N4 N5

Design and manufacture

Metals

Name: ………………………………………………………… Class:…………… Teacher:……………………………………

Metals

All metals in use today are either PURE METALS or ALLOYS. **Copper**, **iron**, **tin**, **lead**, **gold** and **silver** are all examples of **PURE METALS** which have been mined from the Earth and extracted from the ore using a process called **SMELTING**.
An **ALLOY is a mixture** of pure metals or a metal with a substance such as carbon added; examples of alloys are:- **Steel** (Iron & Carbon), **Duralumin** (Aluminium & Copper), **Brass** (Copper & Zinc) & **Bronze** (Copper & Tin).
Metals are classified into two main groups; Ferrous and Non-Ferrous Metals.

Ferrous Metals

This category of metals **contain iron** and are usually **magnetic**; examples of such are Cast Iron, Mild Steel, High Carbon Steel, etc.

Name	**Composition**	**Properties**	**Uses**
Cast Iron	Iron + 3.5% Carbon	Smooth, soft core, strong when compressed, cant be bent or forged.	Vices, lathe beds, garden bench ends and car brake drums.
Mild Steel	Iron + 0.15 - 0.35% Carbon	Ductile, malleable, tough, high tensile strength, corrodes easily. Easily welded.	Car bodies, machine bodies, nuts and bolts, screws, nails and girders.
High Carbon Steel (tool steel).	Iron + 0.8 - 1.5% Carbon	Very hard, rather brittle, difficult to cut, poor resistance to corrosion.	Tool blades e.g. Saws, chisels, screwdrivers, centre punches and so on.
High Speed Steel	Iron + Tungsten, chromium vanadium.	Very hard, heat resistant, remains hard when red.	Drills, lathe cutting tools, milling cutters, power hacksaw blades and so on.
Stainles s steel	Iron + chromium, nickel, magnesium.	Tough, hard, corrosion resistant, wears well, difficult to cut, bend and file.	Cutlery, sinks, teapots, kitchen ware, saucepans and so on.

Non-Ferrous Metals

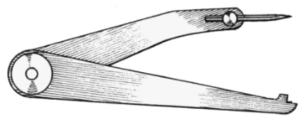
As the name implies (NON), this category of metal does **not contain iron** and is usually **non-magnetic**; examples are, Aluminium, Copper, Brass, Duralumin, Lead, Gold, Silver, etc.

Name	**Composition**	**Properties**	**Uses**
Aluminium	Pure Metal	Strong, light, malleable, ductile, difficult to weld, non-toxic, resists corrosion, conducts electricity and heat well and polishes well.	Kitchen foil, drinks cans and saucepans.
Duralumin	Alloy = Aluminium + Manganese, magnesium.	Stronger than pure aluminium and nearly as strong as mild steel but only one third the weight.	Greenhouses, window frames and aircraft bodies.
Copper	Pure Metal	Tough, ductile, malleable, conducts heat and electricity well, corrosion resistant, solder and polishes well.	Electrical wire, central heating pipes, circuit boards, saucepan bases.

Tools for use with Metal

Scriber
Use to draw lines on metal by scratching a line on the surface.

Centre Punch
For accurately punching holes before drilling.



Odd Leg Callipers
Use to draw a line parallel to a edge on metal.

Spring Dividers
Used to draw arcs and circles onto metal.

Engineers Square
Use to draw a line at 90° to an edge.

Junior Hacksaw
Used for cutting small pieces of metal such as sheet metal and wire.

Hacksaw
Used for cutting thick and large pieces of metal

Ball Pein Hammer
This is a general use hammer although the ball pein end of the hammer is used specifically to round the heads of the snap head rivet.

Raw Hide Mallet
This mallet is used when it is important not to make any marks on the metal.

Micrometer
For very accurate measurement of outside diameters on metal or plastic Can also be used with wood and plastic.

