

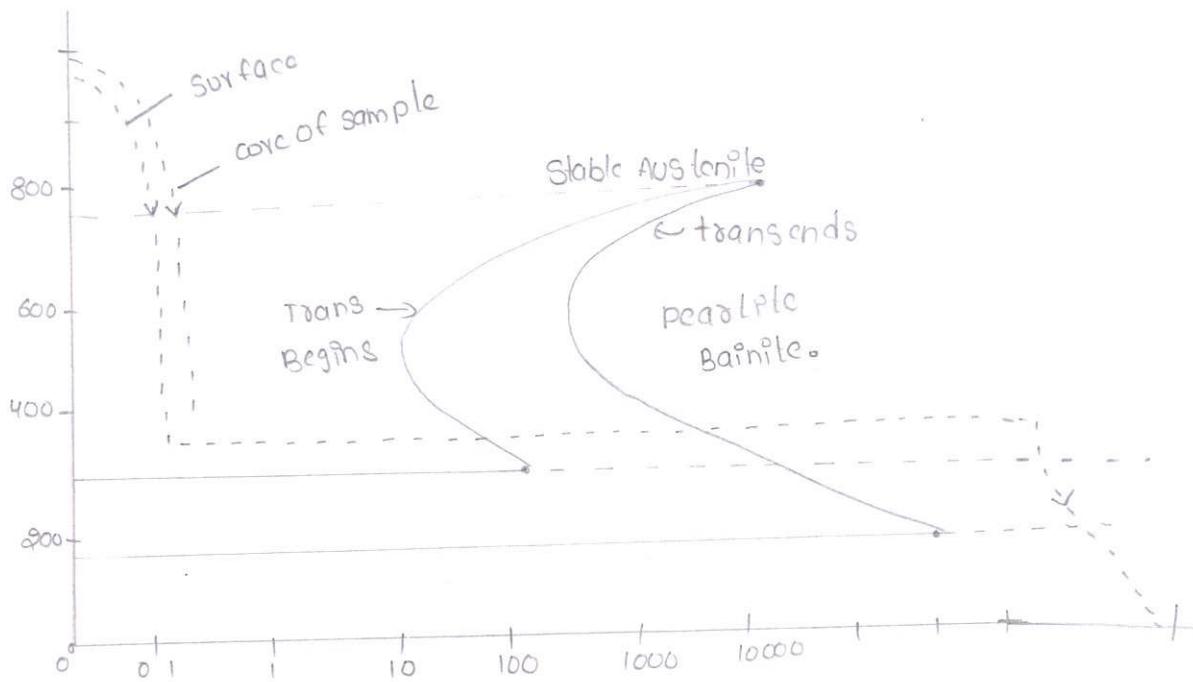
## \* IV Th unit \*

### \* Austempering :

- Austempering involves heating a steel to the austenite state and then quenching it to a temperature slightly above the  $M_S$ - point (temperature at which martensite starts to form).
- The quenching must be at a cooling rate greater than or equal to the critical rate of cooling so that no pearlite is formed.
- The steel is held at this temperature, i.e. slightly above  $M_S$ - point until the austenite is completely transformed into bainite, then the steel is cooled at any rate to the room temperature.
- Austempered steels are less harder and wear resistance than hardened and tempered steel. The bainite structure cannot be obtained hardness range (RC 60 to RC 65) required for cutting tools.

The other limitations associated with austempering are:

- 1) Austempering is suitable only for small sections less than 12.5 mm thickness to avoid pearlite transformation.
- 2) Austempering is not practicable for alloy steel because of long duration required to bainite formation.



