UNIT 1 – INTRODUCTION TO MATERIAL

DEFINITION

Material technology is a branch of engineering and science which deals with study of structure and properties of the materials.

CLASSES OF ENGINEERING MATERIALS

1. **Metals**
2. **Ceramics**
3. **Organic polymers**

1. METALS:

It is an elemental substance & it has following characteristics.

1. It is solid at room temperature.
2. Good conductor of heat and electricity
3. Non transparent
4. Reflective when polished
5. Expand when heated & Contracts when cooled

CLASSIFICATION OF METALS

1. **Ferrous**
2. **Non Ferrous**

FERROUS METALS:

It content iron as their main constituent. Ex: Pig Iron, Cast Iron, Wrought Iron etc.

NON FERROUS METALS:

Ferrous metals are those which do not content iron as their main constituent. It melting point is less than ferrous metal.

2. CERAMICS:

These materials consisting of phases, a phase is physically separable and chemically homogenous constituent of materials.
Ex: Rocks, Glass, Ceramics, etc.

3. ORGANIC MATERIALS:

They usually consist of carbon chemically combined with hydrogen, oxygen or other non metallic substances.
Ex: Plastic, synthetic rubbers,

PROPERTIES OF MATERIALS

1. Physical properties of materials.
2. Chemical properties of materials.
3. Magnetic properties of materials.
4. Chemical properties of materials.
5. Mechanical properties of materials.

MECHANICAL PROPERTIES

1. Elasticity	**7. Toughness**
2. Plasticity	**8. Stiffness**
3. Ductility	**9. Resilience**
4. Malleability	**10. Fatigue**
5. Strength	**11. Creep**
6. Hardness	

1. ELASTICITY:

It regains its original position after removal of external load.

Ex: Steel, Rubber.

2. PLASTICITY:

It is the ability of material it undergoes some permanent deformation without regaining the original position after removal of load.

Ex: Clay, Lead, Steel.

3. DUCTILITY:

The property of metals which allows them to be drawn into wires is known as ductility.

Ex: Copper, Silver, Aluminum.

4. BRITLNESS:

It is the property of material of breaking or shuttering without much permanent deformation.

5. MALLEABILITY:

It is the ability to be flattened in to their sheet without cracking by pressing or rolling.

6. STRENGTH:

It is the capacity of the materials to withstand destruction under the action of external load.

7. HARDNESS:

It is the property of the materials, which enables it to resist abrasion, indentation machining and scratching.

Ex. Diamond is harder than Glass.

8. TOUGHNESS:

It is the property of material which enables it to be twisted, bent or stretched under a high stress before rapture.

9. STIFFNESS:

It is the property of the material which enables it to resist deformation. A materials suffers slight deformation under load has a high degree of stiffness.

10. RESILIENCE:

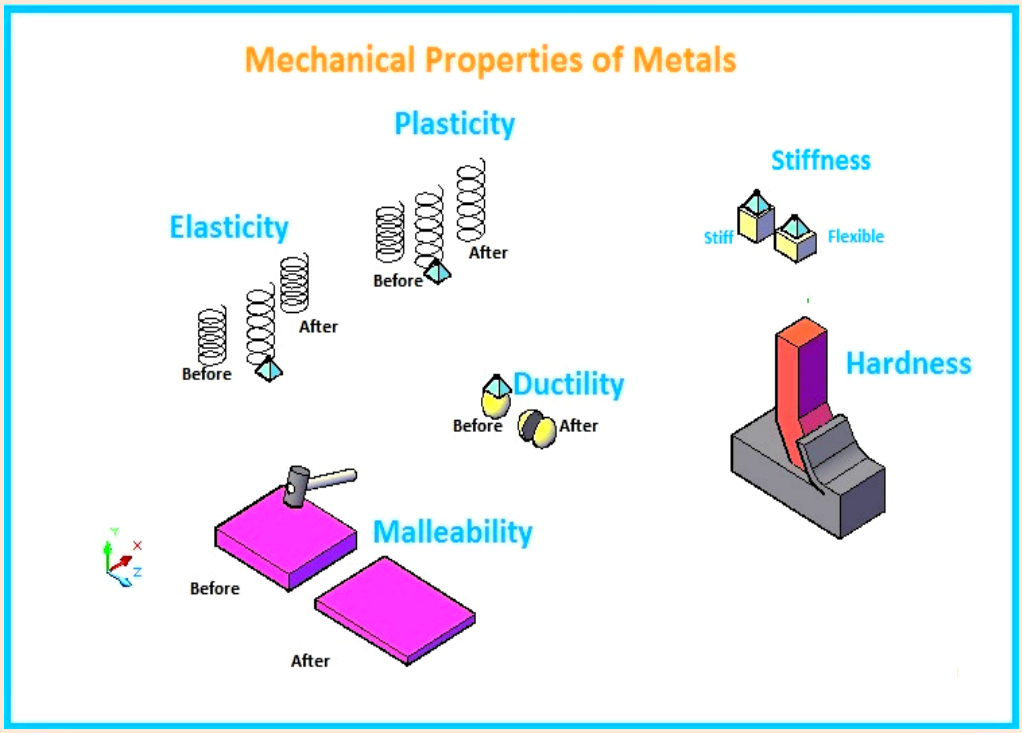
It is the property of materials, which enables it to store energy and resist shock and impact.

11. FATIGUE:

The term fatigue is referred to effect to cyclically repeated loads. It is found the metals used for construction are fractures by cyclically repeated stresses.

12. CREEP:

It is the property of the materials, which enables it under constant stress to deformation slowly but progressively over a certain period.



Figures: of Plasticity, Elasticity, Stiffness, Hardness, Ductility and Malleability.

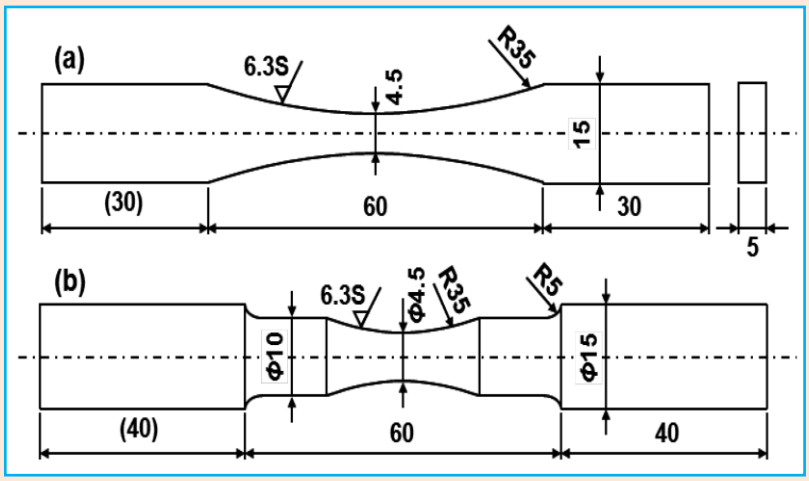


Figure: - of Fatigue

STRUCTURE OF METALS

STRUCTURE:

The internal structure of material can be studied at various levels of observations. The magnification and the resolutions of the levels of observations,

CRYSTAL STRUCTURE:

Crystal structure refers to the details of the atomic arrangement within a crystal.

ATOM:

All substances, whether present in the form of solids, liquids, or gases are build up the particles known as atom. In Greek word atom means “not divided”.

CRYSTAL:

A crystal is the regular polyhedral form (Many side solid), bounded by smooth surfaces, which is assumed by a chemical compound, under the action of its inter atomic forces, when passing under suitable conditions from the state of a liquid or gas to that of a solid.

CRYSTALLINE STRUCTURE:

The arrangement of atoms is in a periodically repeating pattern is known as crystalline.

NON-CRYSTALLINE STRUCTURE:

No such regularity of arrangement is found.

CRYSTALLIZATION:

When a metal freezes from a state of fusion, it crystallizes. The atoms are very active in the liquid state and the greater the temperature, higher is the mobility of the atoms. During solidification, the atoms of the liquid metal arrange or group themselves in a systematic manner is called crystallization.

SPACE LATTICE:

The atoms present in any crystalline material are arranged in a regular three-dimensional repeating pattern. This three dimensional pattern present in a crystalline material is known as space lattice.

UNIT CELL:

A unit cell is defined as the volume of a solid from which the entire crystal structure obtained by translation repetition in space of minimum number of atoms, molecules or group of crystal is known as the unit cell.

The simplest repeating unit in a crystal, opposite of a unit cell are parallel, the edge of the unit cell connects equivalent points.

Most of the metallic elements crystallize in the following structure.

1. Body Centered Cubic structure (BCC)
2. Face Centered Cubic structure (FCC)
3. Hexagonal Close Packed structure (HCP)

1. BODY CENTERED CUBIC STRUCTURE:

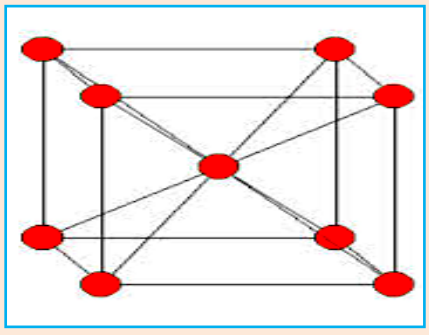
This is a body centered cubic crystal with nine atoms of which eight are located at the corners of the cube and ninth at the centre. This type of lattice found in metals like Iron, Barium, Chromium, Tungsten, Vanadium etc.

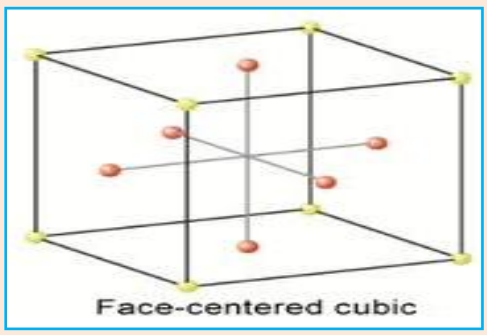
2. FACE CENTERED CUBIC STRUCTURE:

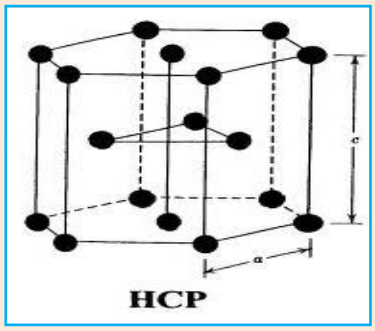
This crystal has fourteen atoms, of which eight are located at the corners of the cube and six at the centers of six faces. This has more compact packing. This is in metals like Aluminum, Copper, Gold, Lead, Nickel, Platinum, Silver Etc (All Non-ferrous metals).

3. HEXAGONAL CLOSE PACKED STRUCTURE:

It is simply hexagonal and has compact arrangement of atoms. This crystal has seventeen atoms. This found in metals like Cobalt, Magnesium, and Zinc etc.







FILL IN THE BLANKS WITH APPROPRIATE WORDS

1. The ferrous metals contain _____ as their main constituent.
2. Total number of atoms in BCC structure is _____.
3. The property of material to be rolled into sheets is called as_____.
4. There are two types of metals _____ and _____.
5. FCC structure contains _____ number of coordinate atoms in cubic area.
6. _____ is the property of materials breaking without permanent deformation.
7. _____ is the property of material can be converted into thin sheets.
8. _____ is the property of material to get original shape and its size.
9. Non ferrous are not content _____ as their main constituent.
10. The total number of atoms in HCP structure is _____.

