

2 Engineering Manufacturing Processes

Key words/ terminology

Manufacturing process	an operation that changes the form or properties of a material in a useful way
Additive manufacture	a manufacturing method where a part is built up by adding material where it is required

Non-negotiable Knowledge (What you need to know)

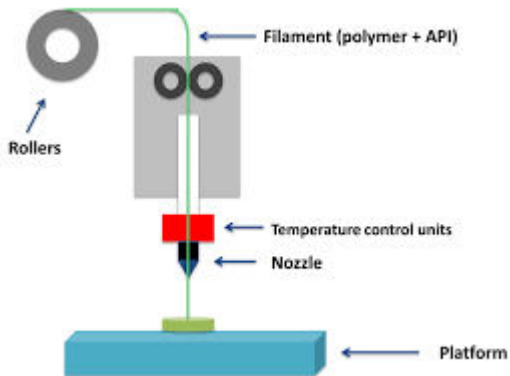
- Additive manufacturing processes



Rapid prototyping uses additive manufacturing to make a complete part or component from a single operation.

Fused deposition modelling is a rapid prototyping process that prints a part, layer by layer.

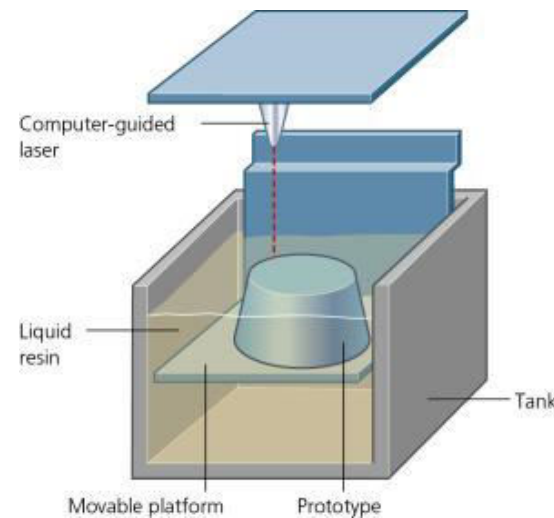
This is the process used in 3D printers. Usually it is supplied as an extruded wire stock form/ form of supply, which is placed around a reel.



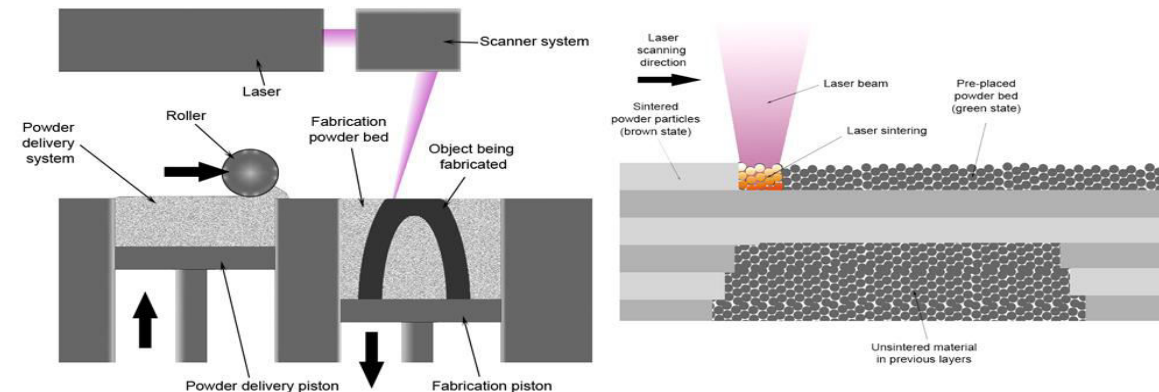
Example of a 3D printer



Stereolithography is a rapid prototyping process that uses a laser to build up a polymer part.



Sintering is an additive manufacturing process used to make products from metal powders.



