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MOBILE REVISION

FINISHES TO METALS AND MODIFYING SURFACE STRUCTURE

This mobile revision pdf is based on detailed work found in the 'MATERIALS' FINISHES section.
Tap on the green link button below to go to the complete website section

Tap the blue button to view FINISHES covered by this Revision PDF

FINISHES TO METALS AND MODIFYING SURFACE STRUCTURE

1.CORROSION

2. WHY IS A FINISH APPLIED TO METALS?

3. FINISHES AND SURFACE TREATMENTS FOR METALS

4. COMMERCIAL CARBONISATION, CRITICAL POINTS, NORMALISING AND ANNEALING

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WHY IS A FINISH APPLIED TO METALS?

1. To protect them against the elements and resulting corrosion.
2. To increase the aesthetic / visual appeal.
3. To increase or reduce electrical conductivity.
4. To prevent or limit tarnishing of the surface, therefore, no need for repetitive polishing.
5. To provide decoration, such as the technique called etching.
6. To increase surface wear and resistance.

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WHAT IS ANODISING?

An electrochemical process that converts the aluminium surface into a decorative, durable, corrosion-resistant, anodic oxide finish. It increases the wear resistants of the metal and produces a better surface for the application of primers and paints. Anodising is often followed by dying, to produce an attractive, colourful finish.

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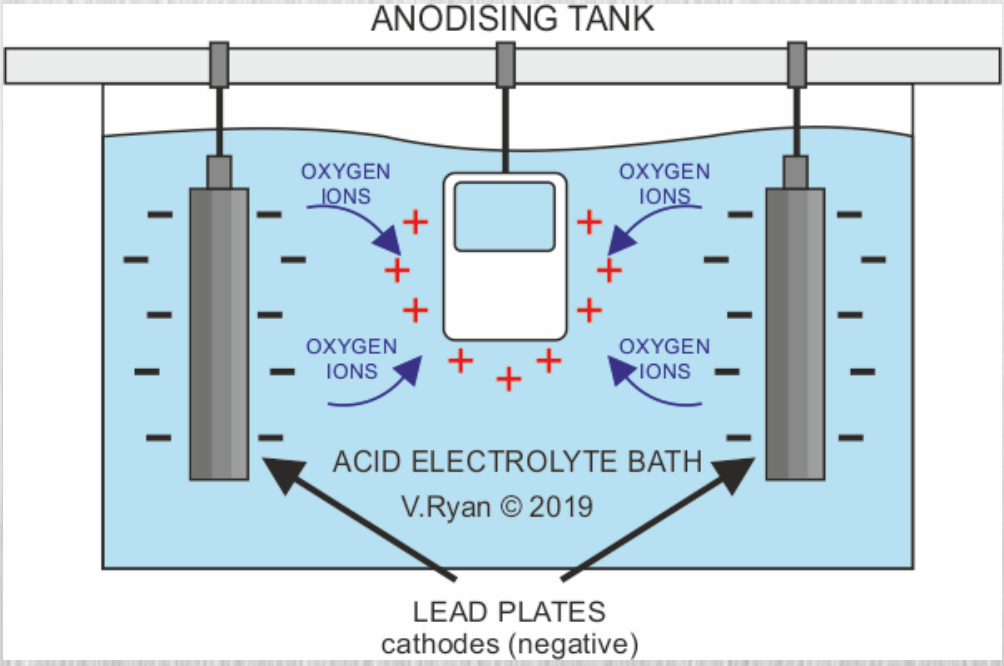

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WHAT IS ANODISING?

An anodised finish can be found on products all around us. It is used as a finish on some of the worlds must famous high buildings, including the Sears Tower in Chicago. It is often found as a finish on interiors, such as aluminium stair cases and escalators. A recent medical innovation is in the production of anodised titanium dental implants and other medical implants. MP3 players, mobile phones and many other electronic gadgets, have an anodised finish, that is also colourfully dyed. A range of scientific instruments are also anodised.

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PLANISHED / HAMMERED FINISH

A planishing hammer is used to 'hammer' a patterned finish into the surface of a metal. Copper is often given a planished / hammered finish. It is first softened by a heat treatment process called annealing. It is cleaned before being planished. As the copper is 'planished', it is rotated on the stake. Planishing hardens the metal, ensuring the final shape (such as a bowl) has the strength to resist drops and knocks.

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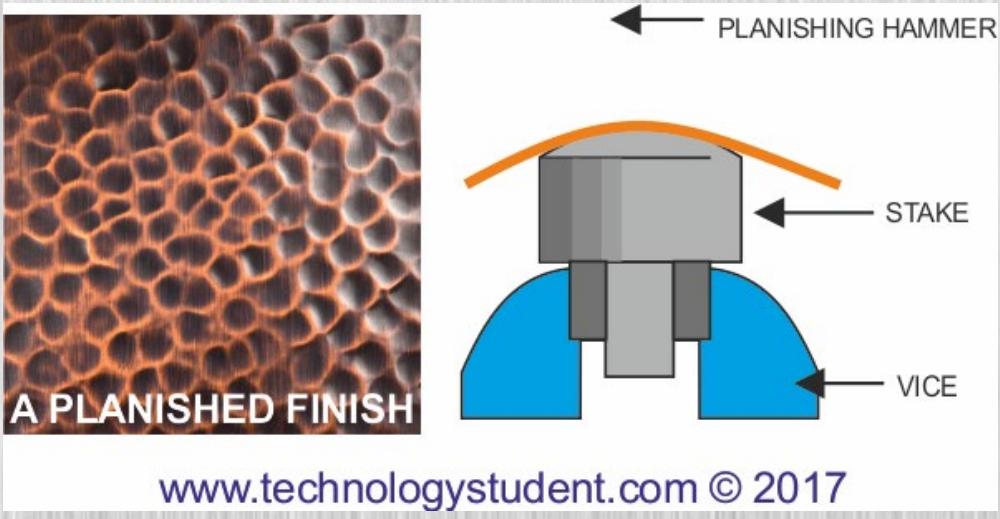

