HEAT TREATMENT PROCESSES

Annealing
This is the process by which heat is introduced to relieve internal stresses.

Ferrous metals are heated until bright cherry red (725°C), allowed to soak at this temperature and then allowed to cool slowly.

Aluminium is heated to 350-400°C and then allowed to cool. A temperature indicator soap is rubbed on to the surface and turns black when the temperature is reached.

Copper is heated to dull red and either quenched in water or allowed to cool.

Brass is heated to dull red and allowed to cool.

Copper and brass need pickling in dilute sulphuric acid after being treated to remove surface scaling.

Normalising steel
This process is only used for steel in order to refine the structure of the material after work hardening. This involves heating the steel to its 'upper critical limit', which is between 700 and 900°C depending upon the carbon content of the steel, soaking at that temperature for a short while, and then allowing it to cool in air.

This process results in a tougher metal than would otherwise be achieved by the process of annealing.

Hardening steel
The physical properties of steel vary according to the carbon content. Hardening of steel is achieved by heating to above the upper critical point and then, after soaking at this temperature, cooling rapidly by quenching. Quenching is normally carried out in water although more rapid cooling can be achieved using brine (salt water). Slower cooling can be achieved using oil. With high carbon steels, oil is used for quenching so as to reduce the risk of cracking the steel.

The degree of hardness depends upon the amount of carbon present. Mild steel, with a carbon content below 0.4% cannot be hardened in this way. High carbon steels however become so hard that they are too brittle for many applications and so they have to undergo tempering to make them tougher.

Tempering
This process involves raising the temperature of the hardened steel to 230-300°C depending upon its intended use. Within manufacturing industry this takes place in a temperature controlled oven. In a workshop tempering involves cleaning the hardened steel to brightness with emery cloth so that oxide colours will be visible as an indicator of the temperature. As the bright steel is heated using a gas air torch, coloured oxides develop and move along the steel as the heat is conducted. When the desired colour reaches the working part of the tool then the tool is immediately quenched in cold water.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Hardest</th>
<th>Approx temp (°C)</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pale straw</td>
<td>Hardest</td>
<td>230</td>
<td>Lathe tools, scrapers, scribers</td>
</tr>
<tr>
<td>Straw</td>
<td></td>
<td>240</td>
<td>Drills, milling cutters</td>
</tr>
<tr>
<td>Dark straw</td>
<td></td>
<td>250</td>
<td>Taps and dies, punches, reamers</td>
</tr>
<tr>
<td>Brown</td>
<td></td>
<td>260</td>
<td>Plane irons, shears, lathe centres</td>
</tr>
<tr>
<td>Brown-purple</td>
<td></td>
<td>270</td>
<td>Scissors, press tools, knives</td>
</tr>
<tr>
<td>Purple</td>
<td></td>
<td>280</td>
<td>Cold chisels, axes, saws</td>
</tr>
<tr>
<td>Dark purple</td>
<td></td>
<td>290</td>
<td>Screwdrivers, chuck keys</td>
</tr>
<tr>
<td>Blue</td>
<td>Toughest</td>
<td>300</td>
<td>Springs, spanners, needles</td>
</tr>
</tbody>
</table>
Case hardening mild steel

We have seen that mild steel, because of its low carbon content cannot, be hardened by the above process. Case hardening involves introducing a surface layer of carbon to the steel so that this outer surface can then be hardened. This can be carried out either by heating the steel to a cherry red heat and dipping it in carbon - this process is repeated several times to build up a thickness - or by packing the steel in charcoal and cooking it in an oven at 900 °C for several hours. Packing in charcoal is called carburising or pack carburising.

The steel can then be hardened as before. Case hardening does have an advantage in that the softer core of the steel remains tough whilst the outer surface is hard.

METAL FINISHING

The purpose of finishing metals is to:

- provide protection against tarnishing (oxidation) and corrosion;
- enhance the appearance of the end product.

Whatever surface finish or protection is applied to metals it is important that first the surface is 'finished' and is free from dirt, grease and oxide films. Care should be taken with handling as this is the major contributor to surface deterioration. Hand finishing usually involves a succession of abrasive treatments: filing, drawfiling, emery cloth and polishing.

METAL FINISHING PROCESSES

Oil blacking

This traditional and simple process is normally applied to forged steel products. It involves heating the steel to a dull red heat and then quenching it in a high flash point oil. The oil burns black onto the surface providing a thin protective skin that can then be lacquered to provide additional protection.

Painting

To ensure that paint stays on metal surfaces the metal must be thoroughly cleaned and degreased using a spirit such as white spirit or paraffin, and then a primer should be applied. Metal primers such as red-oxide and zinc chromate provide adhesion to the metal surface and form a suitable surface for an oil-based undercoat followed by a top coat. It is important not to contaminate the primed surface with grease through handling.
**Plastic coating**

This process can be applied to most metals and is used for coating wire metal baskets, racks and handles for tools such as scissors and pliers. The product should be cleaned, degreased and heated in an oven to approximately 180°C. The coating process is called *fluidisation* and takes place in a fluidisation tank. The tank contains plastic powder with air passing through it which makes it behave as a liquid. The work is plunged in, left for a few moments whilst the plastic melts and fuses against the hot surface, and is then removed.

Returning the product to the oven then ensures a smooth high gloss plastic surface.

**Lacquering**

Lacquer involves spraying or brushing a thin layer of cellulose or varnish onto the surface to provide a clear protective barrier against tarnish and oxidisation. This is particularly suitable for items such as jewellery manufactured from attractive non-ferrous metals such as copper as it allows the colour of the metal to show through.

**Enamelling**

This decorative process uses powdered glass which is melted to flow over the metal to give a hard colourful and protective finish.

Vitreous (stove) enamelling is used on steel for equipment such as cookers and provides a finish which is heat, chemical, wear and corrosion resistant. Enamelled jewellery is made using a base metal such as copper or gilding metal. Small enamelling kilns are used for this purpose.

**Electroplating**

Electroplating is used to give metals such as copper and brass a decorative protective finish. The product to be coated is immersed in a metallic salt solution called an electrolyte. A current is passed between the metal to be used for the coating and the product causing deposits of the coating to be formed on the product. Electroplating is used for chrome plating taps and silver plating jewellery.

**Anodising**

Anodising is a process that is used on aluminium to thicken the oxide layer of the surface. It is an electro process similar to electroplating except that no other metal is introduced. Colouring dyes are added to the process to provide a colourful ‘metallic’ surface finish.