## Properties of steel

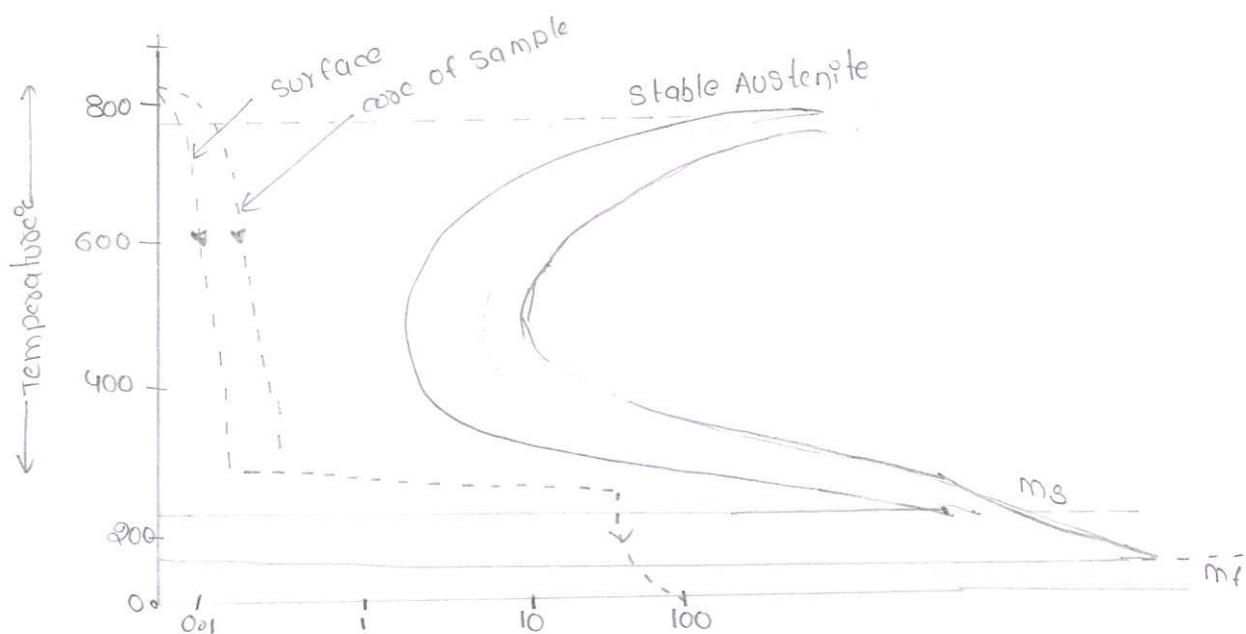
Treatment	Hardness, HV	% elongation.	Toughness (J)
Austempered	545	11	58
Hardened and tempered	560	01	16

### (e) Martempering:

Martempering consists of heating a steel to its austenitic state, and then quenched it to a temperature just above  $m_s$ -point. It is held there until the temperature is uniform in the steel allowing to form bainite.

- It is then cooled in air to transform the austenite into martensite.
- The cooling rate in the initial quenching must be faster than the critical rate of cooling.

The process of martempering is illustrated in Fig 7.17 in this case, the transformation tends to occur more uniformly throughout the section.



- Martempering is used to minimise quenching distortion. The hardness and ductility are same as obtained by hardening followed by tempering however the impact strength of martempered steel is higher.

### 3) Nitriding:

Nitriding involves diffusion of nitrogen in to the product to form nitrides. The resulting nitride case can be hardened then the carburised steel. This process is used for alloy steel containing alloying elements (Al, Cr and molybdenum) which forms stable nitrides.

Nitriding consists of hardening of heating a component in a retort to a temperature of about 500 to 600°C. Through the reaction retort the ammonia gas is allowed to circulate. At this temperature the ammonia dissociates by the following reaction.



→ The depth of nitrided case ranges from 0.2 to 0.4 mm and no machining done after nitriding

→ Nitriding increases wear and corrosion resistance and fatigue strength of the steel

→ Nitriding is used for cams, cylinder liners, shafts and piston rods of aircraft engines.

### \*Carbonytating:

→ Carbonytating is a surface hardening process, that involves the diffusion of carbon and nitrogen.

→ In carbonytating the part is heated to a temperature of about 800 to 850°C in an atmosphere of carbon and nitrogen.

→ The depth of the case is attainable depends on the composition of steel and other processing parameters, but in most of cases it ranges from 0.05 to 0.45 mm.

