8 PROCESSES FOR COMBINING SINGLE PARTS

CHAPTER CONTENTS

Introduction

Manufacturing processes discussed so far include operations for producing of a single product, i.e., product that consists of a single piece of metal. But in the real life very few of the manufactured products consist of a single part. Most common situation is when a commercial product is an *assembly*, a composition of single parts, or single parts and so called *subassemblies*, which are groups of single parts combined to serve certain purpose and forming part of a larger assembly. For example, a simple ballpoint pen an assembly composed of three single parts, a plastic tube and two caps, and one subassembly, a cartridge. The cartridge itself can be considered as an assembly of few more single parts, in which a fine metallic or ceramic ball rotates against a supply of semisolid ink.

Manufacturing processes, in which single parts are combined to form an assembly are referred to as *manufacturing processes for joining and assembling*. These processes can be divided into two major classes,

❶ *processes for non-permanent combining*, which allow for multiple disassembly and assembly of single parts and/or subassemblies, and
❷ *processes for permanent combining* of single parts and/or subassemblies. Eventual disassembly would result in severe damages to the components in the assembly and the subsequent assembly if attempted would not be possible any more.

Further classification is possible with respect to the operational methods used as follows,

❖ *mechanical assembly*, which involves the use of various fastening methods to mechanically attach two (or more) parts and/or subassemblies together. This group includes processes for permanent (*riveting*, *press* or *shrink fitting*) or non-permanent (assembly with *threaded fasteners*) assembly;
❖ *joining processes*, in which two (or more) parts and/or subassemblies are jointed together to form a permanent assembly. Examples are *welding*, *adhesive bonding*, *brazing* and *soldering*.

Most of these processes are discussed in the present chapter.

8.1 MECHANICAL ASSEMBLY

For purpose of organization, we divide processes for mechanical assembly into the following categories;

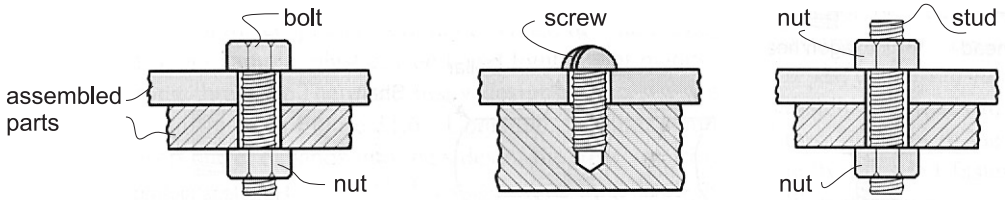
- *processes for non-permanent assembly* with threaded fasteners - screws, bolts, studs, and nuts, and
- *processes for permanent assembly*, which include assembly with rivets, and press and shrink fits.

Processes for non-permanent assembly

Threaded fasteners are components that have external or internal threads for assembly of parts. The common threaded fastener types are *screws*, *bolts*, *studs* and *nuts*.

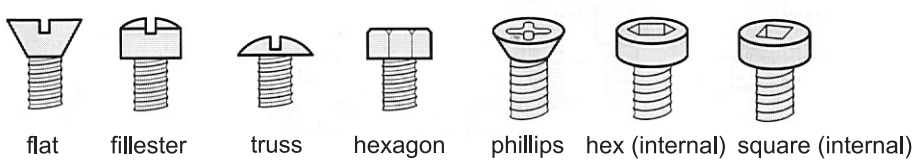
- *bolt* is an externally threaded fastener that is inserted through holes in the parts and screwed into a nut on the opposite side;
- *screw* is an externally threaded fastener that is generally assembled into a blind threaded hole and no nut is required;
- *stud* is an externally threaded fastener, but without the usual head possessed by a bolt. Studs can also be used to assemble two parts using a nut. They are available with threads on one end or both;
- *nut* is an internally threaded fastener having standard threads.

The typical assemblies that result from the use of screws, bolts, studs and nuts are shown in the figure:



Typical assemblies using (a) bolt and nut, (b) screw and (c) stud and nut.

Threaded fasteners come in a variety of sizes, threads, and shapes. Also, numerous head styles are available on bolts and screws, some of which are illustrated in the figure. The geometries of these heads, as well as the variety of sizes available, require different hand tools for the operator.



Various head styles available on screws and bolts. There are additional head styles not shown.

In addition to screws, bolts, studs and nuts, other types of threaded fasteners and related hardware are available. These include *screw thread inserts*, *captive threaded fasteners*, and *washers*.

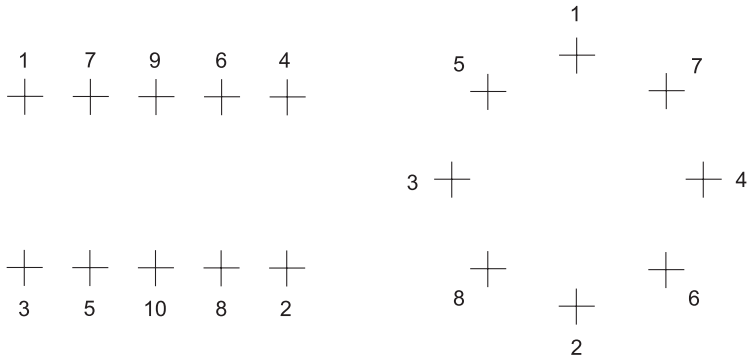
Tightening of threaded fasteners

Whether a threaded fastener serves its purpose depends to a large degree of the amount of torque applied to tighten it. Once the threaded fastener has been rotated until it is seated against the part surface, additional tightening will increase the amount of tension in the fastener (and simultaneously the amount of compression in the parts being held together) and an increasing torque will resist the tightening.