- Nike have used advanced 3D printing to speed up the design and manufacture process when designing the Nike Vapour agility boot.
- It is also used in modelling and prototyping stages by companies



Further reading-
<https://www.notimpossible.com/projects/project-daniel>



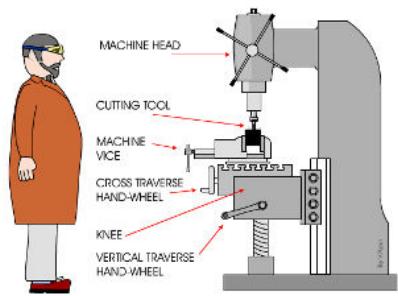
Non-negotiable Knowledge (What you need to know)

- Machining Processes- Milling, Drilling, Turning
- Metal Forming Processes- Casting, Forging, Press forming, Punching and Stamping

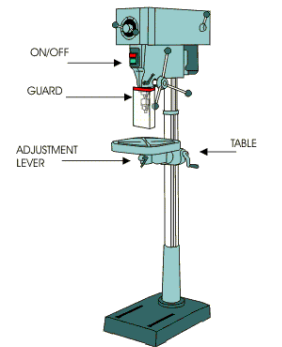
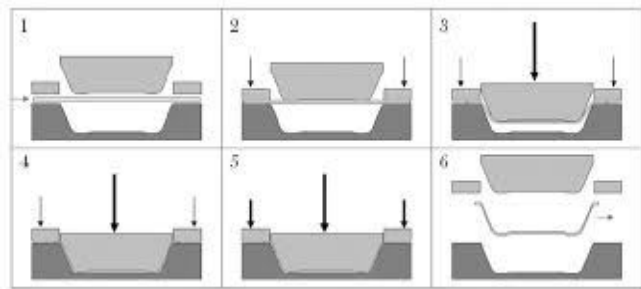
Key words/ terminology

Machining processes	A machining process is where machines are used to remove material from a work piece for a specific reason e.g. to join or shape.
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Milling uses a milling machine to remove material to make a part/ component.

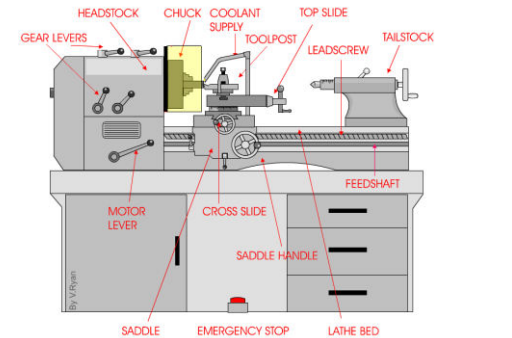


Press forming uses a hydraulic press to shape sheet material.



Drilling makes holes in material using a rotating tool, which progressively removes more material.

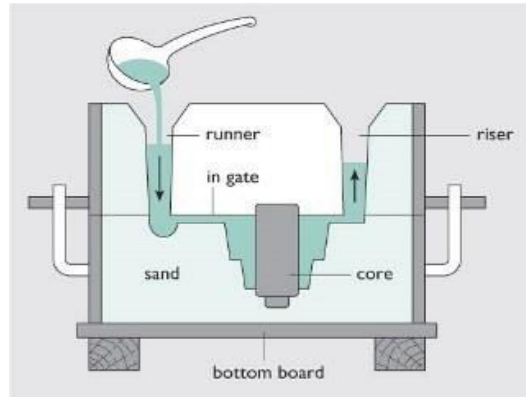
Turning uses a lathe to make parts with a circular profile.



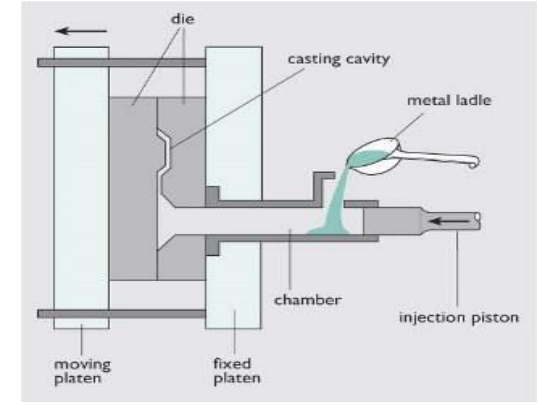
Casting

Casting involves heating a metal above its melting point so it becomes molten/ fluid. It can be poured/ pushed into a mould to make a specific shape.