MULTIPLE CHOICE QUESTIOINS

1. The total number of atoms arranged in HCP
   a. 18 b. 16 c. 17 d. 20
2. BCC structure is found in
   a. Aluminum b. Copper c. Sodium d. Zinc
3. The total no. of atoms in FCC are
   a. 14 b. 9 c. 22 d. 17
4. The ability of material to absorb a large amount of energy is
   a. Ductility b. Hardness c. Toughness d. Resistance
5. The carbon percentage of wrought iron
   a. 2% b. 3% c. 0.03% d. 18%
6. The three dimensions regular pattern in a crystalline solid is known as
   a. Unit cell b. Space Lattice c. Lattice d. Crystal
7. The property of material to be rolled in to thin sheet is called
   a. Ductility b. Malleability c. Hardness d. Strength
8. Ability of material which can be drawn into thin wires
   a. Ductility b. Malleability c. Weldability d. Toughness

2 MARK QUESTIONS

1. Define material technology?
2. What is structure of metals?
3. Define Crystallization?
4. Explain space lattice?
5. Define unit cell?
6. What are the common characteristics of metals?

3 MARK QUESTIONS

1. Write the types of mechanical properties of materials.
2. Define ductility and malleability.
3. Classify engineering materials.
4. Explain the Organic materials and ceramics.
5. List out the general properties of materials.

5 MARK QUESTIONS

1. Explain the following properties
   a. Elasticity b. Plasticity c. Creep
2. With a neat sketch explain the BCC structure.
3. Write the difference between Ferrous and Non Ferrous metals
4. Explain crystal structure.

8 MARKS QUESTIONS

1. Explain the following mechanical properties of materials
   a. Strength b. Toughness c. Resilience d. Hardness
2. With a neat sketch explain FCC and HCP structures.
3. What is metal? Explain the classification of metals.

Books References:

- Material science and Metallurgical engineering – O. P. Khanna
- Material science and Metallurgical engineering – William Callister
- Material science - V. R. Raghavan
- Material science – B.A Shrinivas

Online Class References

- Material Properties: - http://youtu.be/BHZALtqAjeM
- Materials Mechanical Properties: - http://youtu.be/Ztjra5pl4eY
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- Materials Mechanical Properties: - http://youtu.be/UZkUvWiNeDs
- Classification of metals: - http://youtu.be/u8wybljJ6uc
- Engineering Materials structure: - http://youtu.be/1aJloLBo_Ng

UNIT 2 – MANUFACTURING OF IRON

IRON ORES

The production of iron and steel starts from melting of iron ore to pig iron. Iron ore is the main element for production of pig iron.

TYPES OF IRON ORES

1. Hematite
2. Limonite
3. Magnetic
4. Pyrite
5. Siderite

PIG IRON MANUFACTURING

PIG IRON

The crude impure iron, which is extracted from iron ores, is known as Pig Iron.
Uses: - Cast iron, Steel, Wrought iron.

BLAST FURNACE

The Pig iron is manufactured in blast furnace.

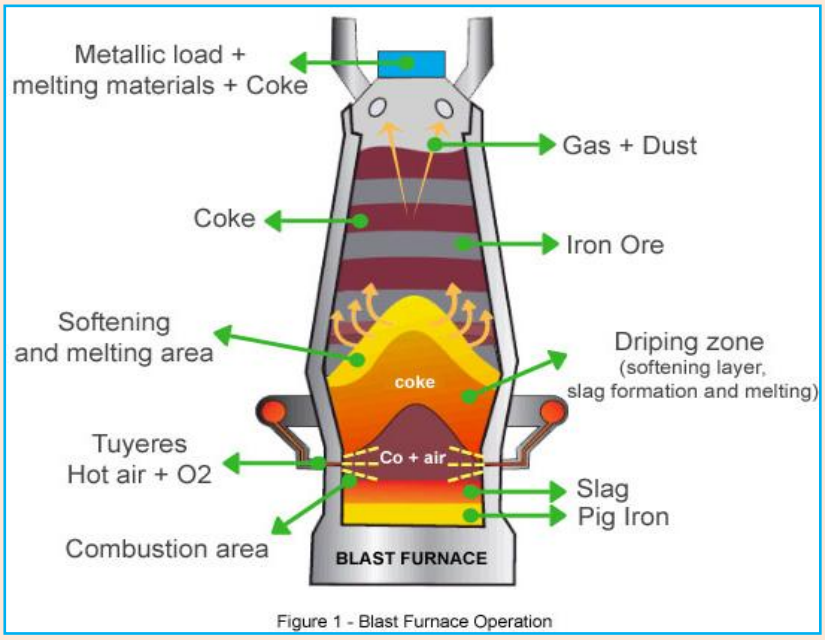


Figure 1 - Blast Furnace Operation

The following are the **three Operations** involved in the manufacturing process of Pig iron.

1. Dressing
2. Calcinations and Roasting
3. Smelting or Melting

1. DRESSING:

The iron ores obtained from mines are crushed in to pieces of sizes 25mm diameter. This helps in two ways.

I. The ore particles uniform size is obtained
II. The reducing gases penetrate the ores in better way.

2. CALCINATIONS AND ROASTING:

After iron ores are dressed, they are calcined or roasted, the calcinations consisting heating ores in presence of air so that they are oxidized.
The water and carbon oxide is removed from ores by calcinations.

3. SMELTING or MELTING:

Separate of metals from Ore is known as smelting. It is carried in blast furnace. Consist of blast furnace is Vertical steel Cylinder, The outer shell of furnace is of steel plate of about 30 to 40 mm thick plates. It's inside surface is covered by lining of fire bricks.
The capacity of Blast furnace 100000 KN per day,

WORKING OF BLAST FURNANCE

The row material consists of iron ores fluxing materials and fuel, the fluxing material is limestone, and fuel is coke or charcoal. The mixture of raw material is poured through throat portion of hopper of the furnace.

A blast of hot air is forced through blast pipe and Tuyers. The blast pipe runs around the furnace .At a temp of 1000 to 1700 C the substances inside in the furnace starts melting.

The Pig iron which is formed and collected in the Heart portion, the slag also collects in hearth and as it is light in weight and floats on molten pig iron.

The hot gases and dust escapes through outlet which is provided in the throat portion of the furnace. The pig iron obtained is 93% to 95% of iron, 4 to 5% carbon and remaining being manganese, sulphur etc.

CAST IRON MANUFACTURING

CAST IRON

It is manufactured by remelting of pig iron with coke and lime stone. It is a mixture of carbon and iron in which carbon varies from 2.5 to 5.5%.

Uses: Water pipe, Manhole, Machine bed, Fittings and frame, Agriculture equipments etc.

CUPOLA FURNACE

The remelting of pig iron and coke, Lime stone is done in furnace is known as Cupola furnace. It is smaller in size. Its shape is cylindrical with diameter about 1 meter and height is about 5 meter.

The raw materials contained pig iron, coke and lime stone mixture are fed from the top after the raw material are placed the furnace is fired and blast of air is forced through Tuyers.

The blast air is cold as impurities in pig iron are removed by oxidation. The molted cast iron is led in to moulds of required shape to form castings.

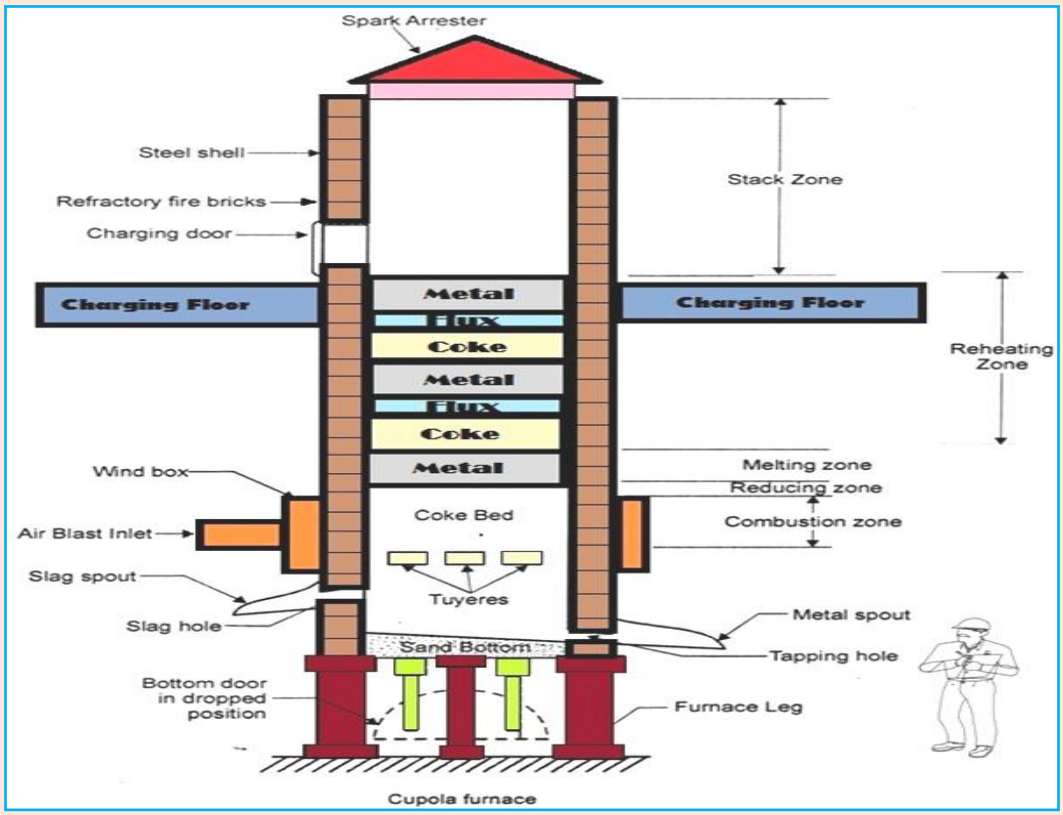


Figure:- Cupola Furnace

ZONES IN CUPOLA FURNANCE

1. STOCK ZONE:

Extends above preheating zone to top of cupola, it carries gases generated within the furnace to the atmosphere.

2. PRE HEATING ZONE:

It contains charge as alternate layer of coke, limestone and pig iron pre heating above 1100 C.

3. MELTING ZONE:

It starts from first layer of metal to certain height; the highest temp is developed in this zone.

In this iron reacts with coke to give iron carbide and carbon dioxide,

PROPERTIES OF CAST IRON

1. If placed in salt water it becomes soft.
2. It can be hardened by heating, sudden cooling
3. Cannot be magnetized, It shrinks on cooling

TYPES OF CAST IRON

1. Grey Cast Iron
2. Malleable Cast Iron
3. Nodular Cast Iron
4. Chilled Cast Iron
5. Alloy Cast Iron
6. Mehanite Cast Iron
7. White Cast Iron

GREY CAST IRON

The grey cast iron is obtained by cooling and solidifying the molten metal slowly. After solidifying the iron contains greater part of carbon in the form of graphite flakes.

Grey cast iron contains large quantity of carbon and small quantity of elements like silicon, phosphorous, manganese and sulphur.

USES:-Dies, Moulds, Pipes, Beds of engine, slide ways.

PROPERTIES OF GREY CAST IRON

1. It is brittle
2. Compression strength is more
3. The tensile strength is varies from 120 to130 N/MM
4. Easily machinable
5. It posses good fluidity.

WHITE CAST IRON

When iron and carbon are chemically combined in the form of cemented, the iron known as the white cast iron is obtained. It consists of large quantity of manganese small quantity of silicon by rapid cooling.

USES:-Railway Carries, Brakes

PROPERTIES OF WHITE CAST IRON

1. It is very hard
2. When fractured the surface has a silvery appearance
3. Not easily machinable & It does not rust so much

MALLEABLE CAST IRON

The metal is said to be malleable if it may easily be caused to spread and flattened under pressure of hammering.

The malleable cast iron is manufactured by two methods

1. White hearth method
2. Black hearth method.

USES: - Automobile parts, Brake, Pedal, Steering, Gear housing, washing machine parts.