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METAL - LACQUERED FINISH - 1

Many metals suffer from surface tarnishing and even corrosion, if left open to the atmosphere / air. Surfaces can be protected through the application of different finishes such as paint or powder coating. However, sometimes the surface of metals can be attractive without a coloured coating. This is when lacquer is most useful. Lacquer is usually applied as a clear coating, leaving the surface texture on view. Lacquer forms a protective clear layer on metals and is particularly useful on brass, aluminum, silver and copper which are often in the form of decorative items. When lacquered, polishing and cleaning will no longer be required.

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METAL - LACQUERED FINISH

Lacquer is used on brass ornaments and on the surface of finely machined steel. This ensures that the surface remains as clean and polished / machined, as the day the initial finish was applied.

Materials to be lacquered must have a clean surface, with all dirt / grease removed.

Lacquer should be applied in a dust free environment, with the workers wearing appropriate protective clothing and a breathing mask. The spray 'can' version of lacquer is the easiest to apply.

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LACQUERED METAL PRODUCTS

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POWDER COATING OF METAL

The coating offers surface protection combined with a decorative appeal, due to the vast range of colours that are available. A dry powder coating can improve the functionality of the product. A mixture of resin and a pigment is electrostatically charged by a special spray gun. When sprayed, the particles are attracted to the material being coated.

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POWDER COATING OF METAL

Powder coating is a specialist process and is carried out by trained operators. It is applied in a well ventilated area, by skilled technicians wearing appropriate protective clothing, with goggles and breathing masks.

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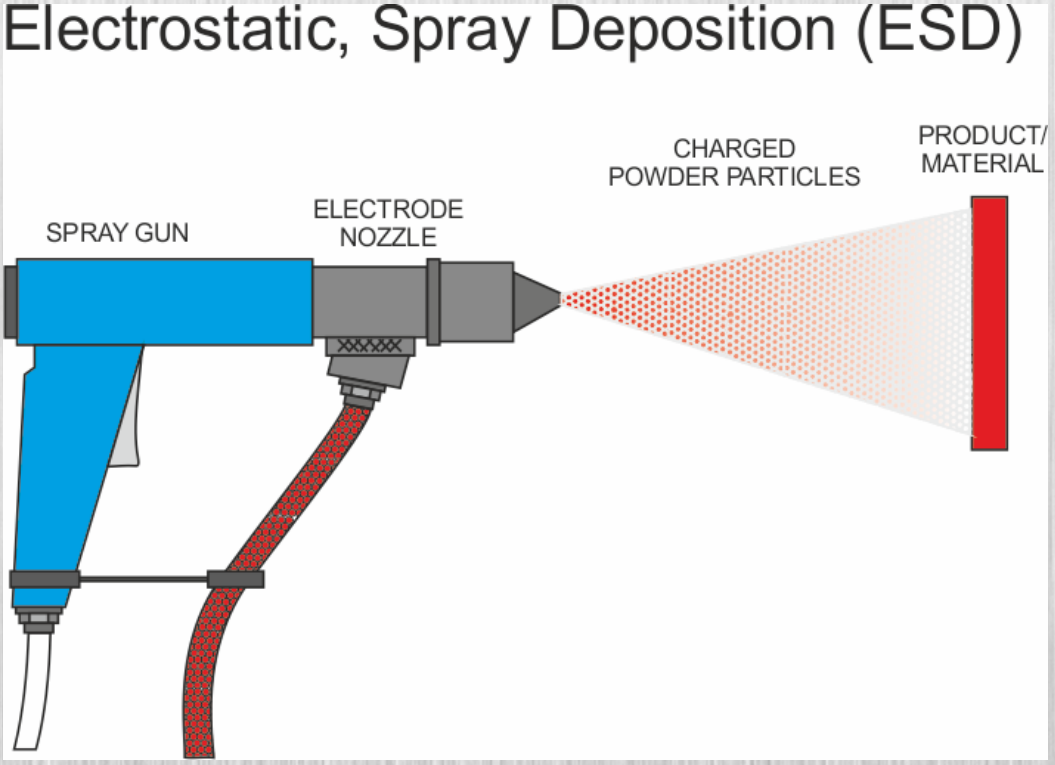

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SAMPLE POWDER COATING COLOURS

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SPRAY PAINT FINISHES FOR METAL

Spray paints (in the form of spray cans) can be bought straight 'off the shelf' of most hardware stores.

Metal may need a primer and undercoat, although it depends on the instructions on the paint can. Hammerite paint can be applied to a surface without the need for a primer or undercoat. Some cheaper paint sprays need a carefully cleaned surface, prepared with primer and an undercoat.

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BRUSH PAINT FINISHES FOR METAL

Paint can also be applied with a brush. Again the surface should be clean of rust and grease. Depending on the instructions written on the tin, a primer coat and undercoat may be required. Some brush-able paints only need one coat, without a primer or undercoat.