Sand Casting



Die Casting



- Less initial setting up costs
- Good for one off and small batch production
- Good for products **that don't need high dimensional accuracy**
- Low quality surface finish

- More expensive initial setting up costs
- Good for large scale production e.g. mass and continuous production
- Good for products **that need high dimensional accuracy**
- High quality surface finish

Punching

Punching (or piercing) makes a hole in a metal sheet and the material pushed out is scrap.



Stamping

(or blanking) cuts a hole in a metal sheet and that is the part/ component. The surrounding metal is scrap



Blanking

Piercing/punching

Further reading- <https://www.minifaber.com/blog/sheet-metal-punching-and-the-differences-with-stamping>



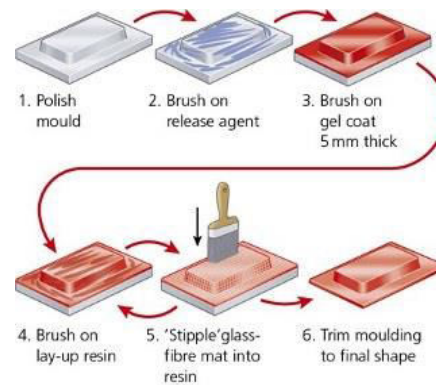
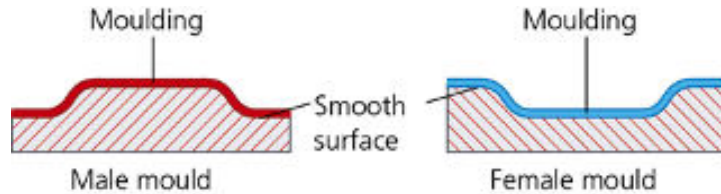
Non-negotiable Knowledge (What you need to know)

- Polymer molding processes- Vacuum forming, injection molding, strip heating, blow molding

Composite lay up

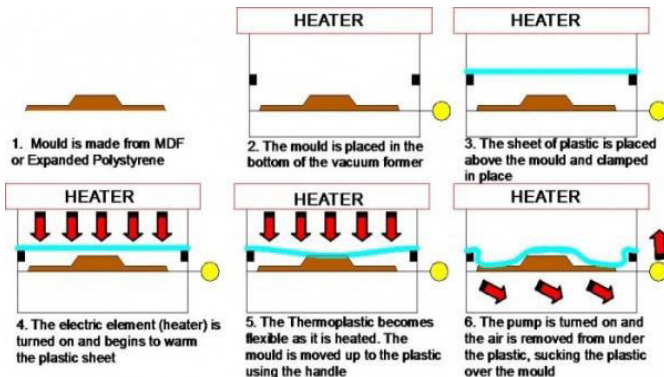
Glass reinforced polymer (GRP) is made from glass fibres surrounded by a matrix of a polymer using **composite lay up**.

Either a male or a female mould can be used – the choice of mould will determine the side of material that should come into contact with the mould.



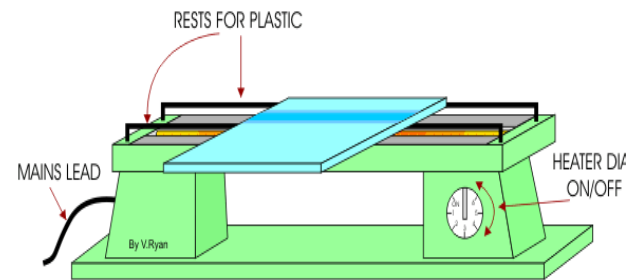
Vacuum Forming

Vacuum forming is a technique that is used to shape a variety of plastics, usually plastics such as; polythene and perspex. Vacuum forming is used when an unusual shape like a 'dish' or a box-like shape is needed



Strip heating

A strip heater heats thin polymer materials at a certain point until they become softer and malleable. The heated plastic can then be folded or shaped for a specific function/ purpose.

