UNIT-2

STEELS AND ALLOYS

- cast iron
- Types of cast iron :- (i) White (ii) Grey (iii) Nodular (iv) Malleable
- selection of appropriate cast iron for engineering application.
- Broad classification of steels.
  (i) plain carbon steels (ii) Alloy steels.
  (iii) tool steel (iv) Stainless steels.
- spring steel - composition and application.
- steel for following - shaft, axles - bolts, nuts - agriculture equipment's, household utensils, Antifriction bearings.
- Designation and coding (as per BIS (~~Bread of~~ Bureau of Indian standards) ASME (American society of Mechanical engineers) alloys steels and cast iron.

cast iron is a versatile ~~and~~

~~#~~ **Cast Iron** :- cast iron is an alloy of iron and carbon in which the carbon is present in the range of 2-4% by wt. and silicon is present in bet^n 1-3% by wt. Some other alloying elements that added to cast iron are manganese, Molybdenum, Chromium, magnesium, Titanium, Vanadium, nickel, Copper, Tin, Zirconium, Bismuth, Boron. ~~The~~

- The melting point of cast iron ranges in bet^n 1127 to 1204 °C
- The Alloying elements are added in order to control the percentage of the carbon and silicon as well as to give desired properties to the cast iron. The %age of the carbon and silicon decides which type of cast iron is produced

properties of cast iron:-

i) Brittle:- cast iron is brittle except malleable cast iron (Brittle means, it breaks into small pieces when hammered)

ii) Low melting point:- It has a low melting point (1127°C-1200°C)

iii) Fluidity:- It possesses good fluidity (The ability to flow easily in a molten state)

iv) Cast ability:- It possesses good cast ability. Cast ability to be is defined as the ability to be cast (to shape) into new parts.

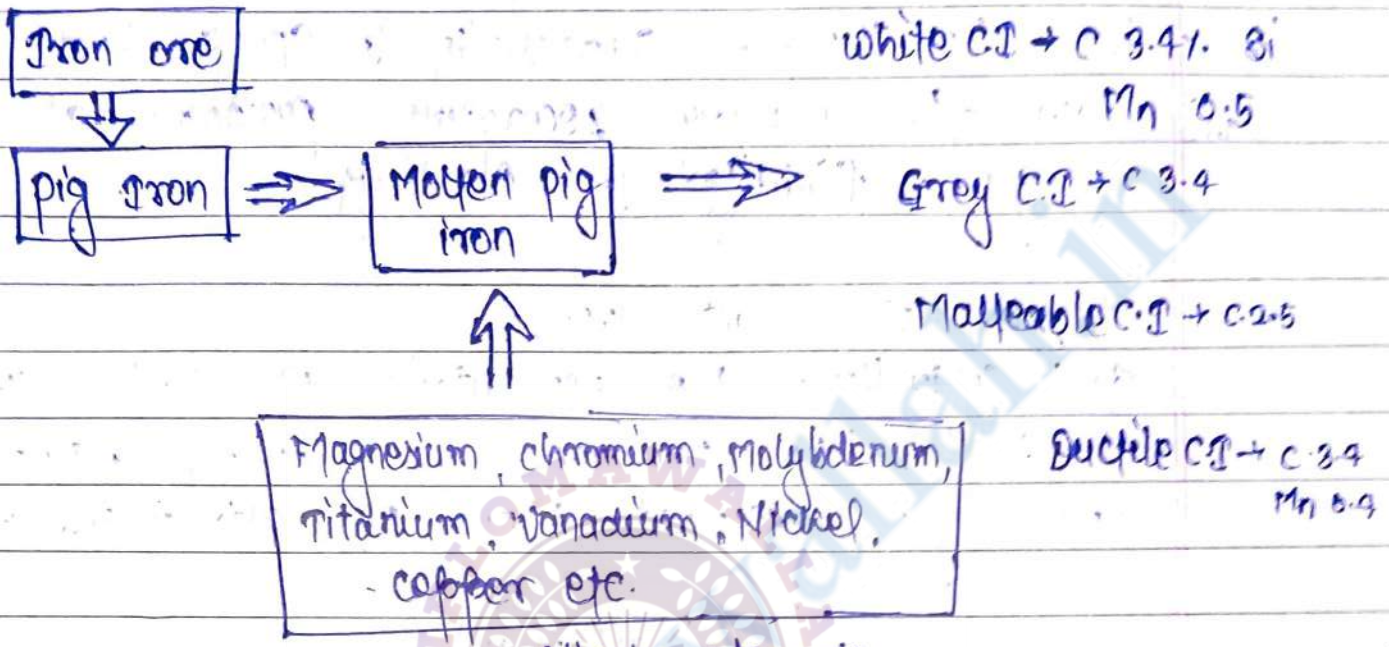
v) Machinability:- It has good machinability. Machinability is defined as the ability of a metal that allows being cut (machined) easily with a good surface finish at a low cost.

vi) Resistance to deformation and wear resistance:- It has excellent resistance to deformation. i.e it does not changes its shape when force is applied to it. It also has wear resistance which means that it opposes the damage in normal usage.

vii) It shrinks on cooling

viii) If placed in salt water, it becomes soft.

