it is not known how the undercut depth H is apportioned between the mating parts, it is assumed for simplicity that only one part undergoes a deformation ε corresponding to the whole undercut depth H.

$$\varepsilon = \frac{H}{D_G} \cdot 100\,\% \quad \text{or} \quad \varepsilon = \frac{\Delta D_K}{D_K} \cdot 100\,\% \qquad (6)$$

3.4 *Ball and socket snap-fit*

Fig. 6



Ball and socket snap-fits (fig. 6) are mainly used as motion transmitting joints. A ball or ball section engages in a corresponding socket; the undercut depth H is the difference between the ball diameter D_G and the socket opening diameter D_K.

$$\text{undercut depth } H = D_G - D_K \qquad (7)$$

D_G ball diameter [mm]
D_K socket opening diameter [mm]

Because the shaft is solid and therefore very rigid, the hole undercut depth H must be overcome by expanding the hub. As a result of this diameter change, the hub is deformed as follows:

$$\text{elongation } \varepsilon = \frac{D_G - D_K}{D_K} \cdot 100\,\% = \frac{H}{D_K} \cdot 100\,\% \qquad (8)$$

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