Joining Metals (temporary)

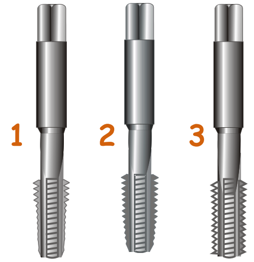
The screw thread is a very important detail in engineering. It is used to **hold parts together.** (e.g. bolt & nut) and to transmit power (e.g. vice screw).

Internal Screw Cutting

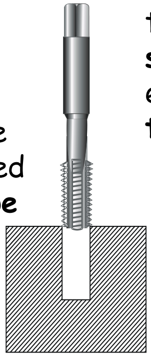
To achieve an internal screw thread, a hole has to be **drilled first** and then a tool called a **TAP** is used to cut a thread within the hole. TAPS are made from high speed steel (HSS). The top of the tap is square which enables the tap to be held securely in a **TAP WRENCH**, which can be seen below.

Taps are generally available in sets of three and are used in the following order:-

1. Taper Tap
2. Second Tap
3. Plug Tap



A blind hole is a hole which has a bottom to it. If a blind hole is to be threaded it is very important to ensure that the depth of the hole is established before commencing to thread the hole. If this is not established it would be very easy to break the taps. **A piece of tape attached to the tap indicating the depth** is an ideal way of avoiding the tap from being broken by being forced into the bottom of the hole.



External Screw Cutting

To cut an external thread on a metal rod a tool called a **DIE** will be used.

Circular Split Die

The picture below shows a **split die**, this is the most common type of die used in the school workshop. These are used for cutting **external threads**. The die is made from high speed steel (HSS). **To assist in starting the thread cut, the split die has a split which enables the die to be opened slightly thus cutting a shallower cut.**

Die Holder or Stock

The circular split die fits into the **die stock** with the tapered side of the thread (shown by the writing on the die). The split in the die fits opposite the centre screw to allow the opening and closing of the die. **The two screws at the side hold the die in the stock** To ensure the die can start to create a thread on the rod **the rod must firstly be tapered at the end.**

Joining Metals (permanent)

Riveting

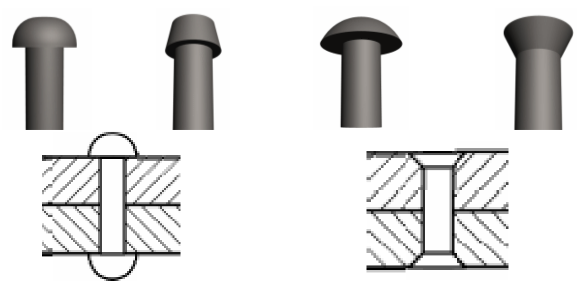
Rivets are used to join plates together and they have been used for hundreds of years. Before the widespread use of welding, rivets were used in heavy industries such as ship building. The steel plates used to build ships such as the Titanic and the naval Dreadnaughts of World War One were held together by steel rivets.

Rivets have largely being replaced by techniques such as welding and brazing. However, joining plates together with rivets is still a useful technique especially if the plates to be joined are quite small.

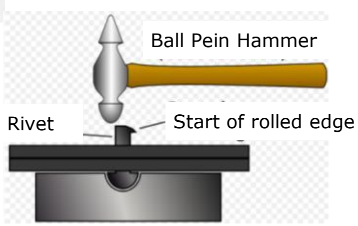
Cold rivets are still used in school workshops although the modern pop-riveting technique is more popular.

Types of Rivet (Cold Riveting)

Snaphead   Panhead   Mushroom   Countersunk



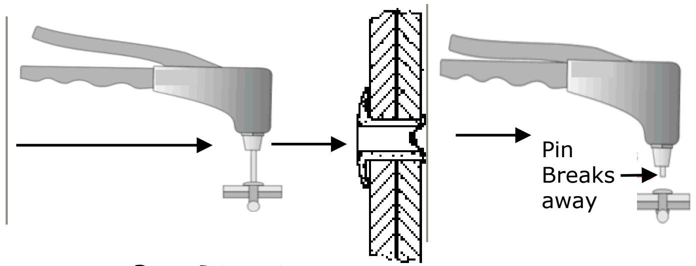
This tool allows us to ensure that **the metal being joined and the rivet are all held together firmly**. A ball pein hammer is then used to flatten the rivet and secure it.