PROPERTIES OF MALLEABLE CAST IRON

1. It is less brittle, tougher and stronger
2. It posses more fluidity
3. It is cheaper than steel & Tensile strength is more

NODULAR CAST IRON

Nodular cast iron is not a single material it is a family of materials. The small quantity of magnesium is added to cast iron and graphite converted in to nodular or spheroidal form.

USES: - Cylinder heads, cylinder valves, compressor.

PROPERTIES OF NUDULAR CAST IRON

1. It has high fluidity.
2. Excellent cast ability.
3. High strength.
4. High toughness.
5. Having more resistance.
6. Higher machinability.

ALLOY CAST IRON

These are developed to overcome deficiencies of ordinary cast iron. The addition of Nickel, Molybdenum, Titanium, Silicon, Copper, and other alloying elements,

CHILLED CAST IRON

Quack cooling is called chilling and the iron produced called chilled iron. All castings are chilled at outer surface by coming in contact with sand in mould. The cast iron has high thermal conductivity. So the chilled portion of casting undergoes solidification and cooling to produce hard surface only penetrates about 1 to 2 mm depth.

USES: - Casting parts, agriculture equipments

WROUGHT IRON

Wrought iron is highly refined iron with small amount of slag forged out in to fibers. The chemical analysis shows 99% of iron. Slag gives more useful characteristics black smiting and resistance to corrosion. The wrought iron is manufactured in Puddling furnace.

USES: - Construction work, Chain links, Crane hook, Railway coupling, Boiler plates, Bolt, Rivets.

PROPERTIES OF WROUGHT IRON

1. It has tough and it can be hardened.
2. It is malleable and ductile.
3. It has tensile strength
4. It cannot be melted
5. It can be forged.

FILL IN THE BLANKS WITH APPROPRIATE WORDS

1. Pig iron is manufactured in _____ furnace.
2. Wrought iron is manufactured in _____ furnace.
3. _____ and _____ ores are to be used for manufacturing of pig iron in blast furnace.
4. The lathe machine bed is made up of _____.
5. Reduction of iron ore to iron in a blast furnace is called _____.
6. The cast iron is manufactured in _____ furnace.

MULTIPLE CHOICE QUESTIOINS

1. In which stage iron is produced.
   a. Dressing b. filtering c. smelting d. adding
2. Cast iron is manufactured in
   a. Blast furnace b. cupola furnace c. open hearth furnace d. LD process
3. Cast iron is a
   a. Ductile material b. Malleable material c. Brittle material d. Tough material
4. The carbon percentage of cast iron is
   a. =2% b. < 0.8% c. >2% d. <2%
5. The carbon percentage of wrought iron is
   b. 2% b. 18% c. 3% d. 0.03%

2 MARK QUESTIONS

1. What are the Ores of iron?
2. Define Wrought Iron.
3. Define Pig iron.
4. Define cast iron.
5. Name the parts of Blast furnace.

3 MARK QUESTIONS

1. Write the applications of wrought iron.
2. Write the properties of cast iron.

3. Explain the white cast iron
4. List out the properties and applications of malleable cast iron.

5 MARK QUESTIONS

1. List out the types of furnaces with their applications.
2. Write the difference between cast iron and steel.
3. What is cast iron list out the types of cast irons and their applications?
4. Write the properties and applications of pig iron.
5. Define gray cast iron and write their properties.

8 MARK QUESTIONS

1. Explain the manufacture of pig iron in blast furnace with a neat sketch.
2. With a neat sketch explain the cast iron manufacturing process in cupola furnace.
3. Explain the manufacture of wrought iron in puddling furnace with a neat sketch.

Books References:

- Material science and Metallurgical engineering – O. P. Khanna
- Material science and Metallurgical engineering – William Callister
- Material science - V. R. Raghavan
- Material science – B.A Shrinivas

Online Class References:

- Iron: - http://youtu.be/hBqhGHfzQFQ
- Pig Iron: - http://youtu.be/zkrTZHufozs
- Blast furnace: - http://youtu.be/Xn7D8GsQS4E
- Types of cast iron: - http://youtu.be/iYesXt3bHNs
- Cupola furnace: - http://youtu.be/8vq6bB3egVY
- Wrought iron: - http://youtu.be/NSmyQoLiqos

UNIT 3 – MANUFACTURING OF STEEL

STEEL

Steel is fundamentally an alloy of iron and carbon, the carbon content varying up to 1.5% maximum. This is due to fact that carbon, if in excess of 1.5% of carbon does not combine with iron and it is present as free graphite. The steel become harder and tougher as the carbon increases.

TYPES OF STEELS

1. LOW CARBON STEEL:

Its Carbon content is 0.05 to 0.3%. Uses for manufacturing of wires, Hinges Keys, Cutting tools, Punches etc,

2. MEDIUM CARBON STEEL:

Its Carbon content is 0.3 to 0.6%. uses for manufacturing of Hinges Keys, Cutting tools, Drills, Cutters, Blades, Automobile parts etc.,

3. HIGH CARBON STEEL:

Its Carbon content is 0.6 to 0.9%. uses for manufacturing of Crane Hooke's, Cutting tools, HSS Cutter, Drills, Reamers, Hacksaws blade Hospital equipments etc.,

4. TOOL STEEL:

Its Carbon content is 0.9 to 1.5%. Uses for manufacturing of Cutting tools etc.,

INTRODUCTION OF STEEL MAKING

Steel making is the process for producing steel from iron ore and scrap. In steel making, impurities such as nitrogen, silicon, phosphorus, sulfur and excess carbon are removed from the sourced iron, and alloying elements such as manganese, nickel, chromium and vanadium are added to produce different grades of steel.

Limiting dissolved gases such as nitrogen and oxygen, and entrained impurities (termed "inclusions") in the steel is also important to ensure the quality of the

products cast from the liquid steel.

The raw materials like Pig iron, iron ores, and steel scraps are poured with mixture of limestone and Fluxes, and alloying elements like Nickel Chromium, Carbons are added for improving the property of steel. The high speed steel, Stainless steel, carbon steels, and Alloy steels are produced by using of Open hearth furnace, Electrical furnace, Crucible furnace, Oxygen process, Bessemer process or Modern process.

HISTORY

Steelmaking has existed for millennia, but it was not commercialized on a massive scale until the 19th century. The ancient craft process of steelmaking was the crucible process. In the 1850s and 1860s, the Bessemer process and the Siemens-Martin process turned steelmaking into a heavy industry.

The modern Steel making process is developed in twentieth century for reduce the production cast, Increase the production of steel and save the production time. The modern steel making process are economical than basic process. Today there are major commercial processes are used for making steel.

THE VARIOUS PROCESS OF MANUFACTURING STEEL

1. Bessemer process
2. Crucible process
3. Open Hearth process
4. Duplex furnace
5. Modern Steel making process:-
    1. L.D. Process
    2. Electric arc process:-
        I. Direct arc furnace
        II. High frequency

1. THE BESSEMER PROCESS:

Introduction:

The Bessemer process was the first inexpensive industrial process for the mass-production of steel from molten pig iron prior to the open hearth furnace. The process is named after its inventor, Henry Bessemer, who took out a patent on the process in 1855. The process was independently

discovered in 1851 by William Kelly. The process had also been used outside of Europe for hundreds of years, but not on an industrial scale. The key principle is removal of impurities from the iron by oxidation with air being blown through the molten iron. The oxidation also raises the temperature of the iron mass and keeps it molten.

Bessemer converter, schematic diagram is shown in fig.4.1. The process using a basic refractory lining is known as the basic Bessemer process or Gilchrist-Thomas process after the discoverer Sidney Gilchrist Thomas.

There are two types of process

1. Acidic process
2. Basic process.

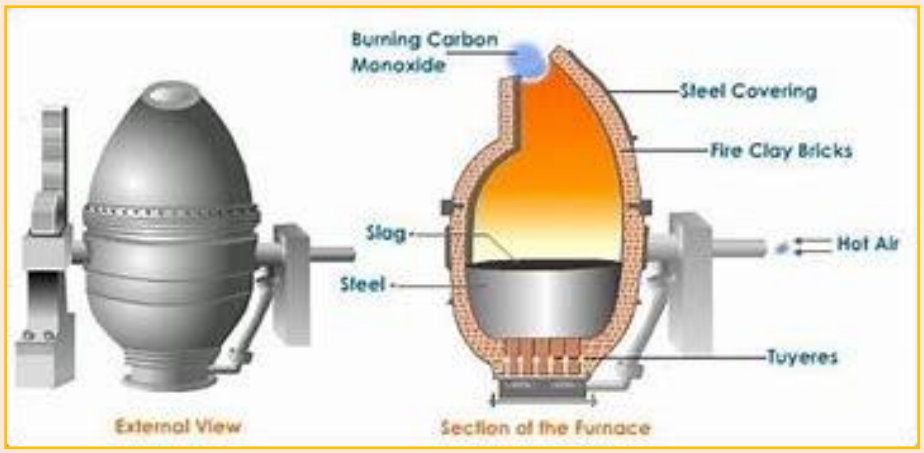


Figure: Bessemer Furnace

OPERATION STAGES

1. Slag formation or blowing period.
2. Brilliant flame blowing period
3. Reddish smoke period

1. Slag formation or blowing period:

In the first stage the converter is tilted and it is charged with molten pig iron. The air blast introduced from the tuyers. The oxygen of the blast oxidizes the iron to ferrous oxide as the ferrous oxide mixes with metal or slag.

2. Brilliant flame blowing period:

After oxidation of iron silicon and manganese when metal reaches high temp. In

this stage burning of carbon from molten bath begins. The produced steel during this stage having carbon monoxide with white flame. It takes 8 to 12 minute to eliminate carbon.

3. Reddish smoke period:

This stage begin when flame drops, it indicates that carbon has been removed from charge. This stage completes in one or two min. after converter turned to horizontal position. It produced 1200 tons of steel per day.

BESSEMER PROCEES AND MODERN STEEL MAKING

It is the mid-1800 and the United States was beginning to make its name in the steel production industry. The growth of railroads during the 19th century in both Europe and America put pressure on the iron industry to produce more, but the steel industry was still struggling with inefficient production processes. Steel still hadn't proved yet to be a structural metal and the production was both slow and costly.

This changed in 1856 when Henry Bessemer discovered a process that had an effective way to add oxygen to molten iron that reduced the carbon content. This was also the same year that Sable Steel was founded.

Now formally known as the Bessemer process, Bessemer invented a pear-shaped receptacle referred to as a 'converter' in which the iron could be heated, and oxygen could be blown through the molten metal. Bessemer converter, schematic diagram is shown in fig. When oxygen passes through the molten metal, it would react with the carbon, releasing carbon dioxide and creating a pure iron.

ADVANTAGES

The process was both inexpensive and fast; it removed carbon and silicon from iron in only a few minutes but was still strong.

Bessemer ultimately found that if he added the right quantities of manganese, it would provide a solution, so he began adding it to his conversion process with great success.

There was still only one problem; Bessemer had failed to find a way to remove phosphorus from his end product, which made the steel brittle. To improve this he came up with the solution by adding limestone to the Bessemer process.

This discovery meant that iron ore from anywhere in the world could be used to make steel. This step moves to improve the changes in technology.

Production costs decreased immediately and prices for steel rail dropped more than 80%. Then he decided to develop the modern process instead of Bessemer.

The modern steel making Bessemer process improves the production. It is a economical process it save the production cost. It produces more output in short period; it also saves the labor cost.