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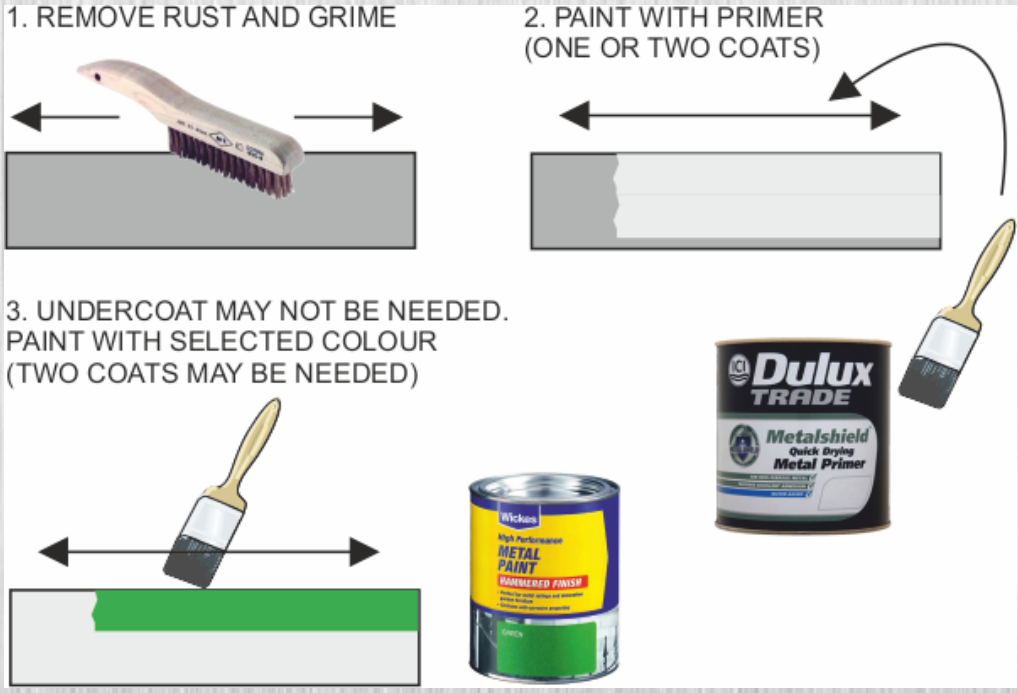

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THE LATHE - TYPICAL MACHINE FINISH

Lathe tools produce a machined finish. They can be shaped to produce a range of different machined finishes - two are shown below. A machined finish can be attractive and also have a practical function, such as a grip.

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THE MILLING MACHINE
TYPICAL FINISHES

Milling machines can be used in conjunction with a variety of cutting tools. Often the tools produce a very accurate, distinctive and fine circular pattern.

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THE SURFACE GRINDER - FINISHES

A surface grinding machine is used to accurately produce a flat surface, after some machining has already taken place (for example, through the use of a vertical miller). A surface grinder is used where absolute precision is required.
As the grinding wheel revolves at high speed, it produces a smooth, flat surface, giving a distinct finish (samples shown below). If real precision is required, a surface grinder is used.

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ELECTROPLATING

In industry, electroplating is the process whereby a cheap base metal, is coated with a much more expensive metal, in order to make it visually attractive and aesthetically pleasing (gold and silver plating are examples). Electroplating is usually a decorative process and is often used to increase the visual appeal of cheaper jewellery. It also serves to provide the surface with a level of protection against corrosion. Some everyday products such as bathroom taps have been electroplated with chrome for decoration, as well as corrosion resistance. Electroplating is also used to apply a conductive surface to metals, that are of low conductivity or non-conductive.

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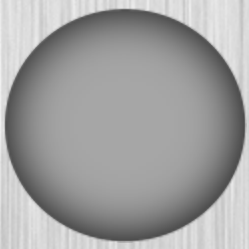

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ELECTROPLATING

The copper anode is ionised once the electrical current is allowed to flow. The ionic solution allows the positively charged copper atoms to flow to the negatively charged base metal, where they are deposited on the surface. This produces an effective coating of copper.

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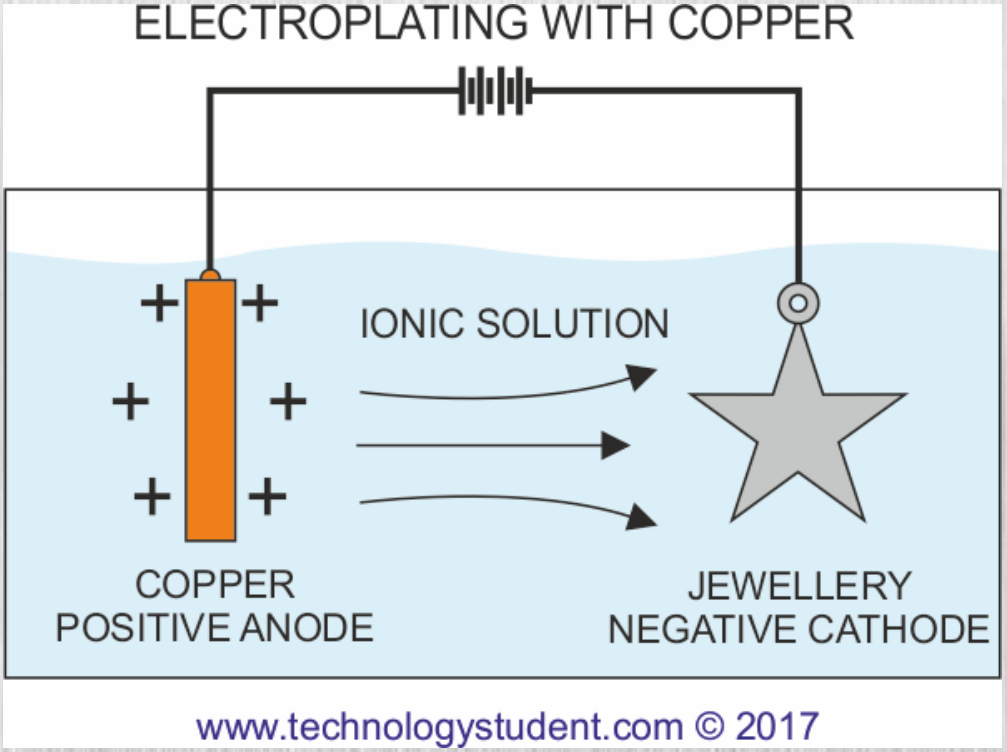