How cast iron is produced (Manufacturing process of CI)



Cast iron (CI) is produced from the pig iron. And pig iron is produced by melting iron or blast furnace. The pig iron is converted into ingots and then these ingots are re-melted again to produce cast iron. CI can also be produced directly from the molten pig iron.

* Application of cast iron:-

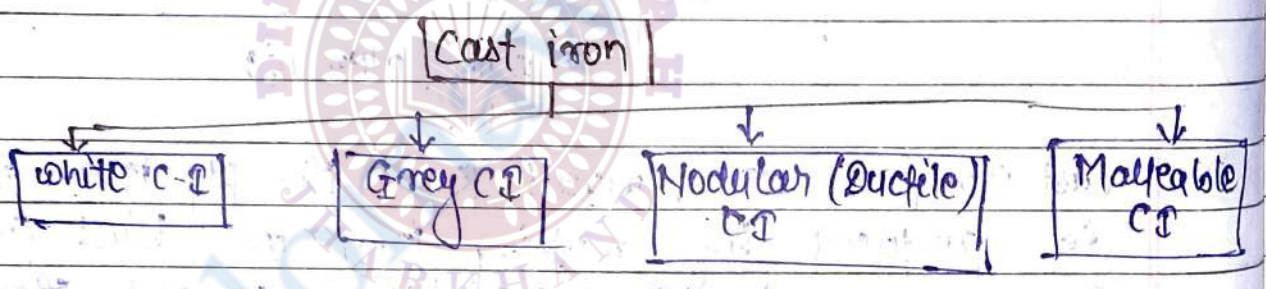
i) It is used in making pipes to carry suitable fluids.
ii) It is used in making different machines & automotive parts due to it high tensile strength.
iii) It is used in making pots, pans and utensils.
iv) It is used in making anchor for ships.
v) It has excellent anti-vibration (or damping) properties and hence, it is used to make machine frames.

vi) it is used in making stoves and firebacks, vechicle vehicles engines because it has good high ~~for~~ thermal conductivity & specific heat capacity.

vii) used for making decorative purposes as it has good fluidity & elasticity.

Types of cast Iron :-

By controlling the percentage of carbon and silicon in the molten pig iron and adding alloying elements we get different types of cast iron.



(1) White CI :- It is a type of cast iron that contains 3.4% carbon, 1.5% silicon and 0.5% Manganese. It is called as white cast iron because it show white cracks when fractured. It is the only member of the cast iron family which is free from graphite. It mainly consists of Iron carbide in its microstructure that makes it hard and brittle. It is produced by the rapid cooling of the molten pig iron.

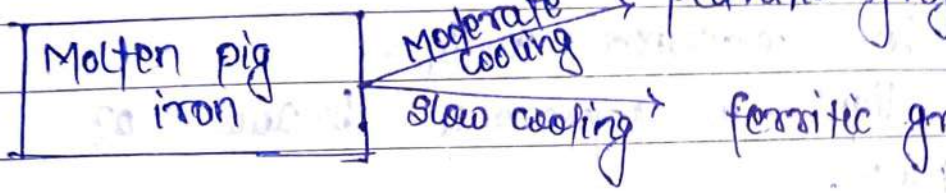
properties of white cast iron :-

i) It is hard & brittle
ii) cannot be machined easily.
iii) It is light in appearance because of the absence of graphite.
iv) It has high compressive strength and it also retains its hardness and strength even at high temperature.
v) Good abrasion resistance.

Application :-

i) It is used to make wear surfaces such as - impeller and volute of slurry pumps.
ii) In ball mills, it is used to make shell liner and lifter bars.
iii) In coal pulverizers, it is used to makes balls and rings.
iv) In excavating machine, the teeth of the digging bucket are made with white cast iron
v) Drawing dies and Dies extrusion nozzle.
vi) A large tonnage of white cast iron used to manufactered the malleable cast iron.