The Bessemer Process and Modern Steelmaking

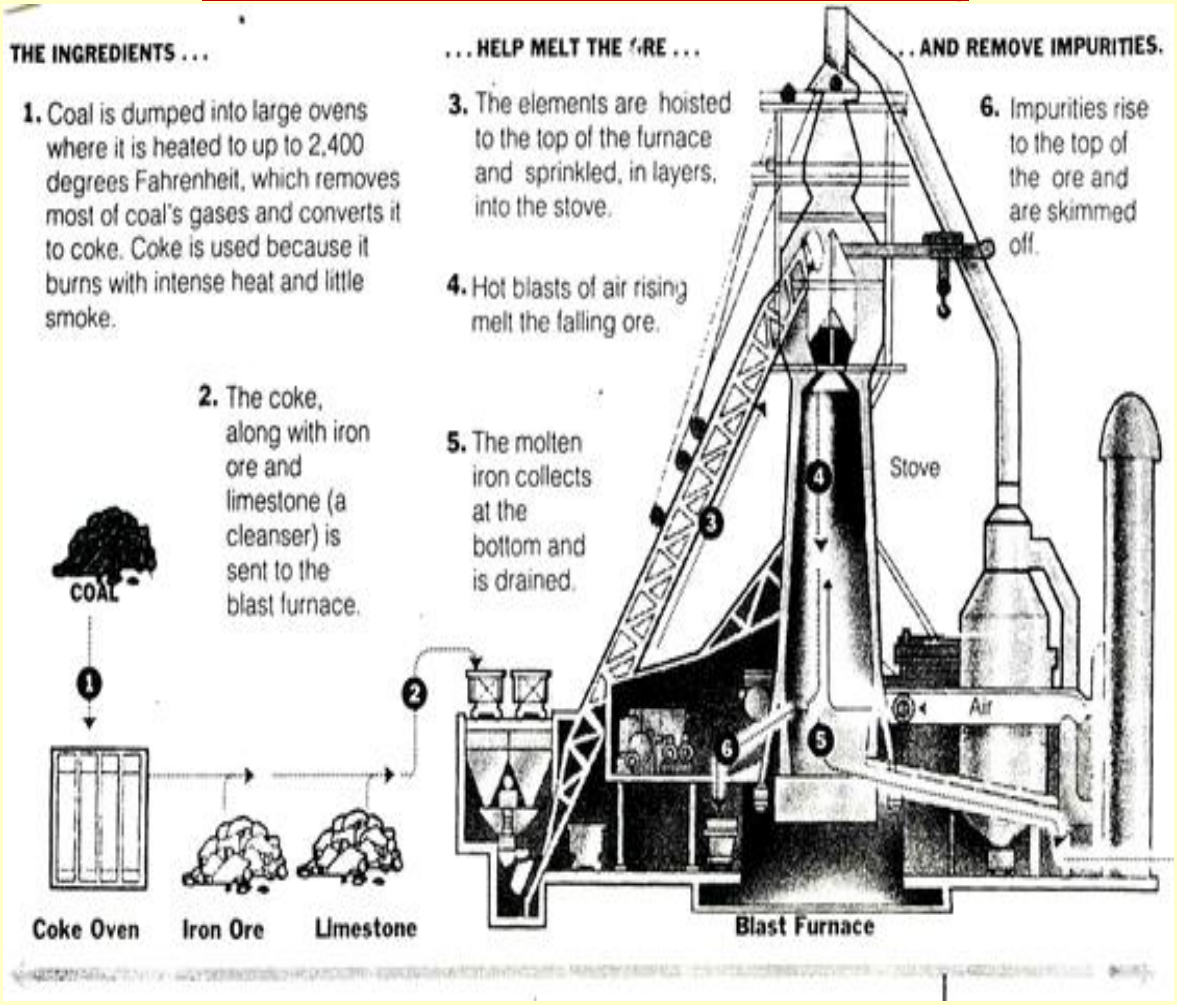


Figure: Modern Bessemer process

2. THE CRUCIBLE PROCESS:

Introduction:

In this process the mixture of wrought iron, steel scrap and ferromanganese are melted with charcoal in a tight crucible. In this process the carbon is added to the iron as wrought iron content less carbon. Necessary carbon is taken alloyed crucibles are taken from furnace known as regenerative furnace.

The schematic diagram is shown in fig, which is heated by gaseous fuel as in the open furnace and finally steel poured ingots of mould the time taken to this process is four hours.

ADVANTAGES:

1. Uniform heating - the technology provides for uniform heating to prevent hotspots at the crucible.
2. Long service life -uniform heating with no hotspots: the crucibles are considerably more durable than they are in conventional furnaces.
3. Low energy consumption - profit from energy savings of up to 20 % in comparison with standard crucible furnaces.
4. High flexibility - The burner is continuously adjustable at uniform emission values.
5. Die-Casting, Structural Components, Sand and Gravity Casting.
6. It has give good consumption
7. It is cheaper in cost
8. Operating is easy because it is a not complex structured

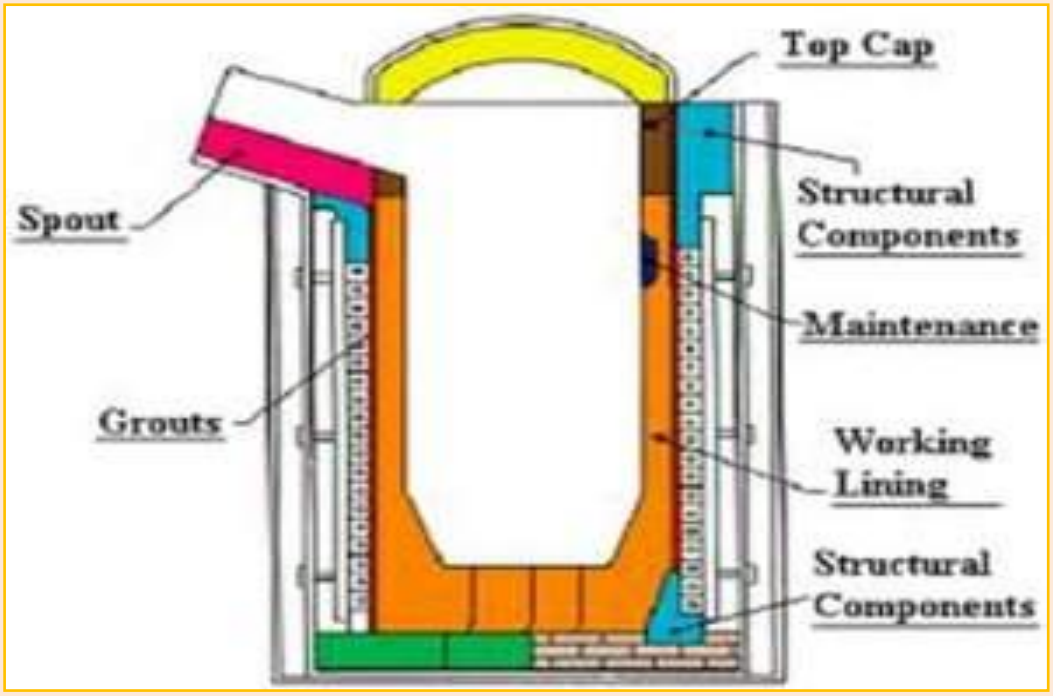


Figure: Crucible furnace

3. THE OPEN HEARTH FURNANCE:

Working Principle:

1. The open hearth furnace is used for producing steel.
2. The pig iron, steel scrap and iron oxide in the form of iron ore melted in open hearth furnace.
3. The hearth is surrounded by roof and walls of refractory bricks. The charge is fed through a charging door.
4. The charging is heated to about 1600 to 1650 C. The quantity of steel scrap is previously charge and heated and partly purified molten iron known as blown metal.
5. Natural gas or atomized heavy oils are used as fuel; both air and fuel are heated before combustion.
6. The furnace is charged with liquid blast-furnace iron and steel scrap together with iron ore, limestone, dolomite, and fluxes.
7. The furnace itself is made of highly refractory materials such as magnetite bricks for the hearths and roofs.
8. Capacities of open-hearth furnaces are as high as 600 tons, and they are usually installed in groups.

9. So that the massive auxiliary equipment needed to charge the furnaces and handle the liquid steel can be efficiently employed.
10. Though the open-hearth process has been almost completely replaced in most industrialized countries by the basic oxygen process.
11. The electric arc furnace, it nevertheless accounts for about one-sixth of all steel produced worldwide.

OPERATION STAGES

1. Blowing molten pig iron in the Bessemer
2. Further purification of the blown metal in the open hearth furnace.

The open hearth furnace is used for producing steel. The pig iron, steel scrap and iron oxide in the form of iron ore melted in open hearth furnace. It has Hearth portion for melting the steel metal. In this stage the molten metal is formed by the combustion procedure which is ignited by the help of fuel and slag is formed by the flux. The hearth is surrounded by roof and walls of refractory bricks.

The open hearth furnace schematic diagram is shown in fig.4.4. The feed charges are heated at the temperature of 1600 to 1650C.

The charge is fed through a charging door. The charging is heated to about 1600 to 1650 C. The quantity of steel scrap is previously charge and heated and partly purified molten iron known as blown metal.

The process of making steel in this way known as duplex process,

Open Hearth Furnace Application:

1. The usual size of furnaces is 50 to 100 tons, but for some special processes they may have a capacity of 250 or even 500 tons.
2. Many nations including U.S. have stopped using open hearth.
3. Nearly half of the steel produced using open hearth furnaces remains Ukraine.

ADVANTAGES:

1. This process is economical because by using regenerative firing heat is produced with less fuel consumption.
2. Unlike conventional furnace, here temperature of the furnace can be

increased up to 1800°C and nearly 600 tons of steel can be produced.

3. It is less fuel consumption it uses regenerative fuels
4. It is an improved process after the basic process of Bessemer.

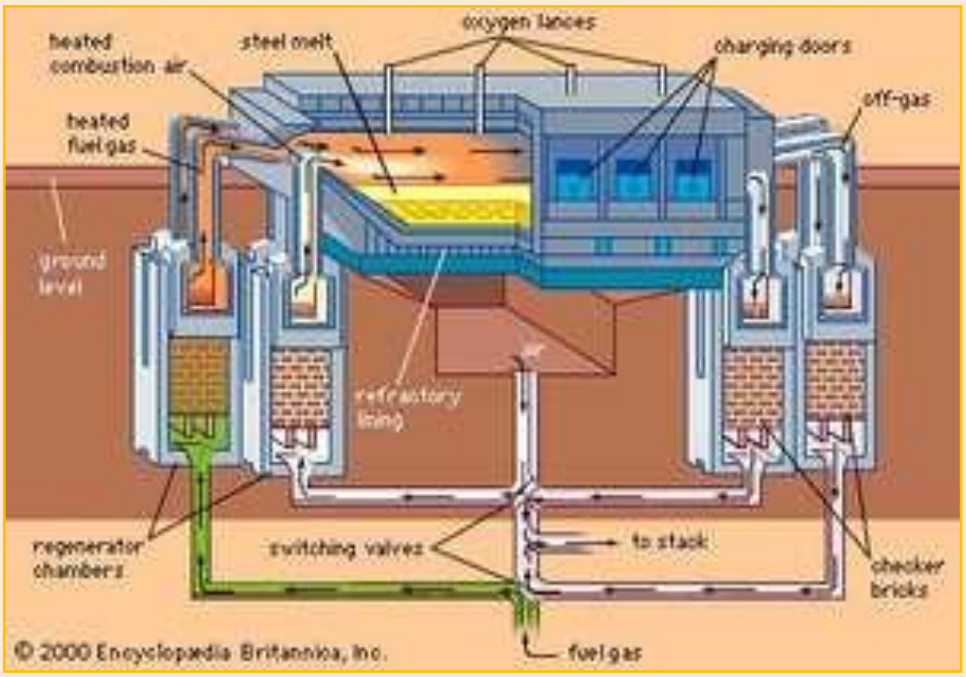


Figure: Open Hearth Furnace

4. MODERN STEEL MAKING PROCESS:

Introduction:

In the modern era, there are two major processes for making steel.