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ELECTROPLATING

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SILVER PLATED GOBLET

CHROME ELECTROPLATED TAP

GOLD PLATED WATCH

COPPER PLATED MUG

SILVER PLATED TEAPOT

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WHY ARE SOME STEEL PRODUCTS GALVANISED?

Steel is a very strong and versatile metal used to manufacture a large range of products. Steel surrounds us in our every day lives, as it is used to construct buildings and structures. It is a versatile material, although it has one weakness, corrosion.

If an exposed steel surface comes in contact with water or moisture, rust can take hold. Rust can damage the surface of the steel as seen on corroded car bodywork. It is possible that on a large structure, such as a bridge, rust can cause structural failure leading to collapse.

Galvanised steel is steel that has been coated with zinc in order to prevent rusting / corrosion.

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HOT DIPPING - GALVANISING

The hot dipping process applies quite a think layer of zinc to the steel, by passing the steel through a molten bath of zinc. The temperature of the zinc is usually in the region of 460 degrees centigrade. The zinc forms a bond with the steel by forming an iron-zinc alloy. The zinc also forms a zinc oxide when it comes in contact with the air which also helps prevent corrosion.

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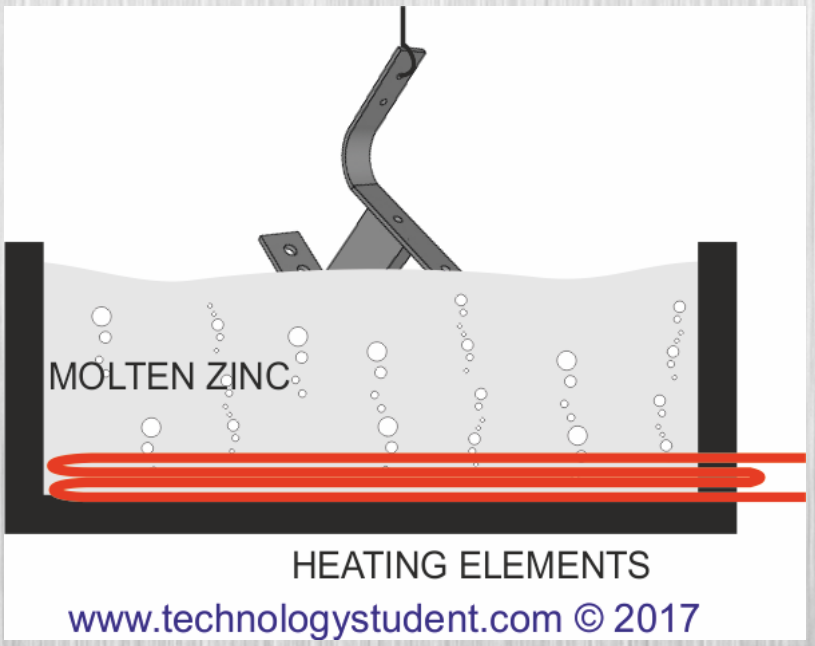

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ELECTROPLATING
ELECTRO-GALVANISED

The steel car body is electrically charged as negative and is suspended in a conducting solution, known as the electrolyte. Rods of pure zinc are positively charged and it is the zinc from these rods that is eventually deposited on the surface of the steel. The rods are suspended in the electrolyte.

'Top of the range' cars often have galvanised steel bodies.

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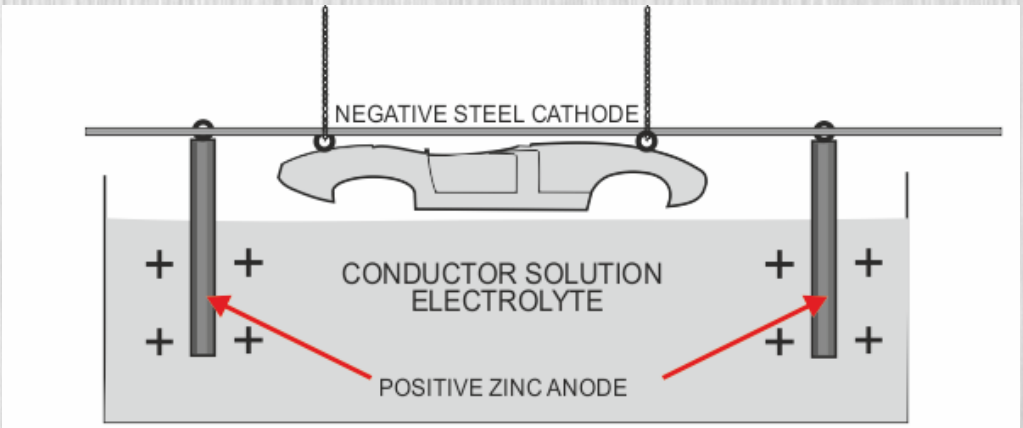

The diagram above shows a car body about to be lowered into the electrolyte solution

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THE POLISHING MACHINE - 1

The Polishing Machine (also called the Buffing Machine) is used to polish soft metals, including copper and brass, as well as plastics, including acrylic. The 'mop spins at high speed when the 'on' switch is pressed. 'Polish' is applied to the mop, before gently pushing the metal against the rotating mop.