Pop Riveting

When Pop Riveting the **rivet is placed in the holes** of the metal being joined. The Rivet gun is then placed over the rivet and the **handles squeezed together**. As you apply more pressure the **rivet expands** in the hole until the **pin eventually breaks away.**

Pop rivets are used to in steel cabinets, such as filing cabinets and lockers.



Pop Riveting

Joining Metals (thermal joining)

Soldering and Brazing

Soldering and Brazing are joining processes where materials, similar or dissimilar, are bonded together using a heating method and a filler metal without melting the base materials. The filler metal melts, wets the base materials, and subsequently flows by capillary action. Wetting of the base materials by the filler metals is enabled by the use of a suitable flux or by acoustic vibrations.
The difference between soldering and brazing lies in the temperature of the heating process: soldering occurs at temperatures less than 450°C, and brazing occurs at temperatures over 450°C. The heating of the filler metal can be accomplished by various methods, including hot plate, induction, torch, and furnace

Soldering

Used for **joining thin sheet metal** and thin bar. A solder bolt is heated in the forge. Once hot enough it is used to **melt a filler metal** along the joint of the metal parts being joined.

Brazing

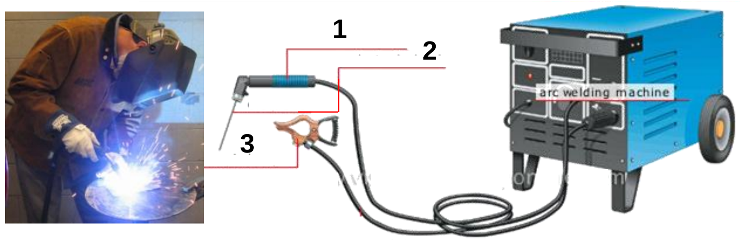
Used for **joining sheet metal and thin metal** bar/rod. A gas air torch such as those seen at the forge, is used to **melt the metal filler** along the joint where the metal is belong joined.
Items such as pipes are brazed together to create a tight water seal.

Joining Metals (thermal joining)

Welding
Welding is the process of joining two metals by melting the parts and using a filler material to form a joint.

Spot/Resistance Welding
Used for **joining thin sheet** metal. An **electric current** is passed through the copper rods and the metal being joined, which causes **heat to build up and melt the metal together.** This process is used a great deal in the production of cars, when spot welding the panels together.

Arc Welding
Used for **joining thick metals** including bar form and round form. Basically a **metal filler** is pushed through the electrode holder using gas. As this is happening electricity is used to produce **heat which melts the metal being joined**. The metal filler then fills gap to create a solid weld.



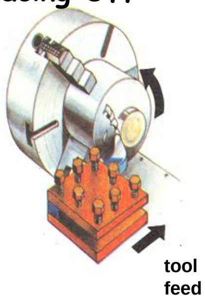
1. *Electrode Holder* **2.** *Metal Filler* **3.** *Ground Clamp*
Safety: Ensure that you always wear a welding mask as your eyes can be damaged and ensure that you are working in an area away from others.

Machine Processes (turning)

Turning is the process of removal of metal from the outer diameter of a rotating cylindrical work piece on a lathe. Turning is used to reduce the diameter of the work piece, usually to a specified dimension, and to produce a smooth finish on the metal.

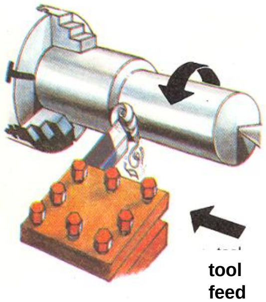
Metal Lathe

Facing Off



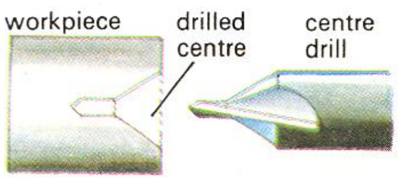
This means cutting **across the end** of a work piece. It is one of the first things normally done at **the start of a new job**. The process allows us to tidy up the face and ensure that it is flat.