1. Oxygen steel making 2.Electric arc furnace

1. The first is basic oxygen steelmaking, which uses liquid pig iron from the blast furnace and scrap steel for the main feed materials. Alternatively, iron ore is reduced or smelted with coke and limestone in the blast furnace, producing molten iron that is either cast into pig iron or carried to the next stage as molten iron. In the second stage, impurities such as sulfur, phosphorus, and excess carbon are removed, and the alloying elements such as manganese, nickel, chromium, and vanadium are added to produce the steel required. The vast majority of steel in the world is produced using the basic oxygen furnace. In 2011, approximately 70% of the world's steel was produced in this way.

2. The second major modern process is electric arc furnace (EAF) steelmaking, which either uses scrap steel or direct reduced iron (DRI) as the main feed material.
3. Oxygen steelmaking is fuelled predominantly by the exothermic nature of the reactions inside the vessel, whereas in EAF steelmaking, electrical energy is used to melt the solid scrap and/or DRI materials.
4. In recent times, EAF steelmaking technology has moved closer to Oxygen steelmaking as more chemical energy is introduced into the process. Fundamentals of Steelmaking.
5. EAF steelmaking is predominantly used for producing steel from scrap and involves melting scrap, and combining it with iron ore.
6. Alternatively, the oxygen method can involve melting DRI using electric arcs (either AC or DC). It is common to start the melt with a "hot heel" (molten steel from a previous heat) and use gas burners to assist with the meltdown of the pile of scrap.
7. EAF furnaces typically have capacities of around 100 tons every 40 to 50 minutes.
8. Regardless of the process used, through casting, hot rolling and cold rolling, the steel mill then turns the molten steel into blooms, ingots, slabs, and sheet.
9. At the typical steel mill, the raw materials are batched into a blast furnace where the iron compounds in the ore give up excess oxygen and become liquid iron.
10. At intervals of a few hours, the accumulated liquid iron is tapped from the blast furnace and either cast into pig iron or directed to other vessels for further steelmaking operations.
11. During the casting process, various methods are used, such as the addition of aluminum so that impurities in the steel float to the surface where they can be cut off the finished bloom.
12. The oxygen steel making process is also called as L.D. process it is very economical process it requires for steel making process.

Modern Steelmaking Can Be Broken Down Into Six Steps

Step -1

1. Iron making, the first step, involves the raw inputs of iron ores coke, and lime being melted in a blast furnace. The resulting molten iron also referred to as hot metal still contains 4-4.5 percent carbon and other impurities that make it brittle.
2. Primary steelmaking has two primary methods: BOS (Basic Oxygen Furnace) and the more modern EAF (Electric Arc Furnace) methods. BOS methods add recycled scrap steel to the molten iron in a converter. The Modern steel making schematic diagram is shown in fig.5.1.
3. At high temperatures, oxygen is blown through the metal, which reduces the carbon content to between 0-1.5 percent. EAF methods, however, feed recycled steel scrap through use high-power electric arcs (temperatures up to 1650 C) to melt the metal and convert it into high-quality steel.

Step -2

1. Secondary steelmaking involves treating the molten steel produced from both BOS and EAF routes to adjust the steel composition.
2. This is done by adding or removing certain elements and/or manipulating the temperature and production environment.
3. Depending on the types of steel required, the following secondary steelmaking processes can be used:

   - Stirring
   - Ladle furnace
   - Ladle injection
   - Degassing
   - CAS-OB (composition adjustment by sealed argon bubbling with oxygen blowing)

Step -3

1. Continuous casting sees the molten steel cast into a cooled mold causing a thin steel shell to solidify.
2. The shell strand is withdrawn using guided rolls and fully cooled and solidified. The strand is cut into desired lengths depending on application; slabs for flat products (plate and strip), blooms for sections (beams), billets for long products (wires) or thin strips.

Step -4

1. In primary forming, the steel that is cast is then formed into various shapes, often by hot rolling; a process that eliminates cast defects and achieves the required shape and surface quality.

Step -5

2. Hot rolled products are divided into flat products, long products, seamless tubes, and specialty products.

Step -6

3. Finally, it's time for manufacturing, fabrication, and finishing. Secondary forming techniques give the steel its final shape and properties. These techniques include:

   - Shaping (cold rolling), this is done below the metal's recrystallization point, meaning mechanical stress not heat affects change.
   - Machining (drilling)
   - Joining (welding)
   - Coating (galvanizing)
   - Heat treatment (tempering)
   - Surface treatment (carburizing)

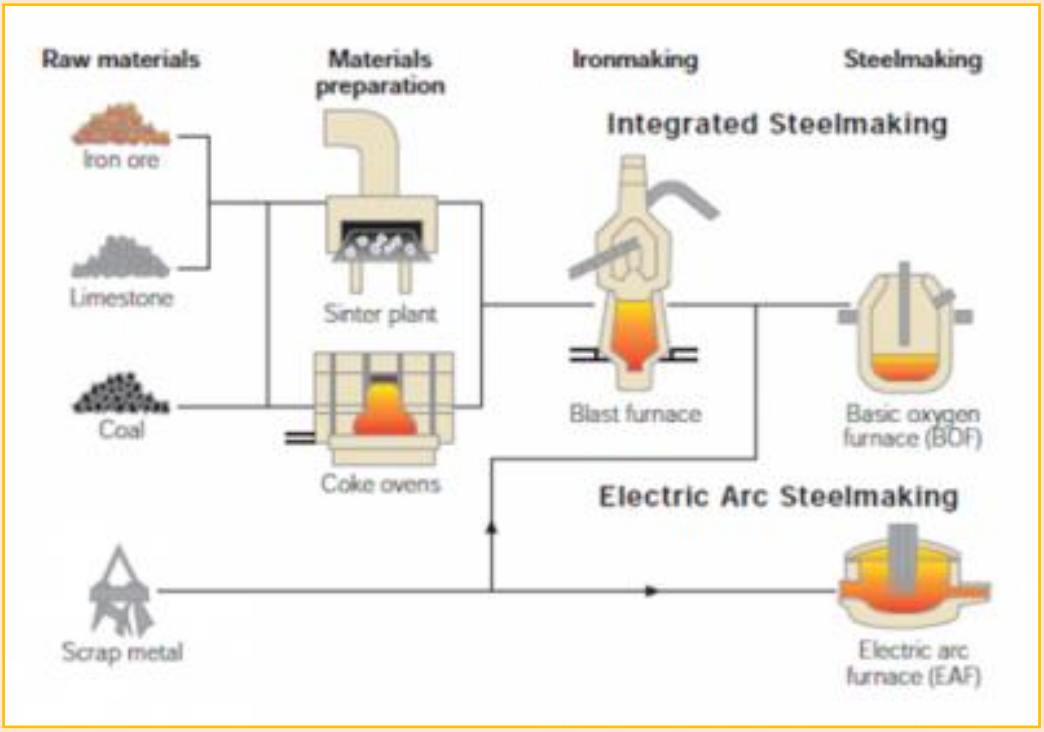


Figure: Modern steel making process

APPLICATIONS:

1. To making High speed steel, Carbon steels, Dies, Cavity etc.,
2. These process are used for manufacturing the Stainless steels
3. It used to manufacture the Alloy steels
4. Used for manufacturing the low carbon steels
5. These are widely used for increase the production rates by economical methods
6. The large production can obtained within a time.

THE VARIOUS PROCESS OF MODERN STEEL MAKING:

There are two major process commonly used for steel making.

1. L.D. Process
2. Electric arc process:-
    a. Direct arc furnace
    b. High frequency

1. L.D. PROCESS:

Working Principle:

It is a method of primary steel making in which carbon-rich molten pig iron is made into steel. Blowing oxygen through molten pig iron lowers the carbon content of the alloy and changes it into low-carbon steel.

The process is known as basic because fluxes of burnt lime or dolomite, which are chemical bases, are added to promote the removal of impurities and protect the lining of the converter.

The latest development in steel making process is the L-D process. It consists of blowing jet of almost pure oxygen and travelling at supersonic speed through water cooled lance on to the surface of molten iron held in a converter. The schematic diagram of L D process is shown in fig.5.2.

The tip of lance is within about 1200 mm from the surface of the bath. The oxygen supersonic speed increases the heat about 2500 -3000 C. It reduces

blowing period time from 18 to 20%. The capacity of furnace is 100 tones/ heat.

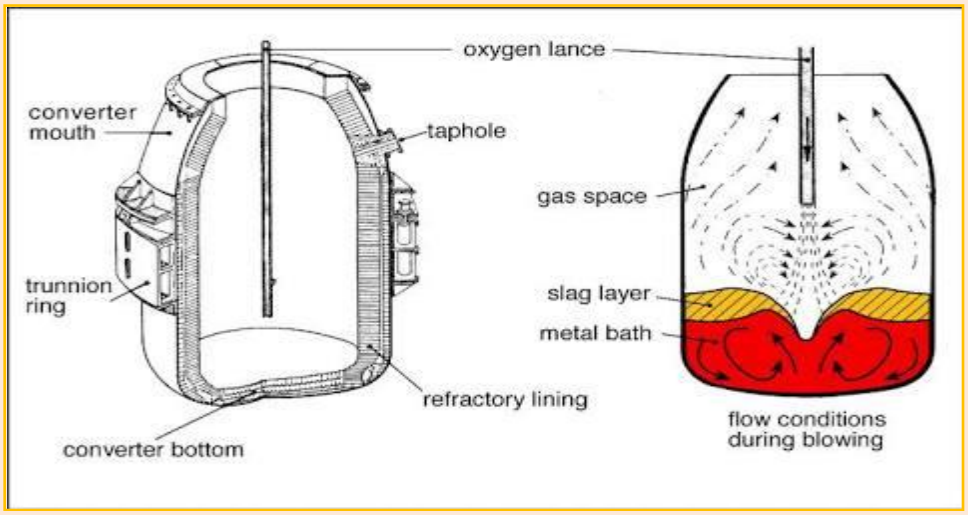


Figure: 5.2 L-D process

STAGES OF L.D PROCESS

1. Charging
2. Blowing
3. Emptying

2. ELECTRIC ARC FURNANCE:

INTRODUCTION:

In this process electricity is used for heating and melting the metal as electricity available cheaply. It permits the addition of the expensive alloying elements such as Chromium, Nickel, and Tungsten etc without loss of oxidation.

ADVANTAGES:

1. It generates high temperature about 2000 C.
2. The temperature all time may be easily controlled and regulated.
3. It permits the addition of the expensive alloying elements such as Chromium, Nickel, and Tungsten etc without loss of oxidation.

4. A great variety of steels, differing in carbon content with any content alloying elements can be manufactured.
5. It better process compare to others

DISADVANTAGES:

1. This process is more expensive than other process.
2. The output of electric furnace is very low.
3. The output production is 30 to 80 tons per day.
4. The Current is costlier

TYPES of ELECTRIC FURNACE

There are two type of electric furnaces used for steel manufacturing

1. Direct arc furnace
2. High frequency furnace

A. DIRECT ARC FURNANCE:

The Direct arc furnace consists of steel shell lined with refractory bricks and removal roof through which carbon or graphite electrodes which are 2 meter long passed. Graphite electrodes are less resistance and it is durable at high temperature. The number of electrodes corresponds to the phases.

