

# Heat and chemical

## SECTION 2.6

Heat treatment can be used to change the properties of metals either by increasing the grain size within the material or changing how the atoms within the grains are arranged.

### Normalising

This is a process carried out on Steel that has been work hardened by exposing the steel to great force. This can create a weakness in the steel that can cause it to shear or snap.

Normalising involves exposing the steel to heat just above its critical point and then allowing it to cool naturally in air. This process allows the time for the atoms to rearrange within the existing grains relieving internal stresses. This results in a steel which is tough with some ductility.



### Annealing

This process involves heating the metal just below its critical point and holding it there for some time. This allows the grains within the metal to grow making the metal softer and easier to work.

This also relieves the internal stresses and allows the dislocations to relocate to the grain boundaries. It is often used to soften metals that have been work hardened. Or to make metals easier to bend into more complicated shapes.

Annealing is used for both Ferrous and Non Ferrous metals.

Steel is Annealed by heating it to just below the critical point. It is then allowed to soak at that temperature for a period of time. How long depends on the size of the part. The metal is then cooled slowly by leaving it in the furnace after it has been switched off.

- Aluminium is annealed after working, care must be taken not to melt the aluminium so a temperature of 350 – 400 is needed but must not reach 660 otherwise the aluminium will melt.
- Copper is easy to anneal as it is heated until it is a dull red then cooled in water or left in the air. However, black scale can build up which needs to be cleaned off by putting the copper into an acid bath, this is known as pickling.
- Brass can also be annealed by heating it to a dull red colour however at this point it is brittle this is known as Hot shortness, as a result it needs to be cooled slowly and like Copper the brass needs to have the black scale removed by pickling.



### Hardening and quenching

High carbon steels containing 0.8-1.4% carbon can be hardened this way.

Hardening involves heating the steel to just above the lower critical point, it is then allowed to soak at this temperature giving the atoms time to arrange and form Austenite.

The steel is then cooled rapidly by quenching it in oil or water, this does not give the time for atoms to arrange making the structure Martensite.



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### Tempering

The issue with Hardening and quenching steel is that it becomes brittle but Hard, so to make it tougher it has to be put through a process of Tempering.

This involves heating it to a temperature of 230 – 300 degrees Celsius, then quenching it again in oil or brine (salty water). This process removes some of the hardness and internal stresses and reduces the brittleness so the metal part is less likely to shatter when used.

The precise tempering temperature used will be selected based upon the hardness and toughness required depending upon what the steel is going to be used for.



Temperature		Color of Heated Carbon Steel	
(°F)	(°C)		
600	316	Blue	Scrapers, spokeshaves
560	293	Dark Purple	Screwdrivers, springs, gears
540	282	Reddish Purple	Cold chisels, center punches
520	271	Red	Taps <= 1/4 inch
500	260	Orange	Axes, wood chisels, drifts, taps >= 1/ inch, nut taps, thread dies
480	249	Light Orange	Twist drills, large taps, knurls
460	238	Yellow-Orange	Dies, punches, bits, reamers
450	232	Yellow	Twist drills for hard use
440	227	Light Yellow	Lathe tools, scrapers, milling, cutters, reamers
430	221	Yellow	reamers
420	216	Yellow	Knives, hammers

# Heat and Chemical

## SECTION 2.6

Define the term work hardening

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What effect does normalising have on the piece of metal?

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Explain how the normalising process works

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Define the term Annealing

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What does Annealing do to the piece of metal?

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Why do you have to be careful when Annealing Aluminium?

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When Annealing Brass and Copper what needs to be done to these metals after the annealing process?

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# Heat and Chemical

## SECTION 2.6

Explain the Hardening and quenching process

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Explain the terms Austenite

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Explain the term Martensite

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What are the advantages of Hardening steel?

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What are the disadvantages?

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Taking into account the disadvantages, why does Tempering need to be done?

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What effects the amount of Tempering needed?

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What are the Tempering colours?