Introduction to Deformation Processes

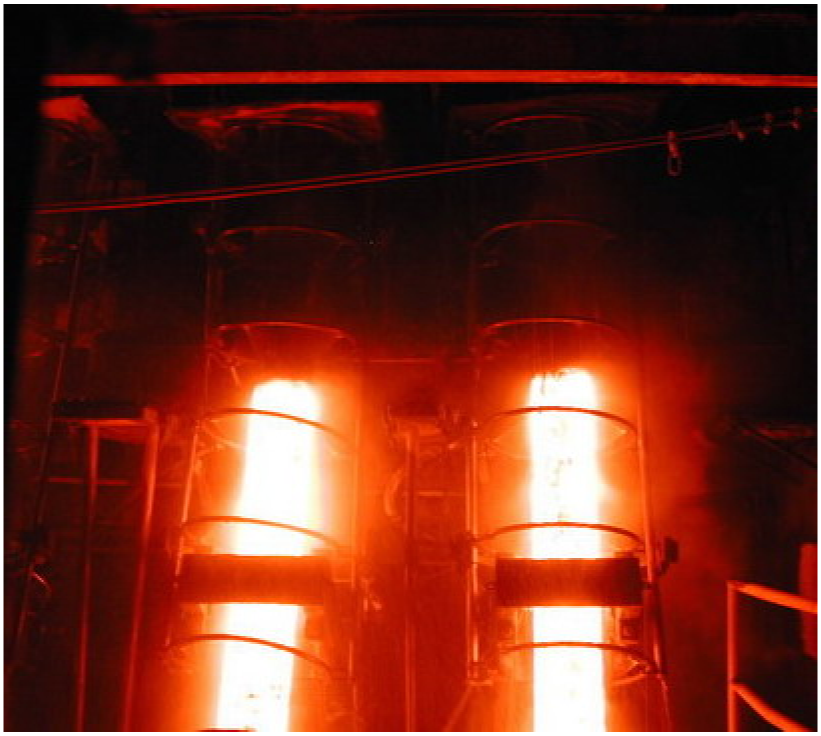
A forming operation is one in which the shape of a metal sample is altered by plastic deformation. Forming processes include stamping, rolling, extrusion and forging, where deformation is induced by external compressive forces or stresses exceeding the yield stress of the material. Drawing is a fundamentally different process in that the external forces are tensile in nature and hence the yield stress of the material cannot be exceeded.

Metals or alloys used in forming processes require a moderate level of ductility to enable plastic deformation with no fracture.

Some formed articles

Forming can be divided into two categories:

Hot Working



Hot ingots from Phase Transition Group web page

Deformation is carried out at a temperature high enough for fast recrystallisation to occur. A crude estimate for a hot working temperature T for a particular metal or alloy is that it must be greater than $0.6T_m$ where T_m is the melting point in degrees Kelvin. This lower bound for the hot working temperature varies for different metals, depending on factors such as purity and solute content. Thus, a highly pure metal will undergo recoveryand recrystallisation at a particular hot working temperature more readily than an alloyed metal.

Deformation energy requirements for hot working are less than that of cold working. At hot working temperatures, a metal remains ductile through dynamic reforming of its grain structure, so repeated, large deformations are possible. The strain rates of many metal-working processes are so high that there is insufficient time for the metal to recrystallise as it deforms.

However, recovery and recrystallisation do occur in the time period between repeated hot working operations.

Hot working achieves both the mechanical purpose of obtaining the desired shape and also the purpose of improving the physical properties of the material by destroying its original cast structure. The porous cast structure, often with a low mechanical strength, is converted to a wrought structure with finer grains, enhanced ductility and reduced porosity. Depending on the final hot working temperature, an annealed microstructure can be obtained.

At elevated temperatures, most metals experience some surface oxidation, which results in a poor surface finish as well as a loss of material. Processing in an inert atmosphere is possible, but it is very expensive and is usually avoided unless the metal is very reactive.

Cold Working

This is the term for processes that are performed at room temperature (or up to about 200°C for some metals). Cold working leads to anisotropy and increased stiffness and strength in a metal. There is a corresponding decrease in ductility and malleability as the metal strain hardens.Advantages over hot working include a better quality surface finish, closer dimensional control of the final article and improved mechanical properties.

Cold working processes can be divided into two broad classes:

1. Those in which cold working is carried out for the purpose of shaping the article only.

- Here, any strain hardening effects are not desired and may have to be removed by annealing both between the various stages of plastic shaping as well as after the final cold working shaping operation.

2. Those in which the object of cold rolling is not only to obtain the required shape but also to strain harden and strengthen the metal.

- Plastic deformation must not be carried beyond a certain point or brittle fracture is likely to result. In order to avoid this, total deformation can be accomplished in a series of steps in which the article is successively cold worked by a small amount and then process annealed in order to reduce hardness and increase ductility, thereby permitting further cold working as required.

Source: http://www.doitpoms.ac.uk/tlplib/metal-forming-2/intro.php