(2) Grey cast iron :-



- when molten pig iron in the presence of alloying elements is cooled moderately or slowly, we get grey cast iron. It has graphitic [i.e graphite flakes present in it] microstructure and shows grey colour cracks when fractured.
- Due to the formation of grey cracks, it is named as grey cast iron. It is the most widely used cast iron based on weight among all types. If molten pig iron is cooled on a moderate rate then we get pearlitic grey cast iron and cooling on slow rate gives us ferritic grey cast iron.

- properties :-
  i) low tensile strength
  ii) It has good stiffness and Hardness
  iii) It has high thermal conductivity and specific heat capacity
  iv) Easy to machines, due to the presence of graphite flakes
  v) Good damping capacity that allows it to used as the base for the machine tool mounting.
  vi) It has higher fluidity and higher brittleness.

- Application :-

i) Because of its stiffness it is used to make housing of cylinder blocks of internal combustion engine, housing pumps, valve bodies, decorative castings and electrical boxes.

ii) It has high thermal conductivity and specific heat capacity that make it perfect to make disc brake rotors and cast iron cookware.

iii) It is used as a base for machine tool mountings because of its very good damping capacity.

(3.) Nodular or Ductile cast iron :-

Molten pig iron —Mg→ Nodular graphite
Ductile cast iron

Ductile cast iron is produced by adding
Ductile cast iron has nodular (spheroidal) graphite in its microstructure. It is also known as nodular cast iron, spherodial graphite iron.
Keith millis discovered cast iron in 1943.

Ductile cast iron is produced by adding nodulizing agent magnesium in the molten pig iron that helps to convert graphite into nodules. Cerium, Tellurium, and yttrium are also possible nodulizer that can be used.

- Properties :-

i) Most of the ductile cast iron has similar properties with the malleable cast iron.
ii) It has good impact and fatigue resistance due to the presence of nodular graphite.
iii) Strength higher than grey cast iron.
iv) It machinability better than steel.
v) Low cost

- Application :-

i) It is used to produce ductile iron pipe that is used for water and power lines.
ii) Automative industry :- It is used to make many automobile components like connecting rods, crankshafts, cylinders, disc brake caliper, gears and gearboxes etc.
iii) wind power industry :- In the wind power industry, it is used for making hubs and structural parts like frames of machines.

(4) Malleable cast iron :-

White CI → Heat treatment (Annealing) for 24 or 48 hrs and then cooled for 24 and 48 hrs. → Malleable CI

Malleable cast iron is produced from the white CI. The white CI is heat-treated (Annealing) at about 950°C for 24 or 48 hrs and then allow to cool for 24 or 48 hrs. This changes the carbon in the iron carbide of the cast iron into graphite and ferrite plus carbon. Nodular graphite is present in the malleable CI.

- **Properties :-**

i) It has excellent strength and toughness.
ii) very ductile and malleable in nature.
iii) Good shock resistance.
iv) Good Machineability.

- **Applications :-**

i) Due to its excellent ductility and tensile strength, malleable CI is used for making electrical fitting and equipments, pipe fittings, hand tools, washers, farm equipment, brackets, mining hardware, and parts of machines.
ii) it is used for making Railways components.

Selection of appropriate cast iron for engineering applications :-

To understand the application of cast iron in engineering field we have to understand the special features of CI. They are :-

i) Strength :- • Cast iron has higher strength at reduced cost.
• They also have higher strength and ductility and are stiffer than pure iron.
• CI has a low melting point and greater fluidity.
• The strength of cast iron is what makes it a workable material for various industries.

ii) Castability :- • Cast iron is used in an array of industries because of ease of its castability.
• The cast iron can be molded into various shapes and sizes based on the industrial needs.
• The cost of production and the minimal usage of tools make it a viable manufacturing material.

iii) Machinability :- • Cast iron can be easily machined into final products.
• The properties of metal like hardness, tensile strength and microstructure alter its machinability.
• Hence, it can be used in a no. of industries for manufacturing numerous products.

iv) low cost and durability :- • cast iron saves tons of money in the long term.

• It requires little or no maintenance for a long time coming. using cast iron in industries can climate unnecessary replacement.

• further cast iron products can be integrated into existing system, thereby minimizing the cost of replacement.

• cast iron is also more malleable than other metals.

STEEL :-

• steel is basically an alloy of iron and carbon with a small percentage of other metals such as nickel, chromium, aluminium, Molybdenum, Tungsten etc.

• steel is a hard ductile and malleable solid and is probably the most solid material after plastic & iron,

• steel may not be as strong as iron but it for more resistant and does not corrode and does not get rusted like ~~like~~ iron does.