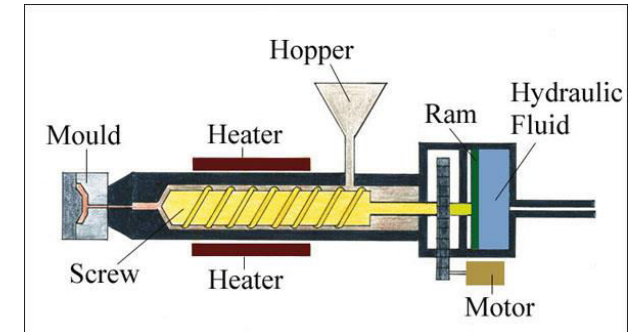
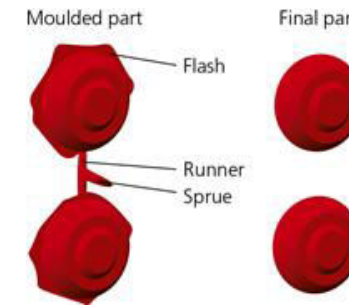


Injection moulding

Injection moulding is a shaping process for polymers, in which a polymer is forced through a reusable metal mould.

Injection moulded products may have:

- a visible sprue point – where the plastic was injected to make them and then cut off
- a parting line – where the two halves of the mould have met.



Advantages

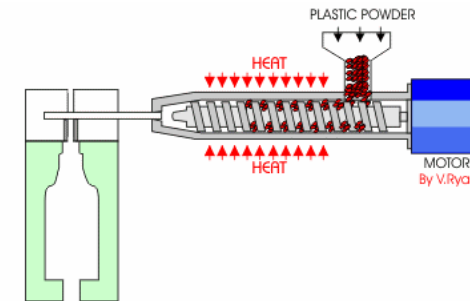
- A versatile process used to produce a range of polymer products
- The process can be completed very quickly, so thousands of products can be produced

Disadvantages

- Equipment and moulds can be expensive.

Blow molding

Blow molding **Process of forming hollow product such as** bottles, cans, jars by expanding a piece of hot plastic (called parison) against the internal surfaces of a heated two-piece mould, with compressed air.



Further reading

<http://www.engineerstudent.co.uk/>

2 Engineering Manufacturing Processes: Joining methods

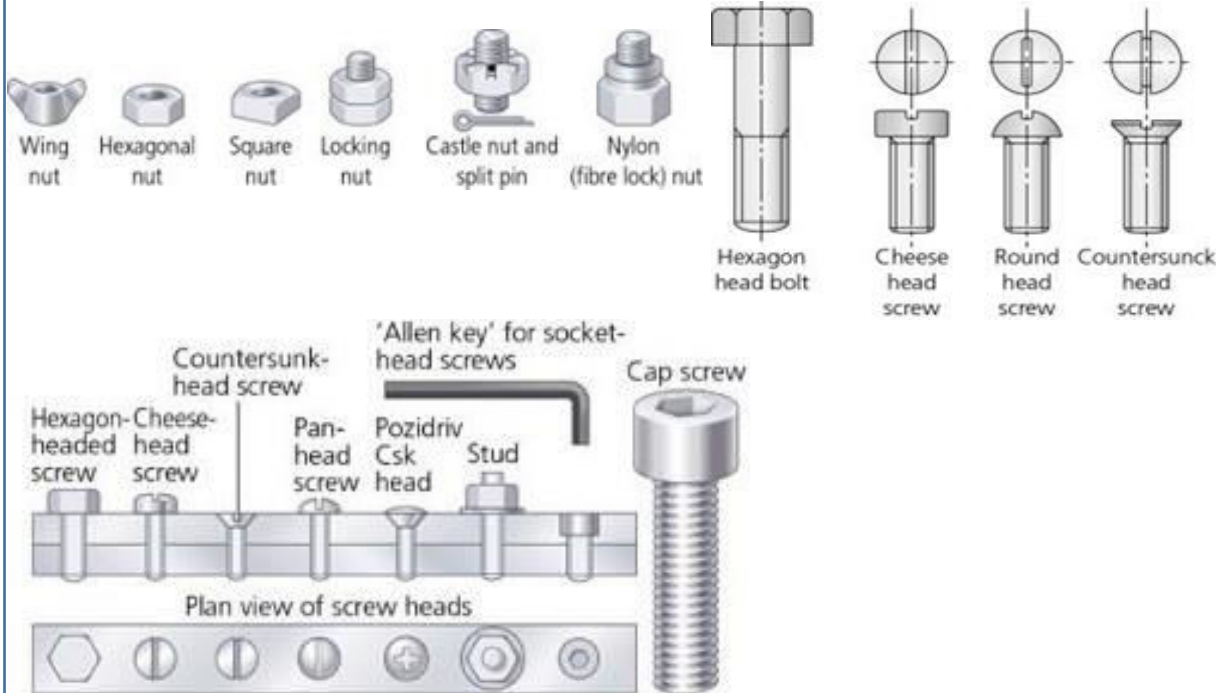
Non-negotiable Knowledge (What you need to know)