→ carbonitriding result in hard and wear resistance surface with good fatigue strength.

→ This process is generally used for mild steels and low alloy steels, and specially effective for small to medium size parts such as gears, pistons, pins, small shafts, etc.

### \*Cyaniding:\*

→ Similar to carbonitriding, cyaniding also involves the diffusion of carbon and nitrogen into the surface of the steel

→ It is also called liquid carbonitriding

→ The components are heated to a temperature about 800 to 900°C in a molten cyanide bath consisting of sodium cyanide sodium carbonate and sodium chloride.

→ Cyaniding is normally used for low-carbon steels and case depth are usually less than 0.25 mm

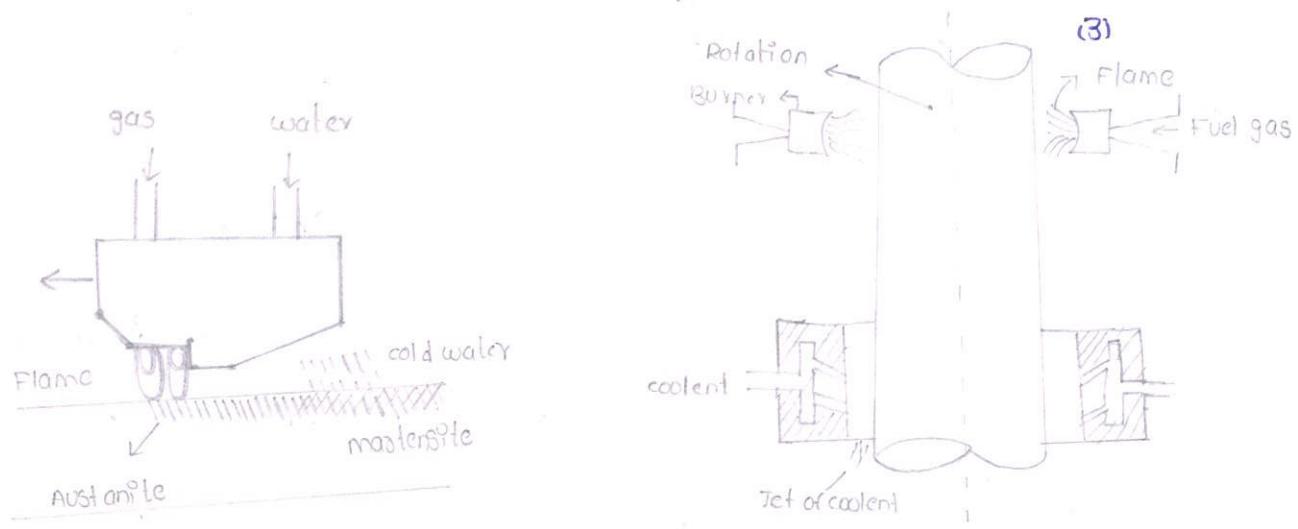
→ It produces hard and wear resistance surface on the steel. Because of shorter time cycles, the process is widely used for the machine components subjected to moderate wear and service loads.

### Flame hardening:

The flame hardening involves heating the surface of a steel to a temperature above  $A_3$ -point ( $850^\circ\text{C}$ ) with an oxyacetylene flame and then immediately quenched the surface with cold water.

→ Heating transforms the structure of surface layers to austenite and the quenching changes it to martensite.

→ The surface layers are hardened to about 50-60 RC. It is less expensive and can be easily adopted for large and complex shapes. Flame hardened parts must be tempered after hardening.