If the material is gently pressed against the mop and moved backwards and forwards, it will be polished.

Before polishing, the material must be filed to removed scratches and then wet and dry paper or emery cloth, is used to further smooth the surfaces. Only then can it be polished on the buffing machine.

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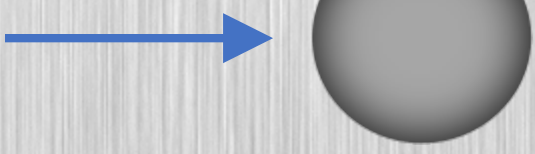

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THE POLISHING MACHINE - 2

Polishing gives the metal a smooth and reflective surface.

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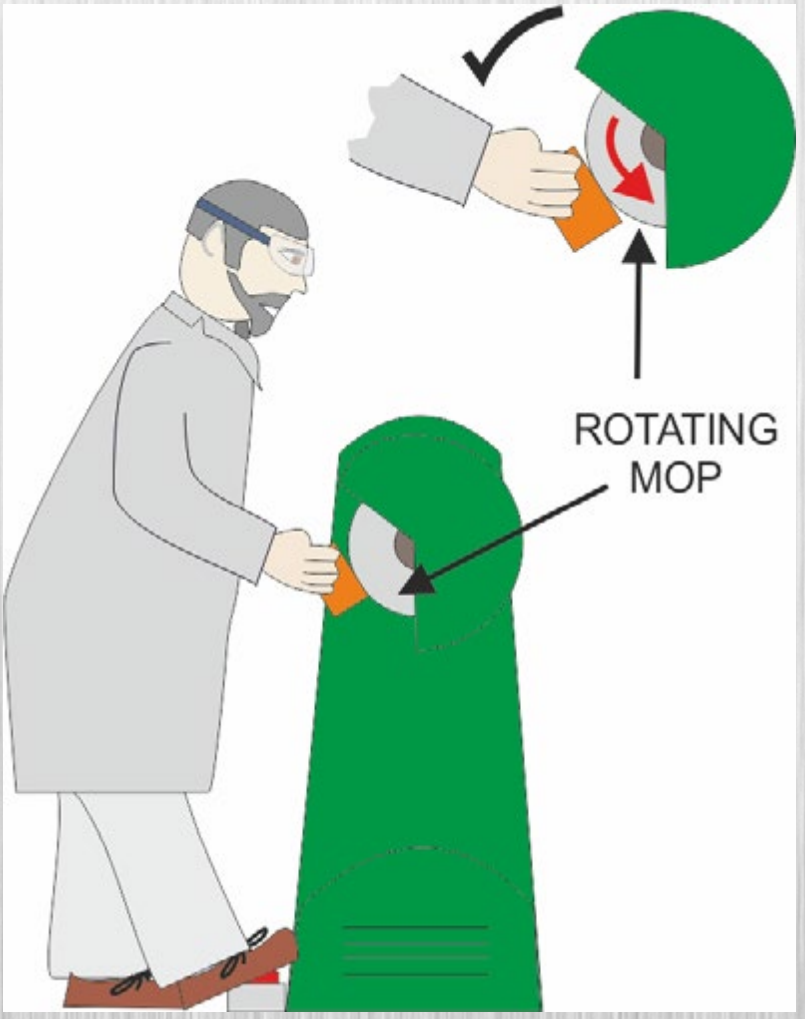

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ETCHING PROCESS
TRADITIONAL METHOD

Traditionally, 'etching' is a process, whereby acid is used to slowly remove the unprotected surface of a metal such as copper.

A pattern is produced by applying a 'resist' substance to the surface of the copper. The resist can be beeswax or shellac. A sharp tool such as a scriber, is used to 'scratch' a pattern into the resist, removing it where acid is to 'eat into' the surface.

When the drawing / 'scratching' is complete, the copper is placed in a suitable acid, in a glass container. The acid slowly dissolves the surface of the exposed copper, producing the pattern. This can take hours.

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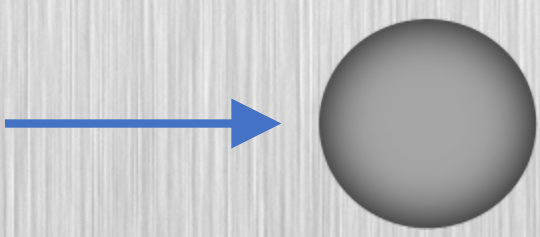

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SAMPLE ETCHED PRODUCTS

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ETCHING COPPER USING A PCB TANK AND A VINYL CUTTER

A shape can be cut out of 'sticky back' vinyl, with a vinyl cutter and then 'stuck' to a piece of copper.

The copper is then immersed in a PCB etching tank, in a mixture of clear etchant. The area covered with the vinyl is protected from the etchant, whilst at the same time the unprotected surface is etched.