Different fastenings/ fixings

Welding and brazing processes

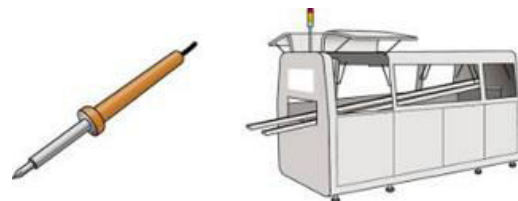
Threaded fastenings

Joining and assembly- Temporary fastenings



Wave soldering

- PCB and components are assembled above a bath of solder.
- A ripple across the solder allows it to flow into the joints.



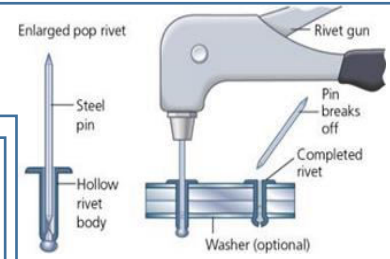
Further reading- <https://me-mechanicalengineering.com/soldering-brazing-joining-process/>

Riveting

Riveting is used in many engineering applications, including steel construction, boat building, fighter jets and railway construction.

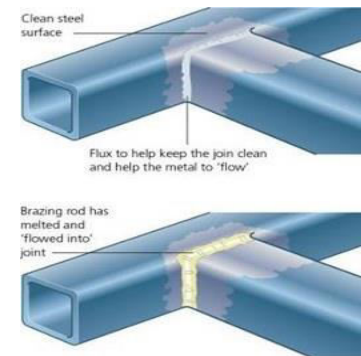
a hole is drilled in overlapping sheets and the rivet is inserted through the hole; the ends are hammered over to hold the sheets in place.

Pop riveting: the pop rivet is paced in the hole and a rivet gun pulls a pin through the rivet. The rivet is deformed to hold the sheets and the pin breaks away.



Brazing also uses a filler wire to join materials, but is carried out at higher temperatures – between 450°C and 1200°C.

- For small quantities: gas torch with filler metal fed into joint
- For larger quantities: filler metal placed in or by the joint and heated in a brazing furnace



Welding

Welding the edges of the parts to be joined are melted to form the joint (additional filler metal can be used).

Temperatures can be above 3000°C

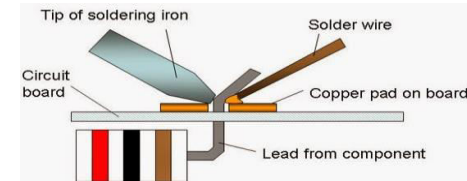
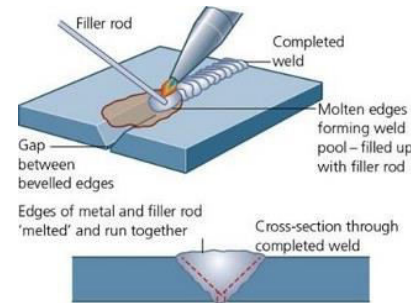
Arc welding

In arc welding an electric spark is used as a heat source.

Arc welding processes:

- Tungsten inert gas (TIG) welding
- Metal inert gas (MIG) welding
- Metal active gas (MAG) welding
- Manual metal arc (MMA) welding

The heat source moves along the joint to create a weld pool; when the heat moves, the area behind it cools and solidifies to join the materials.