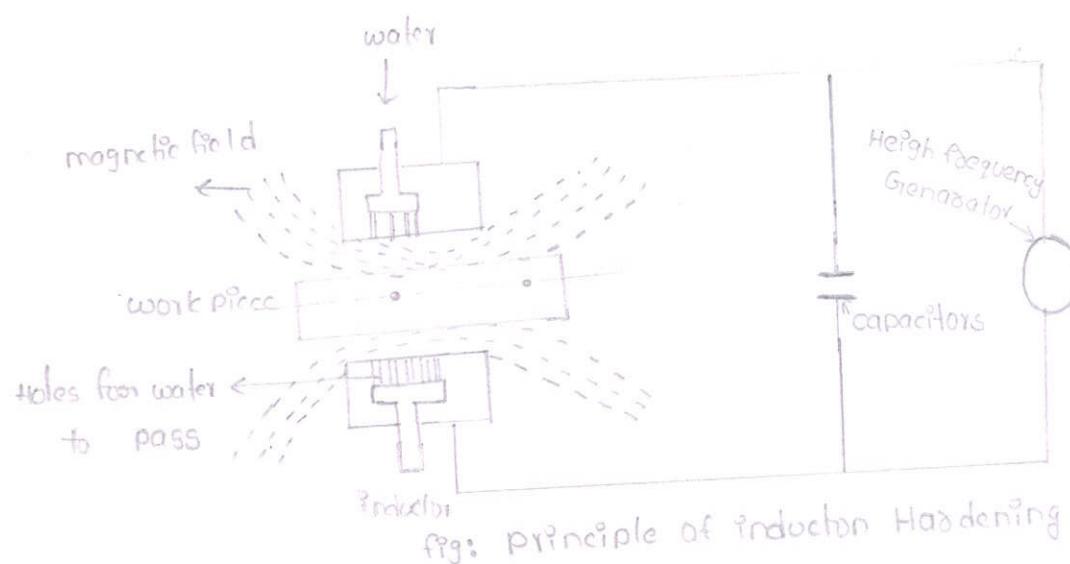


The Flame hardening methods are suitable for the steel with carbon contents ranging from 0.40% to 0.95% & low alloy steels.

### Induction Hardening

Induction hardening involves placing the steel components with in a coil through which high frequency current is passed. The current in the coil induces eddy current in the surface layers, and heat the surface layers upto Austenite state.

The principle of induction hardening is illustrated in fig.



- The advantages of induction hardening over flame hardening is its speed and ability to harden small parts. But it is expensive, like flame hardening
- Typical applications for induction hardening are crank shafts, cam shafts, connecting rods, gears and cylinders.

## Vacuum hardening:

→ During vacuum hardening, material is heated in the absence of oxygen by convection in the medium of inert gas ( $N_2$ ) and/or heat radiation in the under pressure. Steel is hardened with a stream of nitrogen, whereby cooling rate can be determined by selecting the excess pressure. Depending on the workpiece shape it is possible also to choose the direction and time of nitrogen blowing.

## Advantages:

- \* modern computer-controlled process regulation which ensures a high level of repeatability
- \* steel is not carburized or decarburised
- \* dimensional changes are minimal
- \* optimal times of process
- \* flexibility

## Applications:

- Hot and cold-work tool steel products
- tools for plastics
- Forging tools
- cutting tools
- pressing tools
- Die casting tools.

## COPPER AND ITS ALLOYS:

- Copper is an important engineering metal and is widely used in the pure form as well as in the alloy form. It is in the pure form, it has wide range of property for industrial applications.
- The most important alloying elements added to copper are zinc, tin, nickel and silver.

## USE OF PURE COPPER:

- Because of high thermal conductivity copper is used for locomotive fire box plates, radiator elements, domestic boilers, cooking utensils and kettles etc.
- Due to its electrical conductivity copper is universally adopted for electrical conductors switch-gear parts, telegraph and telephone wires and cables.

## COPPER ALLOYS:

The most alloying element in copper form the substitutional solid solutions.

Except when made to precipitate in age hardening. They have a significant effect in decreasing the electrical conductivity. All these copper alloys remains single phase ( $\alpha$ -phase) with FCC structure.

→ As compared to pure copper, the copper alloys offer the following advantages.

- (1) Copper alloys are stronger and harder than pure copper and these properties are further improved by cold working.
- (2) alloying of copper improves the castability and copper alloys, such as brass and bronze, are used to make casting.
- (3) alloys of copper are much easier to machine than pure copper which is too soft to machine.