Parallel Turning



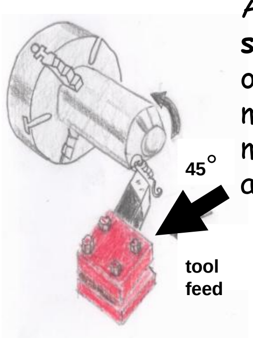
This means cutting **parallel to a job**. The process allows you to turn the metal to **smaller diameter** as you can see in the diagram above.

Centre Drill



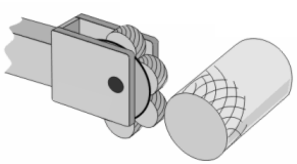
This particular drill is used to **drill a centre hole** before you go ahead and drill the main hole. It is used with the tailstock

Chamfering

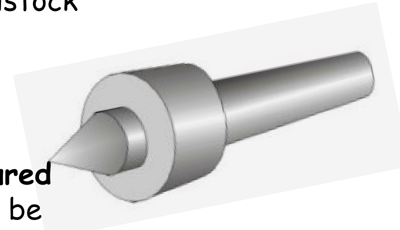


A chamfer is a **slope** on the edge of a piece of material. It is made by cutting at an **angle** on a job.

Knurling



This process is used to engrave a diamond shape **pattern** onto the metal. This pattern acts as a **grip** for handles and screws.



Revolving Centre
The revolving centre is **secured in the tailstock**. The bar to be turned is secured at one end by the chuck and held in place at the other end using the revolving centre. The revolving centre allows **the bar to rotate freely** allowing turning between centres.

Forming Processes (sand casting)

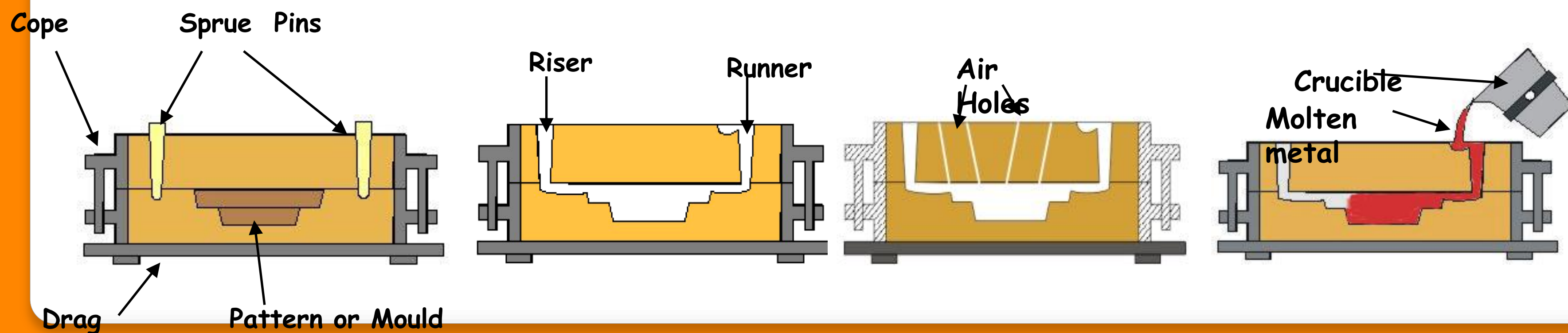
Sand casting is the process of making metal shapes (components) using pre-shaped objects and sand. A typical example of an object which has been cast is the Engineers vice which can be found on the workbench. This tool will have been cast in two separate castings. The bottom part of the casting unit which is called a **DRAG** because of the fact that the PATTERN is dragged from the sand. The top half of the casting unit is called the **COPE**.
Very complex shapes can be made using sand casting, but it is only economical if manufacturing a small quantity of parts.

