9 Hot and cold bulk deformation processes

Metals are initially produced by the refining of ores or scrap metal in furnaces. The molten metals or alloys are usually cast into ingots, slabs, or billets. Before metal goods can be manufactured, it is necessary to transform these cast metal forms into intermediate (or semifabricated) products like metal sheets, wire, and rods, which are the starting point for the manufacture of more complex products. Cold or hot bulk deformation processes like rolling, drawing, extruding, and forging which involve large scale plastic deformation are used for this purpose. Unlike sheet metal working where the changes in thickness are small, bulk deformation processes cause large changes in thickness, diameter, or other dimensions of the cast metal forms.

Strain hardening caused by bulk deformation processes

Stress is required to plastically deform a metal, and this causes strain (or work) hardening (see chapter 2). The metal becomes brittle, and heat treatment may be needed to soften the metal and bring it into a more normal state (see chap 7).

Hot working processes

In hot working processes, the metal is heated to a temperature which is usually above the recrystallization temperature, before it is subjected to plastic deformation. The advantages and disadvantages of hot working are as follows.

- The metal flows more easily at high temperatures, and consequently smaller forces and less power are required for plastic deformation.
- Ductility is high, and hence large deformations without fracture are possible. Complex shapes can be generated without much difficulty.
- Work hardening does not take place, and the components produced (especially forged components) are extremely strong.

Disadvantages are that dimensional tolerances are low, and that the metal surface is spoilt by oxidation and the formation of scale. In addition, large amounts of energy are required to heat the object before it is deformed.
Cold working processes

Cold working usually means working at room temperature. The advantages of cold working are considerable.

- Better surface finish, closer tolerances, and thinner walls in products can be realized.
- The increase in strength due to strain hardening can be retained if required, or if preferred the metal can be returned to a ductile state by heat treatment.

Disadvantages are the high flow stresses involved, which make high tool pressures and large power requirements necessary.

Rolling

Rolling is the most important of the bulk deformation processes. In flat rolling, the thickness of a slab is reduced to produce a thinner and longer but only slightly wider product (Fig.9.1). Initially, cast slabs are rolled by hot rolling processes. Hot rolled plates or sheets have rough surfaces and poor dimensional tolerances. They are relatively thick, and are used in applications like ship building, boiler making, and for the manufacture of welded machine frames.

Thinner sheets are manufactured from the hot rolled sheets by cold rolling. Cold rolled sheets have a better surface finish and tighter tolerances. In addition to flat rolling, hot or cold shape rolling can be used to produce long bars, rods, etc. each having a uniform but different cross-section (Fig.9.2).

In ring rolling (Fig.9.3), and tube rolling (Fig.9.4), pierced billets and centering mandrels are used to manufacture hollow products. Thread rolling is used to manufacture screws, taps, etc. which have stronger screw threads than those produced by screw cutting processes.

Drawing

In the drawing process, the material is pulled through a die of gradually decreasing cross-section. Most types of wire having circular, square, or other types of cross-section, are manufactured by drawing (Fig.9.5). Metal wire is the starting point for the manufacture of a number of products like screws, nails, bolts, and wire frame structures. Seamless tubes can also be produced by a drawing process (Fig.9.6).