

HEAT TREATMENT

Work Hardening

When metal is bent or shaped by hitting with a mallet, the area being reshaped becomes harder and more brittle. This is why it is possible to break a length of steel wire by repeatedly bending it backwards and forwards. Each time it is bent it becomes harder and more brittle until it breaks off.

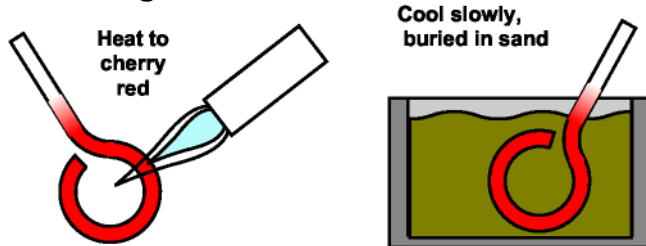
One problem is that new metal products are likely to have areas that have been shaped and are too brittle. It is possible to get rid of the brittle areas by **annealing** the metal.

Annealing

Annealing is the process of heating metal to soften it and remove the brittleness.

METAL	METHOD	COOLING TIME
Aluminium	Put soap on the surface and heat with a blowtorch until the soap turns black (400°C)	Can be cooled by washing off the soap in cold water
Steel	Heat to cherry red (725°C)	Cool slowly buried in sand
Copper	Heat to dull red (500°C)	Cool naturally in still air

Annealing steel



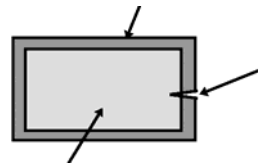
COLOUR	TEMPERATURE	USES
Light brown	240°C (still brittle, not tough)	Drills, milling cutters
Dark brown	270°C (quite tough)	Scissors, knives
Dark purple	290°C (tough, not brittle)	Screwdrivers, spanners

Case Hardening

Mild steel cannot be hardened and tempered because it does not contain enough carbon for the process to work. However, if mild steel is heated to bright red heat and then buried in carbon rich powder, the carbon melts and soaks into the surface of the steel to a depth of up to 2mm.

The mild steel can now be hardened and tempered in the same way as high carbon steel. This is known as **Case Hardening**, because only the surface with the extra carbon becomes hard, the inner core of mild steel remains soft.

Hard outer case



Case hardened mild steel is very tough, because any cracks that start in the hard, brittle outer case are stopped by the soft core.

Soft inner core

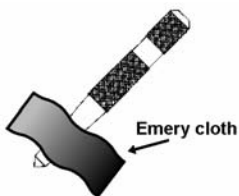
Hardening and Tempering

High Carbon Steel is the only common metal that can be hardened by heat treatment.

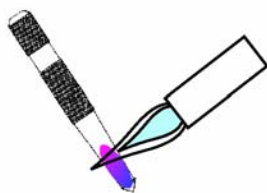
It is **hardened** by heating to bright red and then cooling it quickly by plunging it into room temperature water. It is now very hard, but unfortunately also very brittle, too brittle to use without it breaking. It needs to be softened a little to reduce the brittleness, this is done by the process of **tempering**.

Tempering

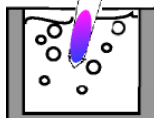
1. Clean the area to be tempered.



2. Heat gently until the correct colour appears and moves to the tip. (see table)



3. Plunge the tip into water and swirl it around. It is now the correct hardness and not too brittle.



KEY WORDS Annealing: Tempering: Case hardening

1. Explain how repeat bending of mild steel wire will result in it breaking in two.
2. What is meant by the term 'annealing'?
3. How would you anneal aluminium?
4. How would you anneal mild steel?
5. How can high carbon steel be hardened by heat?
6. Why does hardened steel need to be tempered?
7. Illustrate the stages of tempering a screwdriver head. (State the colour that you need to heat the blade to).
8. How is mild steel treated so that it can be hardened?
9. Case hardened mild steel is tough. Why?
10. Between the temperatures of 230°C and 300°C, steel can be said to have a built-in thermometer. How can this be true?