## (I) Brass:

- Brass is a binary alloy of copper and zinc. Copper-zinc alloys i.e brasses have two different types of crystal structures. Alpha brasses are solid solutions of zinc in copper with FCC crystal structure.
- The maximum solubility of zinc in the  $\alpha$ -phase is about 38%. It has good corrosion resistance, high strength and ductility.
- Brasses with zinc contents near 40% can have a structure of alpha and beta but around 50% zinc the structure is entirely beta. The properties of alpha and beta structures differ considerably.

## cartridge brass:

- It contains 70% copper and 30% zinc. It is very ductile and has excellent cold working properties. It can be drawn into wires, rods and tubes and can be formed into intricate shapes by pressing.

→ It is used for cartridge cases, locomotive and condenser tubes.

## Admiralty brass:

It is an alloy of copper, zinc and tin. It contains 70% copper and 29% zinc and 1% tin. It has good resistance to corrosion and it is used for condenser tubes and marine parts.

## Muntz metal or yellow brass:

→ It is an alloy with 60% copper and 40% zinc. It is strong hard and more ductile. It is a good hot-working alloy which can also be cold-worked to a limited extent.

It is used for valves, marine fittings, electrical equipments and fuses. It is also used for condenser tubes where corrosive conditions are mild.

## Leaded brass:

Due to high ductility machining of brass is difficult. Lead (3%) max) is usually added to brass to improve machinability. Such a brass

## Naval brass :

Naval brass is an alloy of Cu - 60%, Zn - 39% and Sn - 1%. It has good corrosion resistance against salt water. It is used for condenser plates, propellers shafts and marine parts.

## Bronzes :

Bronze is an alloy of copper and tin. This alloy is also referred as phosphorus bronze because it contains noticeable amount of phosphorus (upto 0.3%). It has low coefficient of friction and it can be rolled into sheets or cast into intricate castings.

The term bronze does not always imply copper-tin alloys. Alloy of copper with other elements (except zinc) are also called as bronzes such that as aluminum bronze, silicon bronze etc.

## phosphor bronze :

→ It is a copper tin alloy with small quantity of phosphorus. The maximum solubility of tin in copper is about 5%. Bronze with more than 5% tin possesses high strength and hardness. Phosphorus acts as deoxidiser during melting operation and can form form of wires, bars and sheets.

name	composition			properties	uses.
	cu	Sn	others		
1. P phosphor bronze	93.07	6	0.3 (P)	possess good castability, high fatigue and strength	springs, gears and bearings
2. Aluminum bronze	90 - 95	-	5 - 10 (Al)	possess high strength and resistance to corrosion	marine engineering guides, seats flanges moulding dies for plastics and condenser tubes.
3. Gun metal	88	10	2 (Zn)	Especially castable possess high strength and toughness	casting guns boiler fittings bolts nuts.
4. Bell metal	80	20	-	Hard and resistance to wear surfaces	Bells gongs and utensils.

### Aluminium bronzes

→ It contains no tin, aluminium is soluble in copper up to 8% and single phase solid solution is formed in this range, commercial aluminium bronzes contain about 10% aluminium, and they possess two phases, They may be heat treated to develop the strength. They possess wear resistance and excellent corrosion resistance. They remain strength and hardness at elevated temperatures.

### Gun metal:

→ It is a copper-tin alloy containing up to 8% zinc. The small addition of zinc improves castability and intricate shapes may be cast with fine details. It has high strength and corrosion resistance. It is used for marine and boiler fittings.

### Bell metal:

It contains 80 percent copper and 20 percent tin. It has hardness and can resist wear. Bell metal is widely used for bell gongs and utensils.

### Copper-nickel Alloys:

Nickel is completely soluble in copper; copper-nickel alloys are ductile and are hardened and strengthened by cold work. The corrosion resistance of these alloys increases with the nickel content. The main copper-nickel alloys are cupronickel and nickel silver.

### Aluminium and its alloys:

Aluminium and its alloys are the most important engineering materials with unique properties and applications. Aluminium and its alloys gained importance in all segments which include transportation, construction, electrical applications containing packing and mechanical equipments.