• There are various modified forms of iron, artificially produced, having a carbon content less that of pig iron and more than that of wrought iron and having qualities of hardness, elasticity and strength varying according to composition and heat treatment, generally categorized as having a high, medium or low carbon content ~~and~~ and named as steel.

Broad classification of steels :-

Classifications of steel can also be classified by a variety of different factors :-

1) Composition :- Carbon range, Alloy, stainless.
2) The production method :- continuous cast, Electric furnace etc.
3) finishing method used :- cold Rolled, Hot Rolled, Cold Drawn (cold finished) etc.
4) form or shape :- Bar, Rod, Tube, Pipe, plate, sheet, structural, etc
5) Deoxidation process (oxygen removed from steelmaking proc killed & semi-killed steels etc.
6) Microstructure :- ferritic, pearlitic, Martensitic etc.
7) physical strength (per ASTM standards)
8) Heat treatment :- Annealed, quenched and tempered etc.
9) quality Nomenclature :- commercial quality, Drawing quality pressure vessel quality etc.

According to the American Iron & steel Institute (AISI), steel can be categorised into four basic groups based on the chemical compositions.

1) ~~plan~~ Plain Carbon steel
2) Alloy steel
3) Tool steel
4) Stainless steel.

1) plain carbon steel :-

- carbon steel is an iron-carbon alloy which contains up to 2.1 wt% carbon.
- for carbon steels, there is no minimum specified content of other alloying elements however, they often contain ~~mag~~ manganese (~~1.65%~~ less than 1.65%)

There are three types of carbon steel :-

(a) low carbon steel or (Mild-carbon steel)
(b) Medium-carbon steel and
(c) High-carbon steel.

(a) low-carbon steel (Mild steel) :-

- It is the most widely used form of carbon steel. These steels usually have a carbon content of less than 0.25 wt. %. They cannot be hardened by heat treatment so this is usually achieved by cold-work.
- It is usually relatively soft and have low strength.
- They have high ductility, making them excellent for machining, welding.
- They have low hardness and cost.
- They have high toughness.

Applications :-

- low-carbon steel are suitable for automobile and refrigerator bodies, corrugated steel, structural, shapes etc.
- it is used for making nails, nut, bolts, boiler-plates, ship-plates, reinforcing bars, pipelines etc.

b. Medium-Carbon steels :-

- Medium-carbon steels contains contains 0.25-0.60 wt-% carbon and 0.60-1.65 wt-% Manganese.
- The mechanical properties of this steel can be improved via treatment involving austenitising followed by quenching and tempering, giving them a martensitic microstructure.
- It has low hardenability.
- Medium strength, ductility and toughness.

Applications :-

- As a result of their high strength, resistance to wear and toughness, medium-carbon steel are often used for making railway tracks, train wheels, crankshaft and gears and Machinery parts requiring this combination of properties.

c. High-Carbon steel :-

- It contains 0.60-1.25 wt% of carbon and 0.30-0.9% wt-% of manganese.
- It has highest hardness and toughness of the carbon steels and
- The lowest ductility.
- High-carbon steels are very wear resistant, they are almost always hardned and tempered.

Applications :-

- Due to their high wear-resistance and hardness, it is used in cutting tools, springs high strength wire & dies. ~~cutting tools~~ such as - Shearing knives, chisels, milling cutter, tapes, razors, hacksaw blades etc.

(2) Alloy Steels :-

Alloy steel is a type of steel that is alloyed with a variety of elements in total amount betⁿ 1% and 50% by weight to improve its mechanical properties. The alloying elements commonly used include manganese, nickel, chromium, molybdenum, vanadium, silicon and boron. These Addition enhance various properties of the alloy steel such as strength, hardness, toughness, wear resistance and corrosion resistance, making it suitable for a wide range of industrial applications.

OR

When other elements comprising metals and non-metals are added to carbon steel; alloy steel is formed. These alloy steels display various environmental, chemical and physical properties that can vary with the elements used to alloy. Here the proporation of alloying elements can provide different mechanical properties.

- Effects of alloying :-
Alloying elements can alter carbon steel in several ways. Alloying can affect micro-structures, heat-treatment condition and mechanical properties. Today's Technology with high-speed computers can foresee the properties and micro-structures of steel when it is cold-formed, heat treated, hot-rolled or alloyed.

- Types of alloy steel :-
There are two kinds of alloy steel :
(a) Low-alloy steel (b) High-alloy steel.

(a) Low-alloy steel are the ones which have up 8% alloying elem

(b) High-alloy steel are have more than 8% alloying elements.