Stage 1
The **COPE** and **DRAG** are both **filled with wet sand**. The pattern (mould) is then pressed into the sand until flush with the surface. As can be seen from the drawing the cope is then placed on top of the drag. Sprue pins are then pushed through the sand to produce a **RUNNER** and a **RISER**. The **runner will be the channel in which the molten metal will be poured into** the mould.

Stage 2
At this stage **the wooden pattern has been removed** and the riser and runner which were created by the **sprue pins** have been extended into the space left by the pattern. This will **allow molten metal to flow through into the mould.**

Stage 3
This shows a cross section (cut through the middle) of the pattern and runners. Very narrow holes can be seen, this allows **excess gas and moisture to escape** thus allowing the metal to fill fully all available space in the pattern.

Stage 4
The final stage in the process is to **pour the molten metal into the runner**. The air which occupies the pattern space is forced out of the riser on the other side. The **finished mould is then removed** from the sand. The mould will also have extensions attached at this stage in the form of a runner and riser. These will simply be cut off and recycled.



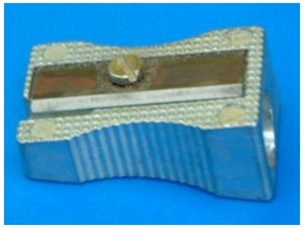
Forming Processes (die casting)

This process is the equivalent of the plastic process of 'injection moulding', where molten material is forced into a mould (die) to cool and set. The dies used are made of special alloy steel and are very expensive to produce, being made in sections for easy removal of the components. The high operating costs make this process viable for high-volume production or 'mass production' where accuracy of shape, size and surface finish is essential.

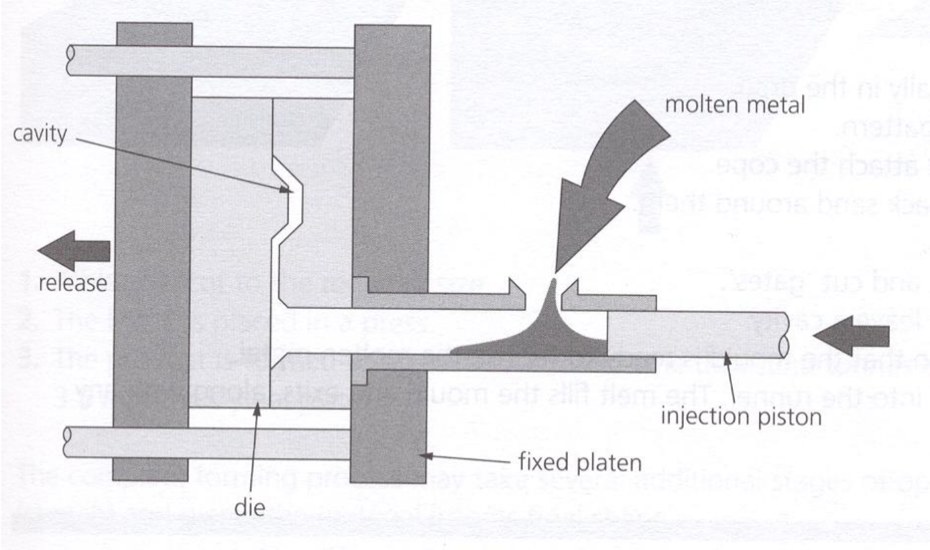
Die casting produces products with a complex shape. The tell tale signs of an item being die cast are the ejector pin marks on the surface of the product.

Process

- A measure of molten metal is poured into the charge chamber.
- An injection piston then forces the metal into a water-cooled die through a system of sprues and runners.
- The metal solidifies rapidly and the casting is removed, complete with its sprues and runners.



This pencil sharpener has been 'die cast'. It has ejector pin marks on each corner.



https://youtu.be/iSyBsdJkQu8