Soldering is a joining process where metal parts are joined together using a filler wire, which melts and runs between them.

- **Soft soldering:** solder melts below 450°C
- **Hard soldering:** solder melts above 450°C



2 Engineering Manufacturing Processes: Chemical and Heat Treatments



Non-negotiable Knowledge (What you need to know)

- Heat/ chemical treatments

Changing the properties of metals

Alloying is one way to create a metal with properties needed for a product (e.g. higher strength, toughness or corrosion resistance). The properties of metals can also be altered by:

- cold working
- heating
- hardening and quenching
- corrosion
- addition/subtraction of carbon in steels.

Cold working involves bending or hammering a metal.

Many metals get harder as work is done to them. This is called **work hardening**.

As a metal is cold worked:

- the grains in the metal are stretched, making them thinner and smaller.
- atoms move around in the grains into the spaces left by flaws in the metal (called dislocations).
- When the atoms meet they restrict movement and make the metal more brittle/less ductile.

Corrosion is a reaction that occurs between the surface of a material and its environment (for example, low-carbon steel reacting with rain water to form rust).

This can reduce the aesthetics of the metal and reduce its thickness, so it is less resistance when a force is applied to it.

Corrosion can be reduced by:

- Painting
- Polymer coating
- Applying a layer of another metal that will not react with water
- Attaching a metal that can be sacrificed to protect the metal below (e.g. zinc).

The properties of a metal can also be altered by heating. Heating can:

- increase the grain size within the metal
- change how the atoms within the grains are arranged.
- Normalising, annealing, hardening and quenching, and tempering are examples of heat treatments.

Annealing is a heat treatment that makes a metal softer and easier to work.

When the metal is heated, the grains within it grow – this makes the metal softer and easier to work. Annealing is used on ferrous and non-ferrous metals.

Hardening and quenching

Hardening is a heat treatment that increases the hardness and strength of a ferrous metal.

Case hardening is a process in which the amount of carbon in the surface of a low-carbon steel is increased. This allows the toughness of the low-carbon steel to be combined with the hardness of a high-carbon steel.

There are two-parts to the process:

- Carburising – addition of carbon to the surface
- Hardening and quenching

ANNEALED METALS



HARDENED METALS



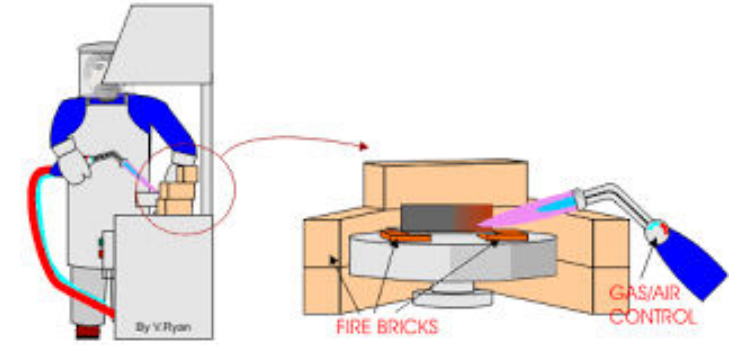
Tempering

Hardening can make the metal brittle, so it is then **tempered** to remove brittleness and make the metal tougher (although this also removes some hardness).

Tempering heats and quenches the metal again.

The temperature used depends on the hardness and toughness required.

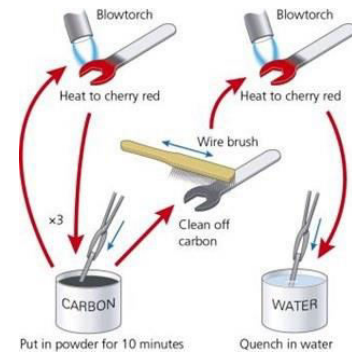
Colour	Temp. °C	Hardness	Typical Uses
Light Straw	230	Hardest	Lathe Tools, Scrapers
Dark Straw	245		Drills, Taps and Dies, Punches
Orange/Brown	260		Hammer heads, Plane irons
Light Purple	270		Scissors, Knives
Dark Purple	280		Saws, Chisels, Axes
Blue	300	Toughest	Springs, Spinners, Vice jaws



Normalising
Normalising is a heat treatment carried out on steel that has been work hardened.