- Alloying elements and effect of alloying element on properties of alloy steel :-
There are around 20 alloying elements that can be added to carbon steel to produce various grades of alloy steel. These provide different types of properties. Some of the elements used and their effects include :-

(a) Aluminium (Al) :- Deoxidizer, limits austenite grains growth.

(b) Carbon (C) :- • The most important constituent of steel. It raises tensile strength, hardness, wear resistance and abrasion.

→ It has lower ductility, toughness and machinability.

(c) Chromium (Cr) :- • Improves hardenability, ductility and wear resistance. • sharply increases corrosion resistance at high concentration (> 12%).

• Increases strength, hardness, hardenability, toughness, resistance to wear and abrasion, resistance to corrosion and scaling at elevated temperatures.

(d) Manganese (Mn) :- • Improves hardenability, ductility and wear resistance.

• Mn eliminates formation of harmful iron sulfides.

• strength increasing at high temperature.

(e) Nickel (Ni) :- Increases strength, impact strength and toughness, impart corrosion resistance in combination with other elements.

(f) Silicon (Si) :- Improves strength, elasticity, acid resistance and promotes large grain sizes, which cause increasing magnetic permeability.

(g) Tungsten (W) :- Increases strength, wear resistance, hardness and toughness.

Tungsten steel have superior hot-working and greater cutting efficiency at elevated temperatures.

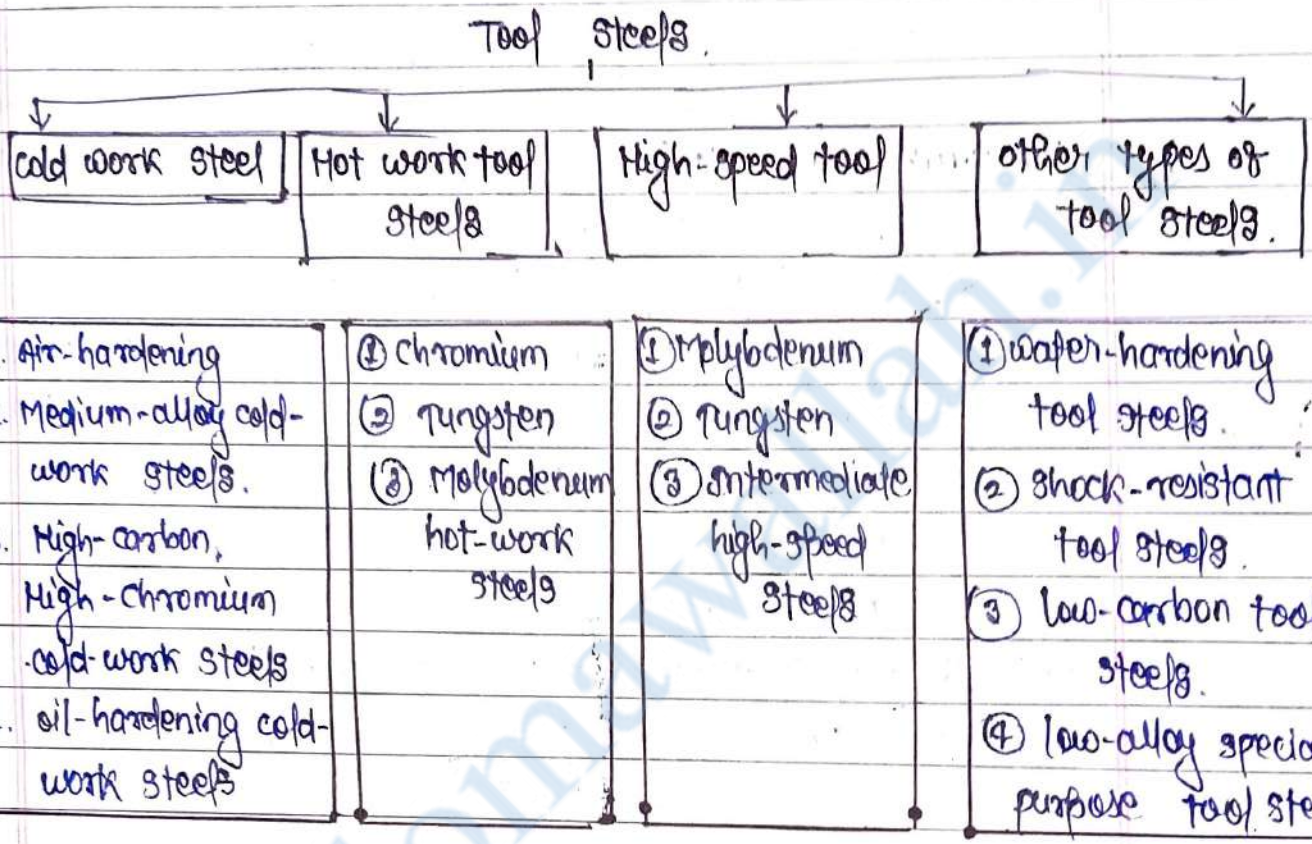
(h) phosphorus (P) :- • Increases strength and hardness and improves machinability.
• However, it adds marked brittleness or cold-shortness to steel.