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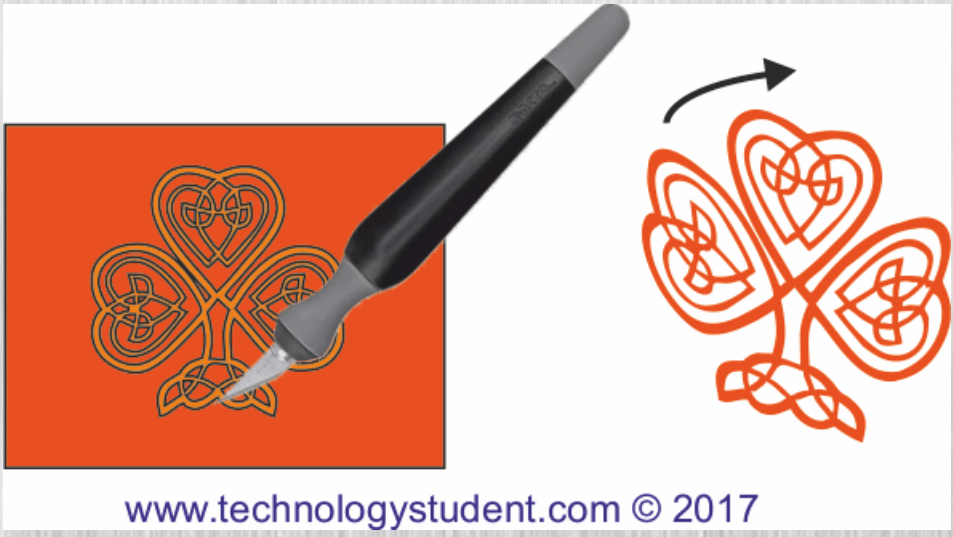

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CASE HARDENING

Case hardening is a method of hardening the surface of steel. This techniques is used for steels with a low carbon content. Carbon is added to the outer surface of the steel, to a depth of approximately 0.03mm. The inner core is left untouched and so still processes properties, such as flexibility and is still relatively soft.

In school workshops, steel is heated on the brazing hearth to red heat and then dipped into a case hardening powder, which has a high in carbon content. It is heated again and plunged into clean, cold water.

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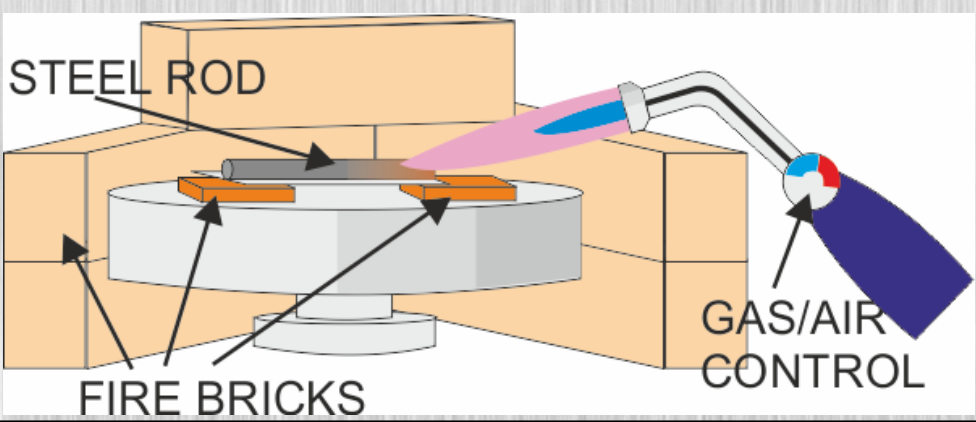

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HARDENING AND TEMPERING

This process results in a blend of hardness, strength and toughness, through the entire section of steel. It is process that is more 'intense' and variable than case hardening. A mild steel or silver steel screw driver blade, is hardened by heating to 'red' heat, to prevent it wearing down when in use. Next, it undergoes another heat treatment called 'tempering'. This second heat process reduces the hardness a little, but toughens the steel. It also reduces the brittleness of the steel, so that it does not break easily.

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ANNEALING METALS

Annealing is a heat process whereby a metal is heated to a specific temperature /colour and then allowed to cool slowly. This softens the metal, which means it can be cut and shaped more easily.

Annealing sheet aluminium: Rub soap on to the surface of the aluminium and heat it on a brazing hearth. In a short time the soap will turn black. Turn off the brazing torch and allow the aluminium to cool slowly. It is now 'annealed' and should be very soft and malleable - easy to cut and shape.

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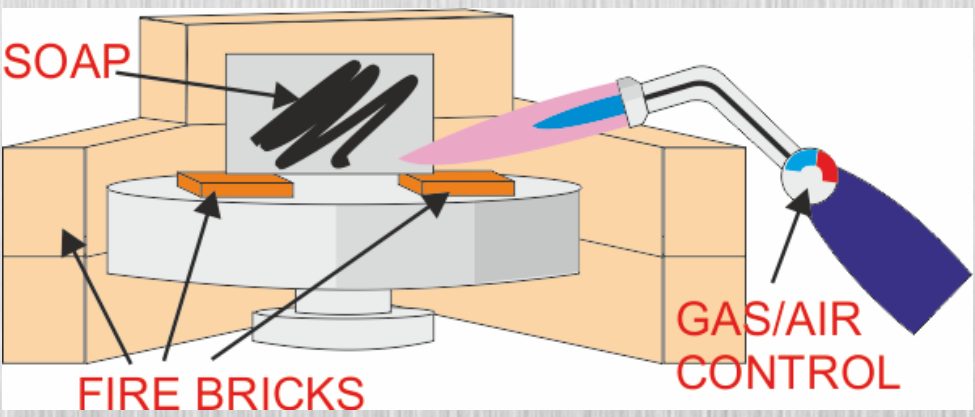

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TRADITIONAL OIL BLACKING OF STEEL

With steel, corrosion to the surface will always be a problem, especially if the product / component is in contact with moisture, as carried in the atmosphere. One of the most cost effective ways of preventing tarnishing / corrosion to the surface of steel, is to 'Oil Black'. This can be achieved on a small scale in schools, although strict safety precautions must be taken.