Various methods are employed to apply the required torque, including

- *operator feel*, which is not very accurate, but adequate for most assemblies;
- *torque wrenches*;
- *powered wrenches* designed to stall when the required torque is reached, and
- *torque-turn tightening*, in which the fastener is initially tightened to a low torque level and then rotated a specified additional amount.

One important issue in tightening of multiple threaded joints is to select the proper sequence of tightening. Some examples are shown in the figure:



Sequence of tightening for multiple threaded joints.

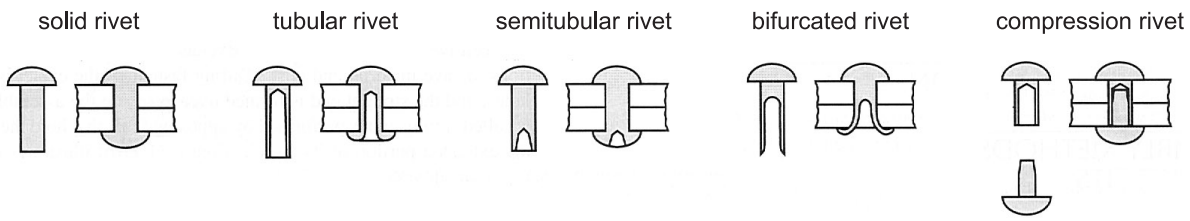
For such joints, tightening is typically done in three steps, initial tightening with 1/3 torque, then additional tightening to 2/3 of the maximum torque, and finally, tightening to the full amount of specified torque.

Processes for permanent assembly

Riveting

A *rivet* is an unthreaded, headed pin used to join two (or more) parts by passing the pin through holes in the parts and then forming (upsetting) a second head in the pin on the opposite side. The deforming operation can be performed hot or cold and by hammering or steady pressing. Once the rivet has been deformed, it cannot be removed except by breaking one of the heads.

Rivet type refers to five basic geometries that affect how the rivet will be upset to form the second head. The five basic types are illustrated in the figure. In addition, there are special rivets for special applications not shown in the figure.



Five basic rivet types.

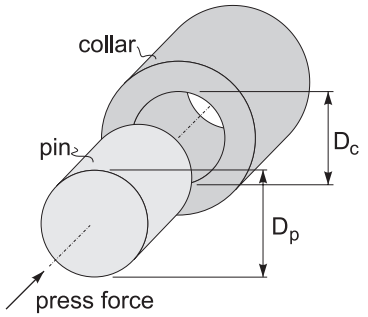
Riveting is a fastening method that offers high production rates, simplicity, dependability and low cost. Despite these apparent advantages, its applications have declined in recent decades in favor of threaded fasteners, welding, and adhesive bonding. Riveting is used as one of the primary fastening processes in the aircraft and aerospace industries for joining skins to channels and other structural members.

Much of the equipment used in riveting is portable and manually operated. Automatic drilling and riveting machines are available for drilling the holes and then inserting and upsetting the rivets.

Press and shrink fits

There are several assembly methods that are based on mechanical interference between the two mating parts being joined. The methods discussed here include press fitting, and shrink fitting.

A *press fit assembly* is one in which the two components have an interference fit between them. The typical case is when a pin of a diameter D_p is pressed into a hole of a slightly smaller diameter D_c:



Press fitting.

Applications of press fitting include locating and locking the components such as the assembly of collars, gears, pulleys, and similar components onto shafts.

The major limitations of press fitting include the necessity of a substantial press force, and the possible damage to the surfaces of components during the process of press fitting. This limitations are overcomed in the process of shrink fitting.

To assemble by *shrink fitting*, the external part is heated to enlarge by thermal expansion, and the internal part either remains at room temperature or is cooled to contract its size. The parts are then assembled and brought back to room temperature so that the external part shrinks and, if previously cooled, the internal part expands to form a strong interference fit.

A modification of the shrink fitting method is so called *expansion fit*, which occurs when only the internal part is cooled to contract it for assembly. Once inserted into the mating component, it warms to room temperature, expanding to create the interference assembly.

Various methods are used to accomplish the heating and/or cooling of the workparts. Heating equipment includes torches, furnaces, electric resistance heaters, and electric induction heaters. Cooling methods include conventional refrigeration, packing in dry ice, and immersion in cold liquids, including liquid nitrogen.

The change in diameter that results from heating or cooling a cylindrical workpiece depends on the coefficient of thermal expansion and the temperature difference that is applied to the parts.

The shrink fitting method is used to fit gears, pulleys, sleeves, and other components onto solid and hollow shafts but the most popular application is to fit bearing onto shafts.