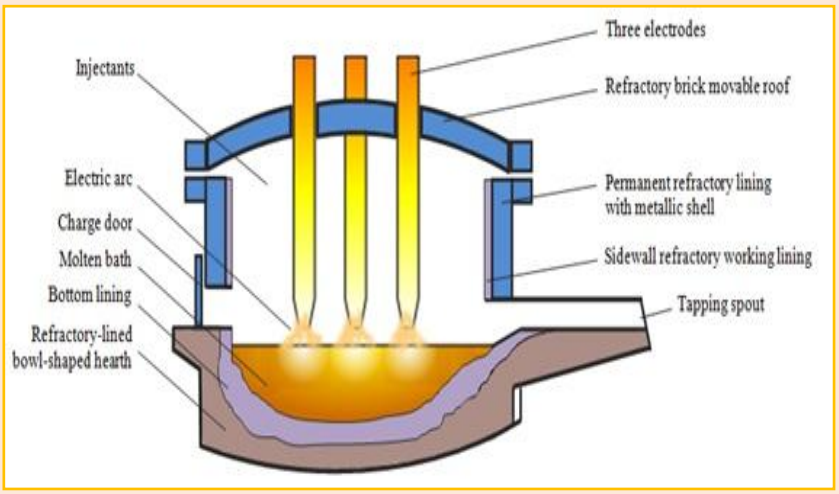
WORKING PRINCIPLE:

The electrodes are lowered into furnace and the current is switched on. The heat generated by power full spark between the electrodes and the metallic charge on the hearth melts the charge. The charge usually consists of steel scrap and iron oxide in the form of iron oxide ore.

Pig iron is not directly heated partly it is purified in an open hearth furnace and transferred to electric furnace for final treatment and alloying.

The schematic diagram of Electric furnace is shown in fig.5.3. This process is used for making the alloy steels. The production rate of this furnace high per unit.

So a definite distance maintained between the electrodes, whenever necessary a new electrodes is built up on the top of the old one. A melt is produced in 6 to 8 hours for an arc furnace 30 to 35 tones capacity. The capacity is 0.5 to 80 tones.



Advantages of modern EAF over basic EAF

1. This process is ecological and economical. It is a healthy and safety process in steel making.
2. The change in these requirements with developing of current steel production.
3. A negative effect of existing contradictory practice is the forming in prices for scrap, iron, electrical energy, and natural gas on general technological progress in steelmaking.
4. Increase in productivity is imp direction in EAF development.
5. The productivity has been increased by 6 times,
6. Electrical energy consumption has been decreased by approximately 1.8 times.
7. The following innovations are analyzed in detail: increase in power of EAF transformers up to 1.0 – 1.5 MVA/temperature.
8. It is continuous charging and melting of scrap in the liquid bath.
9. Electrical circuit specifics of modern EAFs are optimum.
10. A melt is produced in 6 to 8 hours for an arc furnace 30 to 35 tones capacity.
11. The capacity is 0.5 to 80 tones.

Applications:

1. It is used for manufacture the Steel with alloying the elements like chromium, nickel, tungsten for increase the mechanical property of steel.

2. It produce the required properties steel, which may be harden or brittle or tougher
3. This process is more applicable in steel manufacturing industries because it is a economical process.

B. HIGH FREQUENCY FURNANCE:

Working Principle:

It resembles that of a transformer. It has primary coil about which alternating magnetic field setup. When alternating current passed through the coil the eddy current produced in secondary circuit, which helps to heat up and melt the metal. The furnace contains of copper tube coil which contains water.

The schematic diagram of High frequency furnace is shown in fig.5.4.The metal to be melted and charged into crucible where it is melted down by the heavy secondary current.

The crucible is tilted on horizontal trunnions to pour the molten metal. It is operates with AC frequency 500 to 2500 Hz. This type furnace is used to produce high alloy steels and special purpose alloys. Capacity of furnace is 50 kg to 10 tones.

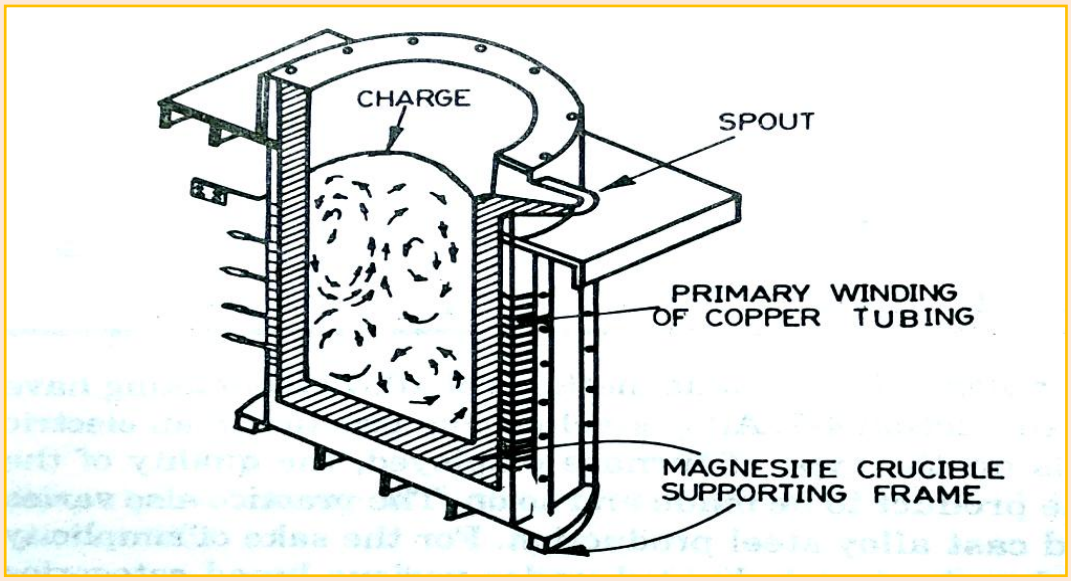


FIGURE: 5.4 High Frequency furnaces

Modern Procedure of High Frequency:

India is the first nation utilizing Induction Melting Furnaces for making mellow steel. In actuality, EAFs are not making mellow steel of basic quality for over 10 years now.

The heft of basic quality mellow steel for long items is made by Induction Melting Furnaces. Amid 2001? 2002 period more than 4.5 million tons of steel were created by Induction Furnaces.

The EAF units have likewise introduced Induction Melting Furnaces. There are a few explanations behind the fame of Induction Melting Furnaces for making steel. They expend less power contrasting EAFs. Consumption on terminal is nil.

They utilize lesser amount of stubborn. Introductory speculation is less on plant and hardware. Accordingly, there are financial points of interest in making steel through Induction Furnaces course.

The main tangle is that at present mass amount steel can't be delivered through Furnace course. May be that in future it might be conceivable to do as such.

Applications of high frequency induction furnace:

1. Low Alloy Steel:

So far none of the Induction Furnaces units have delivered these steels by Comcast prepare however some Induction Furnaces units are introducing spoon refining and Comcast gear to make Comcast billets.

At present Low composite steels are by and large frequently created by Induction Furnace Units in India.

The incorporate EN18, EN19, EN8, EN9, and so on, Compound arrangement is entirely controlled by utilizing spectrometer. Size of ingots differs 3½ x 4½ to as much.

2. Stainless Steel:

Induction Melting Furnaces before making Mild Steel ingots began creating Stainless Steel subsequent to utilizing little size Induction Furnaces.

The crude material was foreign made SS scrap and purging so as to cast ingots fluid metal in spoon, including alloying components and so on and softening mellow steel scrap and including Ferro? Allow and exchanging the fluid metal to AOD vessels for refining. After AOD treatment a few units do further refining in LRF and afterward creating billet by Comcast process.

All units having scoop refining framework have introduced spectrometer for exact and faster shower investigation. Gas levels such N2H2 and Oxygen are additionally dictated by the recently introduced instruments.

The greater part of the Induction Furnaces units are creating utensils grade Stainless steel. Two Induction Furnaces units making Stainless steel have sent out bars and wires. More butt-centric more Induction Furnace units are modernizing and also expanding to esteem included items.

3. Special Cast Iron:

The iron foundries have compound testing, sand testing and physical testing gear alongside ultrasonic testing supplies. It is learnt that these Induction Furnace units have traded unique Cast iron and special iron worth corers of rupees throughout the years.

While numerous cast iron casting foundries have introduced mains frequency Induction Furnaces to make exceptional cast presses, some have introduced medium frequency Induction furnaces to make special cast iron and special iron castings:

FILL IN THE BLANKS WITH APPROPRIATE WORDS:

1. Steel is manufactured in _____ furnace.
2. Hammers are made from _____ carbon steel
3. The structural steels are made from_____ carbon steel.
4. Steel is an alloy of _____ and _____.
5. Low carbon steel contain carbon _____ % to _____.
6. Bessemer converter is used for manufacture of _____
7. Crucible furnace is used for _____ steel manufacturing.
8. 8. Electric arc furnace is used for ---------- steel manufacturing.

MULTIPLE CHOICE QUESTIOINS

1. The mixture of wrought iron, steel scrap and ferromanganese are melted with _____in a tight crucible.
   a. Charcoal b. limestone c. coal d. None
2. The pig iron, steel scrap and iron oxide in the form of iron ore melted In _____ furnace for manufacture of steel.
   a. open hearth b. Crucible c. L D Process d. Electric arc

3. Which process consists of blowing jet of almost pure oxygen and travelling at supersonic speed through water cooled lance on to the surface of molten iron held in a converter.
   a. L-D process. b open hearth c. Crucible d. Electric arc

4. The _____ consists of steel shell lined with refractory bricks and removal roof through which carbon or graphite electrodes which are 2 meter long passed.

a. Direct arc furnace b open hearth c. Crucible d. Electric energy

5. Applications of high frequency induction furnace are

a. Low alloy steel **b**. Stainless steel **c**. Special cast iron **d**. all of above

2 MARK QUESTIONS:

1. Define steel making process?
2. Define steel
3. List out the parts of Open Hearth Furnace.
4. Define L.D steel making process

3 MARK QUESTIONS:

1. Write the applications of Open Hearth Furnace.
2. Write the properties of steel.
3. Mention the applications of Bessemer converter
4. List out the types of steel making process.

5 MARK QUESTIONS:

1. Mention the applications and properties of Low carbon steel and medium carbon steel.
2. Explain with neat sketch the manufacturing process of steel in LD process.
3. Explain with neat sketch the manufacturing of steel in Electric arc furnace.

8 MARK QUESTIONS:

1. Explain with neat sketch the manufacturing process of steel in Open Hearth furnace
2. Explain with neat sketch the manufacturing of steel in Crucible furnace.
3. Explain the classifications of steel based on carbon percentage.

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UNIT 4 – CLASSIFICATION AND STRUCTURE OF STEEL

INTRODUCTION

1. STEEL

Steel is fundamentally an alloy of iron and carbon, the carbon content varying up to 1.5% maximum. This is due to fact that carbon, if in excess of 1.5% of carbon does not combine with iron and it is present as free graphite.

The steel become harder and tougher as the carbon increases. The importance of carbon in steel varies the property of steel when it is subjected to heat treatment process.

The steel is manufactured by various process like Bessemer process, open Hearth furnace and steel is also manufactured by modern process of Oxygen L.D furnace, electric arc furnace, Corex process etc.,

Types of Steels Based on Carbon Content

1. Low Carbon Steel:

Its Carbon content is 0.05 to 0.3%.

Properties:
It has ductility property, it has more Malleability property, It has more tensile strength and Compressive strength.

Applications:
Uses for manufacturing of wires, Hinges Key, Cutting tools, Punches.

2. Medium Carbon Steel:

Its Carbon content is 0.3 to 0.6%.

Properties:
It has Toughness property, It has more Malleability property, It has

tensile strength and more Compressive strength, It has Hardness

Applications:
Uses for manufacturing of Hinges Keys, Cutting tools, Drills, Cutters.

3. High Carbon Steel:

Its Carbon content is 0.6 to 0.9%.

Properties:
It has Toughness property, It has less Ductility property, It has stiffness and Hardness property

Applications:
Uses for manufacturing of Crane Hooke's, Cutting tools, HSS Cutter, Drills, Reamers, Blades etc.,

4. Tool Steel:

Its Carbon content is 0.9 to 1.5%.

Properties:
It has Toughness property, It has more compressive strength, It has stiffness and Hardness property.

Applications:
Uses for manufacturing of Cutting tools, Jigs & Fixtures.