The steel is heated to just above its upper critical point and allowed to cool naturally in the air.

The result is a metal that is tough with some ductility.



Further reading-
http://wiki.dtonline.org/index.php/Heat_Treatment

2 Engineering Manufacturing Processes: Chemical and Heat Treatments



Non-negotiable Knowledge (What you need to know)

- Heat/ chemical treatments

Surface finishes are applied to materials for many reasons. These include-

- Protection against the elements
- To improve aesthetics (colour, texture, Appeal)
- To reduce electrical conductivity
- To increase surface wear and resistance

Painting

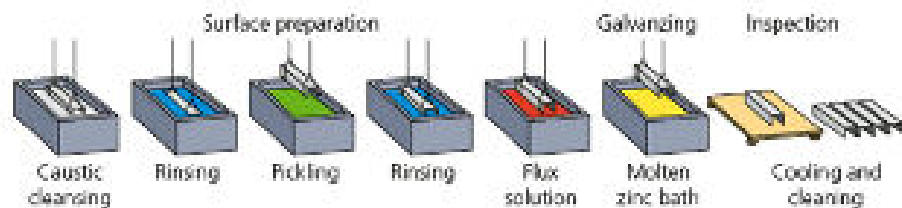
- Painting increases the corrosion resistance and improves the visual appearance of a metal
- All grease and dirt must be removed before painting
- All dents and holes must be filled before painting as they become very obvious



Paint can be applied manually with a brush or can be sprayed on using a spray can or spray gun.

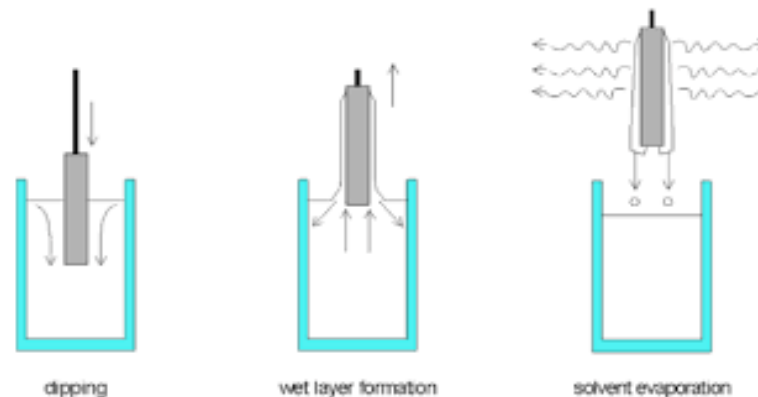
Galvanising

- Gives excellent protection from rusting to steel parts.
- The steel is dipped into a bath of molten zinc, giving the surface a bright grey colour.
- The zinc acts as a sacrificial layer as it is more reactive than the metal it is coating.



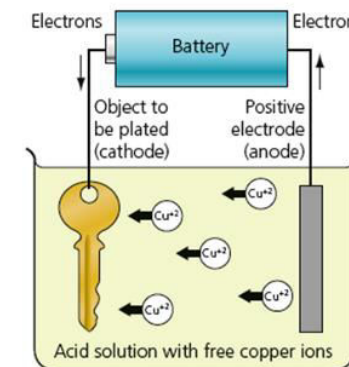
Dip coating

- A thick layer of polymer (e.g. PVC, nylon, polyethylene) is melted onto the surface of the metal
- The part to be coated is cleaned and heated to 250–400°C before being dipped into a fluidising tank.
- The thick, weather-resistant finish prevents corrosion.



Electroplating

Electroplating uses electricity and a chemical solution to create a coating on a metal part.



Varnish is a clear transparent hard protective finish or film. **Varnish** has little or no color and has no added pigment as opposed to paint or wood stain which contains pigment. However, some **varnish** products are marketed as a combined stain and **varnish**



Polishing

After cutting the edge of plastic, to make it smooth again you have to use first a file then abrasive paper. The final step is to use a buffing machine to apply polish to the edge.