(i) Sulphur (S) :- • Improves machinability in free cutting steels but without sufficient manganese it produces brittleness at red heat.
• It decreases weldability, impact toughness and ductility.

(j) Vanadium (V) :- Increases strength, hardness, creep resistance and impact resistance due to ~~fom~~ formation of hard vanadium carbides, limit grain size

(3) Tool steel :-
• Tool steel is the steel be used to manufacture cutting tools, measuring tools, mould and antifriction tool.
• Tool steel offers better durability, strength, toughness, hardness, corrosion resistance and temperature stability.
• Their suitability comes from their distinctive hardness, resistance to abrasion and deformation and their ability to hold a cutting edge at elevated temperatures.
• As a result, tool steels are suited for their use in the shaping of other materials.

Tool steels are classified according to their composition and properties into various categories :-



i) Cold work tool :-

- Cold work tool steel are high carbon steels containing smaller amounts of Manganese, Tungsten, Molybdenum, and chromium.
- They have good dimensional stability, hardenbility, wear resistance and average toughness and heat softening resistance.
- Cold work tool steel are used for gages, blanking, drawing, and piercing dies, shears, forming and banding tools rolls, lathe centres, mandrels, broaches, reamers, taps,

threading dies, plastic molds, knurling tools.
- It is also used in moulds for cutting wire cutting, rolling cutters and shaping wheels in steel industry and wheels, screw moulds, drawing dies in screw industry.

(ii) Hot work tool steels :-
- Hot work tool steel are a group of low carbon steel known as "H-steels".
- It is used to mainly shape and form materials in manufacturing units that perform at high temperature of 450 to 760°C including punching, forging and shearing.
- They have high wear resistance at high temperatures, high thermal conductivity and maintain their mechanical properties up to 540°C.
- They are used in processes such as- pressure die casting, extrusion and drop forging as well as in tube and glass manufacturing.

(iii) High-speed steels (HSS) :-
- High-speed steels are tool steels commonly used for high-speed cutting application. for example :- it is often used in power saw blades, drill bits, planing and slotting tools, twist drills, Turning, threading dies, profile cutting tools.

- High-speed steel is superior to the older high-carbon steel tools in that it can withstand high temperatures without losing its temper (hardness).
- High-speed steels are complex iron-base alloys of carbon, chromium, vanadium, molybdenum or tungsten or combination of these.
- To achieve good cutting performance from HSS, an appropriate hardening response must be provided in heat treatment.

4) Stainless steel :-

- Steel is an alloy of iron and carbon. A stainless steels are steels containing at least 10.5% chromium, less than 1.2% carbon and other alloying elements.
- Stainless steels are corrosion resistance and mechanical properties can be further enhanced by adding other element, such as nickel, molybdenum, titanium, niobium, manganese etc .....

* properties of stainless steel :-

- Higher Corrosion resistance
- Higher cryogenic toughness
- Higher work hardening rate.
- High hot strength
- Higher ductility.
- Higher strength and hardness.
- A more attractive appearance
- Lower ~~maintance~~ maintenance.
- Non-Magnetic / Magnetic property.

* Types of stainless steel :-

There are many grades and surfaces finishes of stainless steel available depending on the environment, the metal is expected to withstand. Based on microstructure they can be classified into four mayor categories :-

(a) Austenitic stainless steel :-

- Austenitic stainless steel contains a minimum of 16% chromium and 6% nickel and having carbon less than 0.15%.
- They range from basis-grades like 304 through to super austenities such as 904L and 6% Molybdenum grades.

composition :-

C :- 0.03 - 0.15%, Mn :- 2.10%, Si :- 1-2%, Cr :- 16-26%, Ni :- 6%

* Applications :-

- Making engine parts in air-crafts.
- used As o heat exchanger in chemical industry.
- Making chemical tanks.
- used in making oven.
- Architectural applications such as roofing and cladding
- Roofing and gutters.
- Door and windows.
- Benches and food preparation areas.
- food processing equipment.
- kitchen sinks.