2. HIGH SPEED STEEL

Definition:

As the name indicates these are cutting tools used at high speed. They may contain up to 1.5% carbon and withstand to the temp temperature 600 C to 620 C. HSS is produced by steel alloying with element like Tungsten, Cobalt, Vanadium, Chromium etc.,

Properties of HSS:

1. Very hard at high temperature

2. Wear resistant
3. It has Toughness
4. High tensile strength
5. It has compression strength
6. It has Malleability property
7. It has good cutting ability

Applications of HSS

1. Cutting Tools
2. Lathe machine
3. Shaper machine parts
4. Wires
5. Drills
6. Knives & Blades etc.,

TYPES OF HSS

1. 18-4-1 HSS:

It contains 18% Tungsten, 4% Chromium, 1% Vanadium &0.75%carbon.

Application:
Used for cutting tools, Bearings, Thermal.

2. Cobalt HSS:

It is also called supper high speed steel. It increases the hot hardness property. It consists of 20% Tungsten, 4% Chromium, 2% vanadium, 12%Cobalt.

Application:
Used for permanent magnet, cutting tools, Ball bearings, Reamers Chisels,

3. Molybdenum:

It contains 6% molybdenum, 6% Tungsten, 4% Chromium, 2% Vanadium & 0.7% carbon this steel having toughness and cutting ability.

Application:
Filaments, Motor, Air craft parts etc.

4. **Stainless Steel:**

It consists of 0.4 % Carbon, 4.5 to 18% Chromium. It has Stiffness property. It has more tensile strength.

Application:

Uses for Cook wear, surgical equipments, Electrical equipments, Home appliances', Industrial etc.

3. ALLOY STEEL

Introduction:

These are the elements used for changing the properties of steel for the various field applications. The alloying elements such as nickel, chromium, manganese, vanadium, tungsten etc, are added to the carbon steels. The steels thus obtained is called alloy steel.

Purpose of Alloy Steel

1. To improve hardness
2. To increase Toughness property,
3. To improve machine ability
4. To increase wear resistant.
5. To increase strength
6. Elasticity property
7. To increase compression strength

Types of Alloy Steel and Their Uses

1. NICKEL STEEL: - IC - engine valve, Spark plug, Boiler, Rivets.
2. INVAR STEEL:- Measuring instrument, slip gauge, pendulum
3. CHROMIUM:- Ball & roller bearing, Springs, cylinder liner
4. MANGANESE:- Gear, Axel, Rails, Agriculture equipments
5. SILICON STEEL:- Springs, Transformer etc.,

CUTTING ALLOYS

These are used for tools operate at very high cutting speed and with high

temp up to 1100 c developing on cutting edges.

Types of Cutting Alloys

1. **Cemented carbides:**
   These are powdery mixture of tungsten and titanium carbides and metallic cobalt, which first compact and then sintered. It has 85 HRC hardness. It retains hardness at 1000C.

   Applications:
   Cutting tools, Carbide cutters, Reamers, Single point cutting tools,

2. **Stellites:**
   These contains large amount of metals like cobalt and tungsten, have hardness 60 to 65 HRC.

   Applications:
   Cutters, wires, Hooks, Engine parts, Punches, etc,

PURPOSES OF ALLOYING ELEMENTS

1. **Carbon:**
   It increase strength and Hardness, Decrease ductility, it decrease weld ability, and it improve the Toughness property.

2. **Nickel:**
   It Increase strength, hardness, decrease corrosion, Improve Heat resistance, Make toughness property,

3. **Chromium:**
   It Increase tensile strength, it improve elasticity property, it improve heat resistant property. Improve wear resistant property.

4. **Manganese:**
   It improve the strength property, Increase wear resistant, it increase the hardness property. Increase magnetic property.

5. **Silicon:**
   It Increase strength, Silicon decrease forge ability, Used for manufacturing chips, Improve electrical property,

6. **Molybdenum**:
   It Increase strength, It elevated temperature, Improve cutting ability, It increase Toughness property, It improve machinability.

7. **Tungsten:**
   It Increase hardness, It increase strength, It improve the Heat resistant property, It decrease the malleability, decrease ductility.

8. **Aluminum:**
   It increases ductility, it improves malleability, it decrease Toughness and hardness property, improve ductility.

9. **Copper:**
   It increases rust resistance, it improves malleability, it increases ductility, It has more tensile strength, improve corrosion resistant.

10. **Vanadium:**
    It has good strength, it has hardness property, it has good cutting ability, it has good machinability, Improve heat resistant property.

11. **Cobalt:**
    It has good Hardness property, it has good toughness property, it has more Cutting ability, it is Heat resistant steel, and it has good wear resistant property.

FILL IN THE BLANKS WITH APPROPRIATE WORDS

1. The steel is an alloy of _____ and _____.
2. The chemical symbol of tungsten is _____.
3. 18/8 steel consists of 18% _____ and 8% _____.
4. Brass is an alloy of _____ and _____.
5. LCP is also known as _____.
6. HCS steel carbon % is _____ to _____.
7. The stainless steel carbon content is _____.

MULTIPLE CHOICE QUESTIOINS

1. Mild steel belongs to the following category
   a. Low carbon steel b. high carbon steel c. medium carbon steel d. alloy steel
2. Steel differs according to the
   a. % of carbon b. % of pig iron c. % of iron d. % of cast iron
3. Brass is an alloy of
   a. Copper & Zinc b. Copper & Tin c. Copper, Tin &Zinc d. None
4. Corrosion resistance of steel is increased by adding of
   a. Chromium & Nickel b. Vanadium c. Sulphur, Phosphorous & Lead d. Aluminum
5. The chemical symbol of mercury
   a. P b. Cu c. Hg d. Al
6. Iron is an alloy of
   a. Fe & C b. Fe & S c. Fe & D d. Fe & B
7. Mention the symbol of tungsten
   a. T b. W c. G d. S

2 MARK QUESTIONS

1. What is an alloy?
2. Name the alloying elements.
3. Define stainless steel.
4. Define structure steel.

3 MARK QUESTIONS

1. What are the types of alloy steels.
2. Write the effects of carbon content on mechanical properties.
3. Explain the alloying elements and its effects.
4. Write a short note on Stainless Steel.

5 MARK QUESTIONS

1. State the properties and applications of
   i. Nickel ii. Chromium
2. Give the effects of following elements
   i. Chromium ii. Nickel iii. Tungsten
3. Write a short notes on High carbon steel and high speed steel

8 MARK QUESTIONS

1. Explain the classifications of steel.
2. Explain the types of alloy steel with their properties and applications
3. Explain the structure of steels.

Books References:

- ☞ Material science and Metallurgical engineering – O. P. Khanna
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Online Classes References:

- ☞ Steel and classifications: - http://youtu.be/SZSzhvCn1ic
- ☞ Steel classifications: - http://youtu.be/09YJLLrWbLk
- ☞ Effects of alloying elements: - http://youtu.be/RekndaQWuVI
- ☞ Steel classifications on carbon: - http://youtu.be/PmMWy6bJjQo
- ☞ Alloy Steel: - http://youtu.be/fFcSjMkYFUs

UNIT 5 – PLASTICS

ELEMENT:

An element is one which cannot be chemically changed or which cannot give some other substance even after subjected to fission by any other means.

COMPOUNDS:

A thing composed of two or more separate elements are called compound.

ATOM:

Every particle is made up of a large number of smallest particles called atoms. The atoms are made up of three fundamental particles are protons, neutrons,& electrons.

Atomic number:

The number of protons must be equal to the number of electrons is called atomic number.

Atomic weight:

The total number of protons and neutrons are called atomic weight or atomic mass.

MOLECULE:

The atoms of one element combine with atoms of other element to form molecules. Ex: 2 atoms of hydrogen with 1 atom of oxygen to form a molecule of water H_2O.

Molecular weight:

It is defined as the atomic weights of all the constituent atoms of a molecule.

Ex: $H_2O = [2x1] + [1x16] = 18amu$

VALENCY:

The combination power of atoms to join with the other atom is called valency. This is actually the number of electrons, which are either gain of loss or shared by atom to complete its outermost orbit.

COVALENT BOND:

The bond setup between two elements by the sharing of the electrons is called covalent. Depending upon the no of pairs of shared electrons, it is called single, double or triple bond.

PLASTIC:

Plastic is a varied group of organic materials having very high molecular weight derived from natural sources or resources like petroleum, coal, cellulose, salts, water, air & natural gas. These can be easily fabricated & formed under the effect of pressure or heat or both.

Plastics can be found as natural materials, semi synthetic & full-synthetic materials.

NATURAL MATERIALS:

Natural materials (plastics) consist of natural asphalts, resin & shellac.

SEMI-SYNTHETIC MATERIALS:

These are refined high molecular weight natural materials, which for the purpose of utility are processed. For example natural rubber having molecular weight 200000 can be refined &we get material of lower weight as per the requirement.

Similarly cellulose, a natural material can be refined by reducing its molecular weight from about 500000 to 50000 to make it useable.

FULL SYNTHETIC MATERIALS:

They are processed & produced from well known materials like petroleum, coal, air, water, natural gas etc. all these materials reduced to more simple materials like ethylene, acetylene, benzene, chlorine, nitrogen & oxygen. With the simple materials as the starting point we produce polymers of plastic by the process of polymerization. For example starting materials for the most & best-known plastic material ethylene are kerosene & plastic or natural gas & carbon.

POLYMERIZATION:

The fundamental process by which lower molecular compounds are converted into higher molecular weight,

1) Addition or chain polymerization
2) Condensation polymerization

1. **Addition or chain polymerization:** This kind of polymerization involves the self addition of monomer units without loss of any small molecule and there is no difference in the chemical composition of monomer and the polymer.
   Ex: polyethylene, polypropylene etc.

2. **Condensation polymerization:**
   It changes the monomers chemically as it provides the required connecting bonds between the atoms. These involves the elimination of small molecules such as water, methanol etc.
   Ex: Nylon 66, Terylene etc.

THERMOPLASTICS:

These plastics become soft when heated & hard when cooled retaining the same chemical composition. Thus plastics undergo forming again & again when thermo plastics are subjected to heat the bonds by which they are held together becomes weak & they yield, while on cooled the bonds become stronger again and the plastics regain their strength.

THERMOSETTING PLASTICS:

Plastics polymers formed by this reaction are known as thermosetting plastics. These are plastics, which undergoes a chemical change with heat & pressure & set into permanent shape. Reheating cannot soften thermosetting plastics.

DIFFERENCE BETWEEN THERMOPLASTICS AND THERMOSETTING PLASTICS

Sl No	THERMO PLASTICS	THERMOSETTING PLASTICS
01	Formed by addition polymerization.	Formed by condensation polymerization.
02	Long chain linear polymers.	Three dimensional network structure joined by strong covalent bonds.
03	Soften on heating & stiffen on cooling.	Do not soften on heating.
04	Can be remolded.	Cannot be remolded.
05	Usually soft, weak & less brittle.	Usually hard, strong & more brittle.
06	Can be reclaimed from wastes.	Cannot be reclaimed from wastes.
07	Soluble in organic solvents.	Insoluble in organic solvents.

ADVANTAGES OF PLASTICS:

1) Light weight.
2) Low cost.
3) Easy to processing.
4) Available in variety of forms.
5) Available in transparent.
6) Available in wide range of colour.
7) Capable of being performed &flexible forms.
8) Resistance to chemical.
9) Good thermal insulating properties.
10) Good strength to mass ratio.
11) Low energy required to conversion.
12) Easy assembly of molded parts.
13) Resistance to corrosion.
14) Properties of modification by bending &by adding.

DISADVANTAGES OF PLASTICS:

1) Plastic is a nonrenewable resources.
2) Plastic is soft.
3) Causes CANSER.
4) Plastics are embrittlement at low temperature.
5) Deformation under load.
6) Low heat resistance and poor ductility.
7) Plastics are combustibility.
8) Produces toxic fumes when it is burnt.
9) It is a recycle process, but it is very costly.
10) Difficult to repair.
11) Objection of odor.
12) Dimensionally unstable.