As engineering material it has the following advantages:

- 1) Good thermal and electrical conductivity
- 2) High strength - to - weight ratio
- 3) Surface can be hardened by anodising and hard casting
- 4) Good corrosion resistance
- 5) High reflectivity
- 6) most alloys are weldable, and can be die cast
- 7) Easily machined
- 8) Good formability
- 9) non-magnetic
- 10) non toxic.

However, the major limitation of aluminium is its relatively low modulus of elasticity.

#### \* Uses of pure aluminium:

pure Aluminium is used for containers (aluminium cans) wrapping, fuels, electrical conductors, pans and other applications where light weight is important.

#### Aluminium alloys:

In its pure form aluminium is soft and ductile and possesses low strength. For many industrial applications the pure aluminium is not suitable, and it is alloyed with other elements to improve and hardness. As compared to pure aluminium, alloys possess low electrical conductivity and poor corrosion resistance.

## Classification of aluminium alloys

\* The Aluminium alloys can be classified into two main groups

- 1) wrought alloys and 2) cast alloys

Both groups include non - heat treatable as well as heat treatable

alloys. Heat treatable alloys achieve their properties by solid solution strengthening

-thinning while non - heat treatable alloys are strengthened by cold working.

The composition properties and applications of important aluminium

alloys are given

\* Hindalium is a trade name of aluminium - magnesium alloy produced by Hindustan Aluminium corporation Ltd (UP)

### wrought alloys

wrought alloys are those that are shaped by plastic deformation. They possess good formability characteristics such as low yield strength, high ductility and good fracture resistance they can be obtained in the forms of sheets, bars and tubes.

The total alloy content in wrought alloy is about 7 percent and include

copper manganese and magnesium.

### cast alloys

Aluminium alloys are cast in considerable quantity. The main alloying elements in cast alloys are silicon copper and magnesium, cast alloys contains enough silicon (11-13%) to form eutectic alloy giving material low melting point and good fluidity.

## Titanium and its alloys:

Titanium possesses high strength and low density; because of its excellent strength to weight ratio, it is widely used in aircraft engines and structures. It is also extremely resistant to corrosion and so it is used in chemical plants and marine components. However its applications are restricted because of high cost, low modulus of elasticity and unstable creep properties. It reacts chemically with other materials at elevated temperature.

### Classification:

Depending on stable phases at room temperature, Titanium alloys are classified

-as

- (i)  $\alpha$  - phase Titanium alloys
- (ii)  $\beta$  - phase titanium alloys
- (iii)  $(\alpha + \beta)$  - phase titanium alloy

$\alpha$  - phase is saturated and hardened by adding about 5 percent aluminum

-um and 2.5 percent tin. Addition of tin improves strength without affecting ductility.  $\alpha$  - phase alloys are used for gas turbines engines casting and chemical processing equipment.

$\beta$  - phase alloys are produced by adding larger amounts of molybdenum,

chromium and vanadium. The usual composition of  $\beta$ -alloy is 13% vanadium, 11% chromium and 3% aluminum. They possess good ductility and formability.

when they are not heat treated age hardening produces very high strength, but ductility and toughness are reduced.  $\beta$ -alloys are used for high strength aerospace components.

An alloy composition of 6 percent aluminium and 4 percent vanadium produces  $(\alpha + \beta)$  phase titanium alloys. This is the most popular titanium alloy accounting for nearly 50 to 70 percent of all titanium alloys used in the entire industries.

Ti-6Al alloys have high strength and good creep, fatigue and corrosion resistance they are used for aircraft components such as airframes, turbine compressor blades and rings.

## MARAGING STEEL:

MARAGING STEEL IS HIGH-STRENGTH STEEL THAT POSSESSES INCREASED TOUGHNESS. IT IS ALSO DUE TO THE AGING OF MARTENSITE, A HARD MICROSTRUCTURE COMMONLY FOUND IN STEELS. THE TERM MARAGING IS DERIVED FROM THE STRENGTHENING MECHANISM, WHICH TRANSFORMS THE ALLOY TO MARTENSITE WITH SUBSEQUENT AGE HARDENING.