1. Clean and degrease the steel. 2. Heat to 'red' heat on a brazing hearth. 3. Use tongs to drop the steel into a container of old engine oil. 4. Allow to cool and remove the steel (now with a blacked finish).

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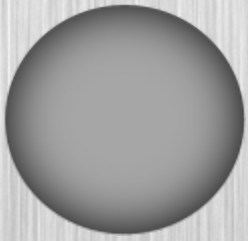

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OIL BLACKED AND CHEMICALLY BLACKED COMPONENTS

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BLACKING OF STEEL WITH A CHEMICAL BLACKING SOLUTION

This is a process called ‘Cold Chemical Blacking and does not require the steel to be heated on a brazing hearth.

1. Clean and degrease the surface of the steel being ‘blacked’. 2. Use tongs to drop the steel into a solution of ‘Chemical Blacking’. Leave for no more than five minutes. 3. Remove from the blacking solution, wash with water, dry and drop in a ‘Dewatering’ solution. Leave for ten minutes. 4. Remove and wash in clean water, revealing a ‘blacked’ finish.

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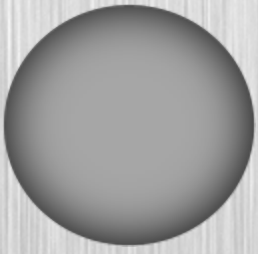

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CORROSION

Corrosion takes place, when the surface of a metal reacts with its environment. If **steel** is left in a moist, humid or wet environment, its surface forms ferric oxide, called rust.

Aluminium - over time, the surface of aluminium forms a layer of aluminium oxide. Although this is corrosion, once the layer has formed, it protects the rest of the aluminium from further corrosion.

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CORROSION

Corrosion poses many problems for engineers. Rust is not aesthetically pleasing and is not a desired outcome. In structures such as bridges, maintenance teams have a continual battle to protect the surface steel, with corrosion resistant paint, which creates a barrier between the steel and air/moisture. Corrosion can lead to structural failure and put lives at risk (see the image opposite). Therefore, preventative measures, in terms of the application of finishes, is always a design and cost consideration.

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THE CARBON CONTENT OF STEEL

The carbon content of steel, determines its hardness, ability to resist wear and its practical application. E.G. a screw driver blade requires a hardwearing surface, to resist wear whilst in use. However, a screwdriver blade that is hardened throughout its cross-section, will be too brittle / inflexible and eventually snap / break. Therefore, retaining a measure of durability / flexibility throughout its cross-section, is a vital characteristic. For this reason, the screwdriver blade has been hardened at its surface (increased carbon content), whilst having a lower carbon content throughout its cross-section.

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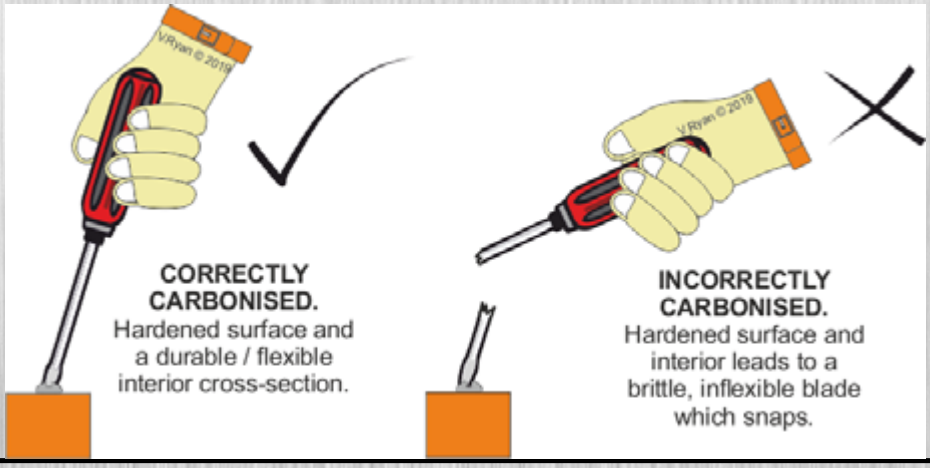

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GAS CARBONISING

The commercial industrial process called 'Gas Carbonising' is seen below. A number of steel gear wheels, for a train, have been set up in a special furnace. The gears are heated to a constant temperature of 1000 degrees centigrade, then a gas rich in carbon is introduced. This process is monitored over a number of hours, until the right amount of carbon is absorbed into the surface of the steel.

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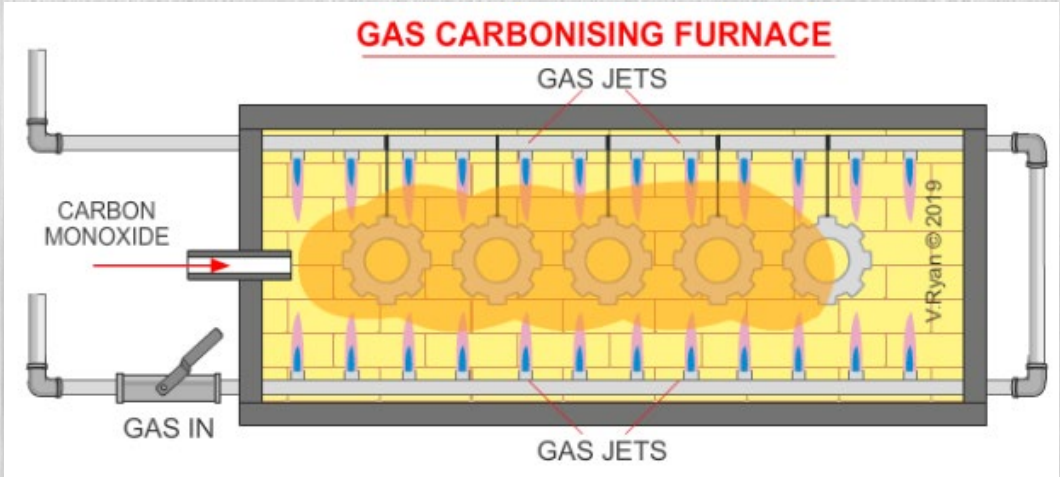

