**Design for Fasteners**

The commonly used threaded fasteners are screws, bolts, and machine screws. A list of recommendation for using threaded fasteners is given below.

1. Drive screws are recommended for moderate strength. Assembly and hole-machining costs are reduced in this case.

2. The screw head plays significant role while driving the screws. Commercially available various types screw heads are shown in Figure M7.3.1. Hexagonal head and the cross-recess (Phillips) head have been found to be more common due to less susceptible to driver slippage and marred surfaces.

![Screw Heads](image)

**Figure M7.3.1:** Various screw-head styles and driving provisions

3. Machine screws are recommended in the applications where mating parts are subjected to misalignment. In such case the points that act as guides and help in avoiding cross threading. Dog and cone points have been illustrated in Figure M7.3.2

![Dog and Cone Points](image)

**Figure M7.3.2:** Dog and cone-pointed screws for misalignment of holes.
4. Screw and washer assemblies are recommended to reduce assembly labor.

![Figure M7.3: Screw and washer assemblies reduce assembly time](image)

5. Self-tapping screws are preferable to conventional screws as they eliminate tapping operations on the parts to be joined. Figure M7.3.4 shows various types of thread-cutting and thread-forming screws.

![Figure M7.3.4: Self-tapping screws to avoid tapping operation](image)

6. Use of spring nuts are recommended if the torque requirement is not high. Spring nuts are inexpensive, easier to assemble, and sometimes stays in place even when the screw is not engaged or not tight.

7. Allowance for the access to screw fasteners by using efficient driving and tightening tools should be provided. For example use powered screw drivers if possible. If not, the design should allow of hand-powered socket wrenches. Open-end and box-end wrenches should be used only for holding a bolt head while the nut is being tightened.

8. Slotted nuts and cotter pins are to be avoided if possible.

9. If production quantities are small it is better to employ separate nuts to hold fastening screws than to tap screw threads into the base part. For high-production applications, the tapping operation often will prove to be more economical.

**Metal Stitching**

One of the most economical methods for fastening nonmetallic and metallic materials, usually done in sheet form. To use metal stitching following conditions have to be satisfied:

1. Use thin materials.
2. It is difficult or costly to drill or punch holes in the materials to be joined
3. Soft (low hardness) materials to be joined
4. Wire or tubular parts are joined to sheet materials.

Figure M7.3.5 illustrates typical stitched assemblies and some thumb rules for the placement of stitches.

**Figure M7.3.5:** Typical metal-stitched assemblies and some design suggestions for metal stitch placement

**Gaskets and Seals**

When a seal is required in an assembly of metal or other rigid parts, it is better to provide a gasket, since it's cheaper. Following design suggestions are intended to make gaskets as economical as possible to incorporate in an assembly:

1. Gasket shapes should be simple if possible as it reduces tooling costs. It also simplifies assembly.
2. O rings or other standard shapes are recommended instead of special gaskets if possible.
3. Gaskets can be avoided by making one of the members of the assembly from plastic, rubber, or other flexible material. This is practical if the member is in compression during the function of the assembly.
4. Liberal thickness and width tolerances should be specified in order to minimize costs of gaskets. Note that tight width and length dimensions increase tooling and unit costs. Normal commercial thickness and recommended blank size tolerances for common gasket materials are provided in Table M7.3.1. The values provided in Table M7.3.1 are for 1.5mm thick material.
### Table M7.3.1: Commercial Thickness Tolerances and Recommended Blank Size

<table>
<thead>
<tr>
<th>Material</th>
<th>Commercial thickness Tolerance (mm)</th>
<th>Recommended blank dimension tolerance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cork composition</td>
<td>0.25</td>
<td>0.40</td>
</tr>
<tr>
<td>Cork and rubber</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Vegetable fiber</td>
<td>0.15</td>
<td>0.40</td>
</tr>
<tr>
<td>Molded sheet rubber</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>Calendered stock rubber-sheet plastics, etc</td>
<td>0.13</td>
<td>0.40</td>
</tr>
</tbody>
</table>

5. If O ring is used as a seal for a shaft or tube, machine an external groove for the O ring in the shaft or tube rather than an internal recess in the female part.

6. The width of the gasket should be at least 3 mm to avoid damages from handling or assembly. Notches for bolt holes are better than projections from holes. (See Figure M7.3.6.)