ADVANTAGES OF PLASTICSOVER THE METAL:

- Light in weight due to density/specific gravity. This results in higher fuel efficiency in automobile, & in conservation of energy.

- Higher strength to weight ratio, thus it is the most resource efficient packing material. Ex: for packing of 500grms of coffee, 12gms of plastics is required as compared to 130gms of tin.
- Design flexibility for complex molded products helps to replace metal parts.
- Freedom from corrosion & rusting.
- Easy for coloring/pigmentation. No need of repainting frequently as in metallic & wooden product.
- Inertness of many polymers to many chemicals makes them suitable for packing, storing, & transporting of chemicals.
- Food contact suitability of plastics enables extensive usage for packaging of liquids, powder & solid food products & pharmaceuticals.
- Capability of plastics to achieve superior properties (impact strength, tensile strength, heat resistance, flame retardency, etc.)By appropriate blends, alloys & compounds.
- Super modification of plastics enhances aesthetic value, for example, electroplating, hot foil stamping, vacuum metalizing, painting, printing in mould printing etc.
- Certain plastics such as PTFE, PETP, PES, PEED, offers high resistance.
- Certain plastics such as SAN, Polycarbonate acrylic, PVC, PP offer excellent transparency & clarity to replace glass. Polycarbonate also offers excellent resistance to breakage.
- Plastics can easily be recycled.
- Energy required to produce plastics is lowest as compared to glass & paper, thus saving on energy resources.

POLYETHYLENE:

It is also known as PE plastics. It is prepared by the addition polymerization of high purity ethylene. Depending upon the specific gravity, polyethylene classified as:

1. LDPE: Low density polyethylene – specific gravity 0.91 to 0.925.
2. HDPE: High density polyethylene – specific gravity 0.94 to 0.965.
3. Int. DPE: Intermediate density polyethylene – specific gravity 0.926 to 0.940.

PROPERTIES:

- Polyethylene appears in its natural form as milky white, waxy feeling material.
- Products made from polyethylene are odorless, tasteless.
- The material can be dyed in various colors.
- It is very tough at low temperature.
- It has excellent chemical resistance.
- It gives good electrical insulation properties.

APPLICATIONS:

Polyethylene finds many product applications like containers, electrical insulators, sheets, and pipes, house hold articles like cups, toys, squeeze bottles, buckets, baskets, freezer bags, eye drops, nose drops, ink fillers, tubes, laboratory apparatus, etc.

POLYPROPYLENE:

Polypropylene is produced by addition polymerization of propylene. It is also called as PP.

PROPERTIES:

- It is fairly hard, cloudy white material.
- It is lightest plastics available with its density in the range of 0.890 to 0.905.
- PP is produced as a moulding material in the form of granules.
- Excellent dimensional stability.
- Easily colored in opaque & translation products.
- Outstanding flex life as hinge.
- It is self-sterilizable.

APPLICATIONS:

PP can be widely used in house wears like washing machines, pipe parts, luggage cases, cosmetic cases, electronic parts aviation components & packaging industries. And it is used in hospital equipments because it is sterilizable, resistance to chemicals & transparent in thin section.

POLYSTYRENE:

It is clear, odorless & tasteless material whose structure is long chain linear & amorphous. It is produced by ethylene & benzene.

PROPERTIES:

- It is crystal clear, rigid & easy processed.
- Easy of moulding at different pressure & temperature.
- High degree of hardness.
- Brittle, except when modified by the addition of Butadiene, Synthetic rubber.
- Good clarity & surface smoothness.
- Easy in fabrication.
- Low cost.
- Poor outdoors weather-ability.

APPLICATIONS:

It is used for many disposable products like picnic utensils, food containers & novelties. It is also used for refrigerator parts, combs, taps, &cassettes, car kits etc.

POLY-VINYL CHLORIDE:

It is produced by acetylene and hydrogen chloride. On heating PVC, hydrochloric acid is liberated. This may corrode the material with which it comes into contact. Therefore, while moulding PVC, corrosion resistance steel should be used.

PROPERTIES:

- It is odorless and in colour it takes white to light yellow.
- Good strength, excellent water & chemical resistance & ultimate colour possibilities.
- PVC exhibits self-extinguishing properties.
- Good weather & electrical resistance.
- Hard PVC is non elastic.
- It is chemically inert to acids, detergents, greases, & oils and therefore, useful for making chemical containers.

APPLICATIONS:

PVC is widely used in applications like automobiles, seat covers, shower, curtains, cloth or paper coated sheets, rain coats, wire coating, chemical storage tanks, etc.

POLYTETRA FLUORO ETHYLENE OR TEFLON:

It is a member of the family of fluorocarbons. It is a close relative of polyethylene, in which all the hydrogen atoms are replaced by fluorine

atoms.

PROPERTIES:

- It is opaque and white with a smooth dull surface.
- It resists attack from almost all of the chemical compounds, even as high temperature.
- The coefficient of friction is the lowest of any known solid material.
- It is extremely tough, having excellent electrical insulation properties & has a waxy feeling when touched.
- It is difficult to process due to its high melting point & poor flow characteristics.
- No solvent can dissolve Teflon or even cause it to swell.
- It is very expensive.

APPLICATIONS:

It is used as linings and plumbing for hot steam, abrasive chemicals. It is very good wire insulator. It is used in chemically resistant gaskets, piston ring for hydraulic purposes, gear rings, tube rims, & as a non-stick coating on frying pans & other cook wares.

ACRYLONITRILE BUTADIENE STYRENE:

The ABS polymer consists of three monomers of Acrylonitrile, Butadiene & Styrene.

PROPERTIES:

- ABS is rugged, tough plastic with good chemical resistance.
- It is one of the few thermoplastics, which combines both hardness & toughness.
- Withstand temperatures up to 100˚c.
- Low co-efficient of friction.
- Good wear & scratch resistance.
- Good electrical insulation properties, but flammable.
- Good colorability but poor transparency.
- Easy to fabricate, that is to drill, tap, cut etc.

APPLICATIONS:

Typical products made of ABS are vacuum formed refrigerator door liners, luggage cases, extruded pipe & pipe-fittings, telephone handsets & power tool housing, tool handles, gears radio & T. V. cabinets.

POLY AMID OR NYLON:

Nylon is a common name of polyamide. It is derived from condensation polymerization. This is a group of complicated, long chain molecule polymers. It is derived from Amino & other acids.

PROPERTIES:

- Nylon is white in colour with a white surface gloss i.e., shiny surface.
- It can be easily colored to a broad range.
- Very low co-efficient of friction.
- It has excellent toughness & flexible strength.
- Excellent water resistance.
- High abrasion resistance.
- High moisture absorption causes, however, dimensional changes.
- Fair electrical insulation properties.

APPLICATIONS:

It is used for manufacture gears, wheels, combs, nuts, bolts, bearings, hinges, drawer slides, rollers, and ship propellers. A very big quantity of Nylon is used in the textile industry.

ACRYLIC PLASTICS:

Acrylic plastics are produced from Petroleum, waste ethylene and propylene. Some of the acrylic plastics are polymethyl methacrylate [PMMA] and polyacrylate.

PROPERTIES:

- They are hard, rigid and transparent. [92% light transmission].
- They process the best weather ability of all transparent plastics. Exceptional resistance to sunlight with a loss of 1% in transmission in 5 years.
- They have good dimensional stability.
- They burn slowly releasing little or no smoke.
- They are much lighter and more elastic than glass. Therefore, articles made from acrylic do not break when they fall.
- They have very low scratch resistance.
- They are tasteless and odorless.

APPLICATION:

They are used for display equipments, lenses, radio & T.V. parts, automobile tail lamps, dash panels, & a big variety of containers.

PHENOL FORMALDEHYDE:

Phenol formaldehyde is also called as BAKELITE. Phenol formaldehyde resins more commonly known as phenolics are produced by the condensation polymerization of phenol and formaldehyde.

PROPERTIES:

- They are hard rigid and resistance materials, which are brittle.
- They can be made tough by addition of suitable fillers.
- They are cheap and excellent insulators, heat resistance up to 260˚.

APPLICATIONS:

They are used in electrical applications, cooker handles, salad bowls, croquet balls etc.

DIFFERENCE BETWEEN ORGANIC AND INORGANIC COMPOUNDS

Sl No	Organic Compounds	Inorganic Compounds
01	Exhibit covalent bonding.	Exhibit ionic bonding.
02	Have low melting and boiling points.	Have high melting and boiling points.
03	Solutions are non conductors of electricity.	Solutions are conductors of electricity.
04	They are generally insoluble in water and soluble in organic solvents like benzene, alcohol etc.	They are soluble in water insoluble in organic solvents like benzene, alcohol, etc.
05	They burn easily.	They are not burn easily.
06	They have colour and odor.	They are colorless and odorless.

INEDTIFICATION OF PLASTICS

Sl No	Material	Material Behavior	Flame colour	Smoke	Other Features	Smell	Density in kg/mm^3
01	PE	Melts and bubbles around the edges	Yellow with blue base	Almost absent	Flaming plastic drips off	Candle wax	0.926-0.940
02	PP	Becomes soft and tends to form a ball	Yellow with blue base	Almost absent	Flaming plastic drips off	Candle wax	0.85-0.92
03	PS	Melts and bubbles around the edges	Orange yellow	Heavy black and sooty	Burns readily	Cinna mon	1.04-1.08

04	ABS	Becomes soft but not fluid	Orange yellow	Heavy black and sooty	drips off	Cinnamon and Strong smell of rubber	1.04-1.08
05	PVC	Softens and chars at the bottom	Yellow with green base.	White	Burns with difficulty and self extinguishing	Acrid smell like chlorine	1.19-1.35
06	PC	Bubbles	Yellow	Smoky	Self extinguishing	-----	-----
07	Nylon	Melts and bubbles around the edges	Blue with yellow tip	None	Material drips	-----	-----

FILL IN THE BLANKS WITH APPROPRIATE WORDS

1. In plastic the _____ resins can be resoftened and remolded by heat and pressure.
2. The atoms of _____ element combine with atoms of _____ element to form molecules.
3. The total number of _____ and neutrons are called atomic weight or atomic mass.
4. Plastic is a varied group of _____ materials having very high molecular weight
5. The fundamental process by which _____molecular compounds are converted into _____ molecular weight.

MULTIPLE CHOICE QUESTIOINS

1. Which of the following are the thermosetting resins
   a. Phenol b. ABS c. PVC d. Polycarbonate

2. Which of the following are the thermo resins
   a. Nylon b. BS c. PVC d. ABS

3. These plastics become soft when heated & hard when cooled retaining the same chemical composition is known as.
   a. Thermo plastic b. thermo setting c. organic d. polymerization

4. These are plastics, which undergoes a chemical change with heat & pressure & set into permanent shape.
   A. Thermo plastic b. thermo setting c. organic d. polymerization

5. Thermo plastics are
   a. Formed by addition polymerization b. lon chain linear polymers
   b. Soften on heating & stiffen on cooling. d. all of above

2 MARK QUESTIONS

1. Define plastic
2. Define Polymerization.
3. What are Monomers?
4. Define Polymers.

3 MARK QUESTIONS

1. Explain the Polymerization.
2. Write the applications of plastic.
3. What are transparent plastics?
4. Explain Thermo setting plastic.

5 MARK QUESTIONS:

1. Write the advantages and disadvantages of plastic.
2. List out the types of thermo plastics and explain any two of them with properties and applications.
3. List out the types of thermo setting plastics and explain any two of them with properties and applications.

8 MARK QUESTIONS:

1. Write the difference between thermo and thermo setting plastic.
2. What is plastic list out the types of plastics with their properties and applications?

Books References:

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Material science and Metallurgical engineering – William Callister
Material science - V. R. Raghavan
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