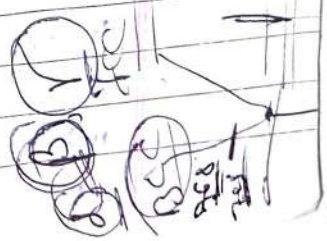
12.1.

(6) ferritic stainless steel :-

- ferritic stainless steel contains only chromium as an alloying element. The chromium contains ranges from 10.5 to 18.1.
- They have average corrosion resistance and poor fabrication, characteristics.
- They generally have better engineering abilities than austenitic grades.
- Heat treatment method do not help in with hardening the metal.
- They are magnetic
- They also have good resistance to stress corrosion.
- lower corrosive material wear.

* Applications :-

- used in vehicle exhausts.
- used in fuel lines.
- used in cooking utensils.
- used in Architectural trim
- used in domestic appliances.
- used as a heating element in furnace.
- used in interior decorative works, screws, fitting and oil burner parts.



(c) Duplex stainless steel :-

- Duplex stainless steel has high chromium and low nickel contains.
- This gives duplex stainless steel microstructure that include both austenitic and ferritic phases.
- They include alloys like 2304 and 2205.
- The alloying elements are chromium which contains 23% , 4% nickel.
- These alloys are named due to their respective composition :- 23% chromium, 4% nickel and 22% chromium 5% nickel.

* Applications :-

- used as a heat exchangers.
- used in making marine applications.
- used in desalination plants.
- used in food pickling plants.
- used in off-shore oil and gas installations.
- used in chemical and petrochemical plant.

(d) Martensitic stainless steel :-

- This type of stainless steel consists of high carbon, and lower chromium like ferritic grades it is magnetic.
- It does display poor weldability compared to other grades
- But it has higher hardenability and can be heat treated to improve properties.
- It have lower corrosion resistance as ~~as~~ compared with austenitic and ferritic grades with the same chromium and alloy contains.

* Applications :-
- used in making knife blades.
- used in making cutlery.
- used in surgical instruments.
- fasteners.
- shafts
- spring.

Spring steel :-
- Spring steel is a name given to a wide range of steels used in the manufacture of springs, prominently in automotive and industrial suspension applications.
- These steel are generally low-alloy manganese, medium-carbon steel or high-carbon steel with very high yield strength.
- Spring steel is known to be resilient, and pliable, with high yield strength.
- It has unique ability to be formed, shaped and post heat treated.

* Composition :-
Most of the springs are made with medium and high carbon steels, alloy steels and stainless steels as given below :-
- Medium and high carbon spring steels :-

→ These spring steels are the most commonly used material since they are less expensive

- These materials can be easily worked and are readily available.
- These steels are not suitable for spring operating at high or low temperatures or for shock or impact loading.

Alloy spring steels:-

- These spring steels are used for conditions of high stress and shock or impacts loadings.
- These steel can withstand a wider temperature variation than high carbon springs steels and are also used in either the annealed or pre tempered conditions.
- Silicon is the key element in most of the alloy spring steels.
- Alloy spring steel contains 1.5% - 1.8% silicon, 0.7% - 1% manganese and 0.52% - 0.6% carbon.

Stainless spring steels:-

The use of stainless spring steel has increased in recent times. There are compositions available which can be used for temperatures upto 300°C. All these steels are corrosion resistant but only the stainless steel of 18-8 composition is to be used at sub-zero temperatures.

*** Applications:-**

- As general use steel, spring steel has a wide range of commercial applications. It is a common material used for manufacturing objects like springs, washers, saw blades.

lock picks, antennas, and scrapers.
- It is also commonly used to create lawnmower parts, the landing gear of small aircrafts and vehicle coil springs.

Steels for following - shafts, axles, bolts nuts, Agriculture equipment, household utensils, Antifriction bearings.

1. Shafts :-
- The material used for shafts is mild steel.
- when high strength is required, an alloy steel such as nickel-chromium or chromium-vanadium steel is used.
- shafts are generally formed by hot rolling and finished to size by cold drawing or turning and grinding.
- load and stress Requirements :- determine the type and magnitude of loads (tensils, compressive)
- Assess exposure to corrosive enviroments, temperatures variation and other environmental factors.

2. Axles :-
- In selecting steel for axles involves considering factors such as- strength, toughness, fatigue, resistance and the enviromented in which the axle will operate.
- Here are some commonly used steels for axels and their characteristics :-

(a) AISI 1045 (Medium carbon steel) :-
properties :- Medium tensile strength, good toughness and machinability.
uses :- Suitable for general purpose axles in applications where high strength is not critical.