![Figure M7.3.6: Recommended gasket width around holes](image)

7. At least one of the flange faces in threaded joints should have a smooth surface to avoid cutting or tearing the gasket.

8. When using molded rubber seals, it is recommended to have them held in place by a snap-in action rather than with fasteners.

9. It is recommended to use formed-in-place gaskets made from silicone rubber or anaerobic-plastic adhesives in case of maintenance and low-quantity production. It is found to be very useful as they eliminate the need to cut and fit sheet gaskets.

**Press-Fits**

Press-fits are low-cost methods for fastening parts securely and permanently. The major disadvantage is that it requires precise dimensional control of the mating parts. Metal-to-metal press-fits are found usually in heavier apparatus involving castings and plates, etc.
An inexpensive way of holding parts together is by roll pins and groove pins (shown in Figure M7.3.7). In fact, they do not require an accurate hole diameter.

**Figure M7.3.7:** Use commercial roll and groove pins instead of plain cylindrical pins

**Snap-Fits**

Spring force can be used to fasten parts together. The fastening effect that can be achieved with spring-steel holding devices is shown in Figure M7.3.8 through a typical spring-clip application.

**Figure M7.3.8:** Typical spring-clip application

In this assembly operation the spring should only be snapped in place and thus eliminates reaming and tapping. Flexibility of the parts is preferred to use than a separate fastener to hold the parts together. A typical snap-in-place assemblies with metal parts is illustrated in Figure M7.3.9.

**Figure M7.3.9:** Snap-in-place assemblies to eliminating the need for screw fasteners.
Automatic Assembly

The most tedious part is mechanization of assembly operation. Adjustments for component variations are difficult to incorporate in assembly machines. However, there are machines that automatically assemble mechanical components. In order to mechanize the assembly, knowledge of designing component to facilitate assembly is required.

Design modifications that help manual assembly will also aid automatic assembly. But automatic assembly need good quality designs.

Following are some design recommendations for automatic assembly:

1. Symmetrical components are recommended. They should be stocky. (Refer Figure M7.3.10)

2. If symmetry is not feasible, non symmetrical attributes should be emphasized to orient parts during automatic feeding. (See Figure M7.3.11.)

Figure M7.3.10: Preferred shapes of small parts for automatic hopper feeding

Figure M7.3.11: Use nonsymmetrical attribute of the part during automatic feeding
3. For the marking of the parts, some physical differences are to be kept so that the feeding mechanism can be designed to position the part with the marking in the specified direction. (Refer Figure M7.3.12.)

![Figure M7.3.12: Attribute to orient the part coming from the hopper](image)

4. Dimensions for locating parts during automatic feeding and placement must be consistent.

5. Flexible parts are excluded from automatic assemblies as these are difficult to feed, orient, and place automatically. Few examples of flexible parts are springs and parts made from wires, thin strip metal, or rubber.

6. In automatic assembly methods press fits are considered to be suitable fastening methods. It is preferred to use press fits and other attachment methods those do not require separate fasteners. Other methods include spot welding, twisted or bent lugs, and snap-in-place parts.
TOLERANCE RECOMMENDATIONS

Recommended dimensional tolerances for finished assemblies have been provided in Table M7.3.2.

Table M7.3.2: Recommended Dimensional Tolerances for Mechanical Assemblies (mm)

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Recommended tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions which result, from face-to-face fit of mating parts</td>
<td>+0.13,-0.00 plus sum of the parts tolerances of the parts</td>
</tr>
<tr>
<td>Dimensions dependent on visual alignment of assembled parts</td>
<td>±0.8</td>
</tr>
<tr>
<td>Dimensions controlled by fixture stops</td>
<td>±0.25</td>
</tr>
<tr>
<td>Dimensions controlled by dial-indicator gauges on assembly fixtures</td>
<td>±0.05</td>
</tr>
<tr>
<td>Sum of tolerances of the parts</td>
<td>±0.4</td>
</tr>
<tr>
<td>±0.13, ±0.00 plus sum of the parts tolerances of the parts</td>
<td>±0.13</td>
</tr>
<tr>
<td>Sum of tolerances of the parts</td>
<td>±0.025</td>
</tr>
</tbody>
</table>