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What is the Critical Point and Critical Range of metals?

When metals are heated, they eventually reach a temperature, when their crystalline structure begins to change. The Lower Critical Point is when the change in crystalline structure starts and the Upper Critical Point, is when the change in structure ends. The alteration in crystalline structure can be quite complex and leads to changes in the metals physical properties, such as toughness, durability, tensile strength and consequently, affects the metals working properties.

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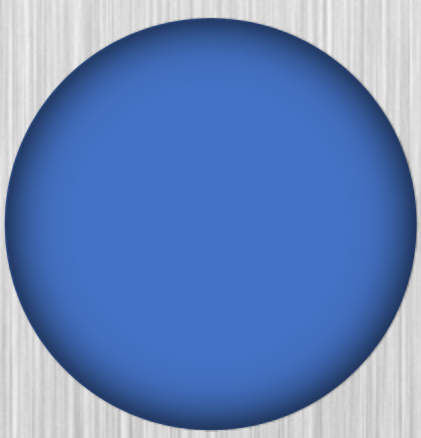

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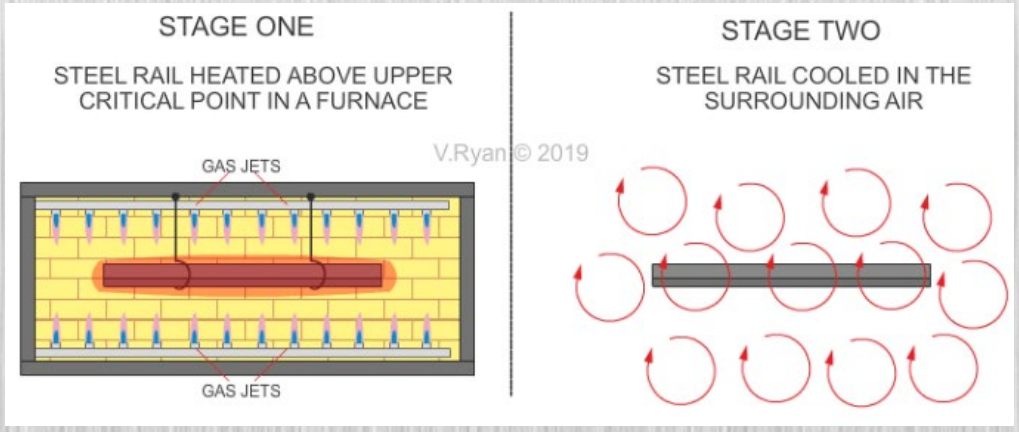
NORMALISING

Normalising, is a process whereby the hot steel (heated above its upper critical point), is taken from the furnace and allowed to cool in the surrounding air. This allows the crystalline structure of the steel to return to a 'homogeneous structure', which means a 'uniform fine structure'. The resulting steel is tough, but with a measure of ductility. This is often a desirable property. See the example of normalising below

Tap the image for information / an exercise



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ANNEALING

Annealing of steel, is a process whereby the metal is heated to a high temperature, NOT above its upper critical point, and allowed to cool slowly, in the furnace. The slowly cooling effect, is a key characteristic of this process. The crystalline structure of the steel is coarse, unlike the fine structure of normalised steel. This results in a 'soft' steel, so that it is easier to work, form and shape. See the example of annealing below.

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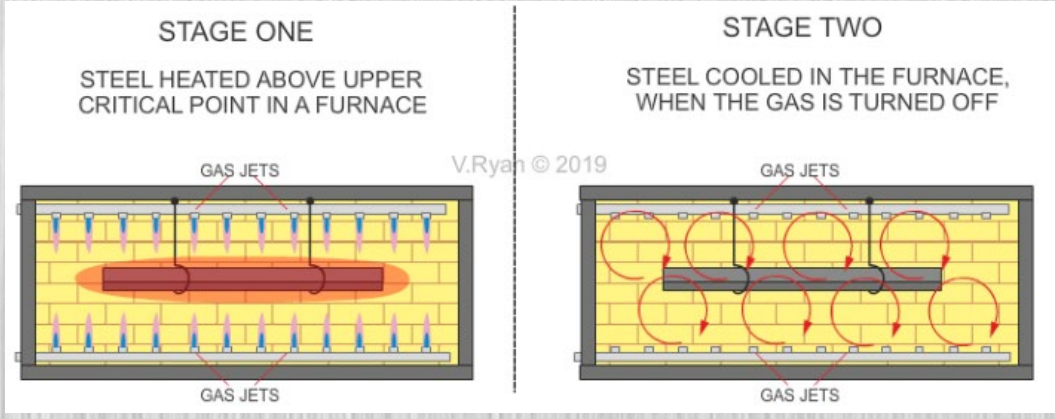

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