(b) AISI 4140 (Chromium-Molybdenum Alloy steel) :-

properties :- High strength, good fatigue resistance, and can be heat treated to increase hardness and enhance mechanical properties.

(3) Bolts :- Most Bolts and screws are made from grade 2, 5 or 8 carbon steel.

Grade 2 :- Inexpensive but least durable.

Grade 5 :- common used in the automotive industry.

Grade 8 :- often used in mechanical applications like vehicle suspension systems.

Stainless steel is the most used primarily for long lasting application due to its corrosion-resistant nature and durability. Stainless is a soft metal due to the low carbon content ; therefore most stainless steel bolts are cold-formed and not heat treated or hardened.

(4) Nuts :-

- Alloy steel is the most common material that fasteners are manufactured in. Alloy steel fasteners are often treated coated or plated with zinc for additional corrosion resistance.
- Alloy steel is used for the hot dipped galvanised process treated in a molten zinc bath, which creates a tightly bonded alloy finish.

(5) Agriculture equipments :-

- Low carbon steel is used extensively in the construction of farm machinery. Frames and most of other members are made out of low-carbon steel.
- Hot-dip galvanized steel provides corrosion protection that can often last for decades, even when exposed to the harsh environment of farming.
- Stainless steel is also utilized for its surface properties. with a standard, shiny finish, it makes it particularly easy to clean.
- Also used in dairy farming, the smooth finish is important because of the need to maintain microbiological quality in the raw milk.

(6) Household utensils :-

- Stainless steel find many applications in the manufacture of kitchen utensils.
- It is made of 75% iron, 15% chromium, 9% nickel and 0.5% carbon.
- It has a brilliant, silvery grey lustre.

(7) Antifriction Bearings :-

- Most ball bearing are made of a type of steel known as carbon chromium steel:, often called chrome steel.
- This is used for reasons of cost and durability.
- Bearing are also made from other materials such as - stainless steel, ceramics and plastic.

#. Designation and coding (as per BIS, ASME) of plain & alloy steel and cast iron :-

- BIS system of designation of steels :-
Some material has names like 40C8, 50C8, Engineering materials have various compositions, types, Applications, properties. Every material has its different mechanical properties. The Bureau of Indian Standards (BIS) have standardised the designation method for steel and other material. These standards are mainly followed by Indian industries, other countries may be using ASME standard.

i) Designation of steels :-
Steels are designated by a group of letters or no. indicating any one of the following three properties
(a) Tensile strength
(b) Carbon content and
(c) composition of alloying elements.

Steels, which are standardized based on their tensile strength without detailed chemical composition, are specified in two ways - a symbol fe followed by the minimum tensile strength in N/mm2.
Another method is fe E steel followed by yield strength in N/mm2.

for eg. :- fe 350 - This indicates a steel with a tensile strength of 250 Newton per mm square.
fe E 250 - Yield strength of 250 N/mm2.

ii) Designation of plain carbon steels:-

This consists following three quantities:-

(a) figure and indicating 100 times the average percentage of carbon.

(b) a letter C

(c) a figure indicating 10 times the average percentage of manganese.

eg:- 55C4 indicates a plain carbon steel with 0.55% carbon and 0.4% manganese.

iii) Designation of Alloy steel:-

The designation of alloy steel consists of following quantities:-

(a) figure indicating hundred times the average %age of carbon.

(b) chemical symbol for alloying elements ~~at~~ always followed by the figure for its average %age content multiplied by the factor. The multiplying factor depends upon the alloying element and ~~it's~~ shown

In alloy steel, if manganese % is more than 1 then chemical symbol and their figures are arranged in descending order of their %age content.

eg:-

25Cr4Mo2 is an alloy steel having an average 0.25% of carbon, 1% chromium and 0.2% molybdenum.

iv) Designation of cast steels:-
Components from cast steel are manufactured by pouring the molten steel into the mold.
There are two varities of steel castings -
(a) Carbon steel castings and
(b) High tensile steel casting.

~~Cast~~ Cast steel are designated according to the tensile strength.
eg:- CS640 is a steel casting with a minimum ultimate tensile strength of 640 N/mm²

Examples of Designated materials:-

i) feE 230 :- Steel (steel having a yield strength of 230 N/mm² with a minimum tensile strength of 230 N/mm²

ii) fG 200 :- Grey cast iron with a minimum tensile strength of 200 N/mm².

iii) 35C8 :- Means carbon steel containing avg. %age of carbon is 0.35 and avg. %age of manganese is 0.8

iv) X20Cr18Ni12 :- Means alloy steel with an average %age of carbon is 0.20, the average percentage of chromium is 25, the average percentage of Nickel is 12.