## APPLICATIONS:

THE MAJOR APPLICATIONS OF TOOL STEELS ARE IN THE FOLLOWING PROCESSES.

- \* FORMING, STAMPING, CUTTING AND SHEARING OF PLASTICS AND METALS.
- \* EXTRUSION OF PLASTIC SECTIONS E.G VINYL WINDOW FRAMES AND PIPES
- \* STAMPING OF COMPUTER PARTS FROM METAL SHEETS
- \* SLITTING OF STEEL COILS INTO STRIPS
- \* DIES FOR COMPACTING OF POWDER METAL INTO FORMS SUCH AS GEARS.

### \* HIGH-SPEED STEELS:

- \* MOLYBDENUM HIGH-SPEED STEELS
- \* TUNGSTEN HIGH-SPEED STEELS
- \* INTERMEDIATE HIGH SPEED STEELS.

### \* HOT-WORK STEELS:

- \* CHROMIUM HOT WORK STEELS
- \* TUNGSTEN HOT WORK STEELS
- \* MOLYBDENUM HOT-WORK STEELS

### \* COLD-WORK STEELS:

- \* AIR HARDENING, MEDIUM ALLOY, COLD WORK STEELS
- \* HIGH-CARBON, HIGH CHROMIUM, COLD WORK STEELS
- \* OIL-HARDENING COLD WORK STEELS
- \* WATER-HARDENING TOOL STEELS
- \* SHOCK-RESISTING STEELS
- \* LOW ALLOY SPECIAL-PURPOSE TOOL STEELS
- \* LOW CARBON MOLD STEELS.

## Ductile Iron:

Ductile iron is also known as ductile cast iron, nodular cast iron, spheroidal graphite iron, spheroidal graphite cast iron and S.G.Iron. It is a type of graphite rich cast iron discovered in 1943 by Keith Mills.

## Malleable Iron:

Malleable iron is cast as white iron, the structure being a metastable carbide in a plastic matrix through an annealing heat treatment; the brittle structure at first cast is transformed into the malleable form.

## White cast iron:

White cast iron is a type of carbon-iron alloy that contains carbon content greater than 2% in the form of cementite. The name white cast is derived from its white surface, which is caused by carbide impurities that allows cracks throughout the metal. White cast iron has high compressive strength and wear resistance.

## Grey iron:

Grey iron or grey cast iron is a type of cast iron, that has a graphitic microstructure. It is named after the grey colour of fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

## Cast Iron:

Cast iron - is a group of iron-carbon alloys with a carbon content more than 2%. Its usefulness derives from its relatively low melting temperature. Iron alloys with lower carbon content are known as steel. Cast iron tends to be brittle, except for malleable cast irons.

## Poo parties:

The primary properties of tool steels are listed below

- \* Toughness
- \* wear resistance
- \* Hardness
- \* heat resistance.

## Stainless steel characteristics:

- \* corrosion resistant
- \* high tensile strength
- \* very durable
- \* temperature resistance
- \* easy formability and fabrication
- \* low-maintenance (long lasting)
- \* attractive appearance
- \* environmentally friendly (recyclable)

## Alloy steels:

→ Alloy steel is steel that is alloyed with a variety of elements in total amounts between 1.0% and 50% by weight to improve its mechanical properties

→ alloy steels are broken down into two groups: low alloying steels and high alloy steels. The difference between the two is disputed. Smith and Hashemi define the difference at 4.0% while Degarmo et al. define at 8.0%. Most commonly the phrase alloy steel refers to low-alloy steels.

Strictly speaking every steel is an alloy, but not all steels are called alloy steels. The simplest steels are iron(Fe) alloyed with carbon(C) (about 0.1% to 1.4, depending on type). However the term alloy steels with other alloying elements added deliberately in addition to the carbon. Common alloyants include manganese, nickel, Cr, molybdenum, V, Si and B; less common alloyants include Al, Co, copper, cerium, niobium, titanium, tungsten, Mn, zinc, lead and zirconium.

