UNIT - III

CAST IRONS AND STEELS

* Fe - C alloys with more than 2 % carbon are called cast irons
* Ferrous material contains iron and the one element people use more than all others is iron.
* The widespread use of ferrous alloy is accounted for by three factors.
  i) Iron containing compounds exist in abundent Quantites within the earth crust
  ii) Metallic iron and alloys may be produced using relatively economical extraction, refining, alloying and fabrication technics.
  iii) Ferrous Material are extremely versatile in that they may be tailored to have a wide range of Mechanical and physical properties.
* The principal disadvantage of many ferrous alloys is their suscepitibility to corrosion.
* Iron alloys with less carbon content are called as "steel"

* Iron (Fe):-
  1) Chemical compound with symbol Fe, 26
  2) It is a metal in the first transition series
  3) It is the 4th most common element in

in the earth crust

4) M.P: 1538°C   B.P: 2862°C

Basics

* Carbon (C) and Silicon (Si) are the main alloying elements with the amount ranging from 2.1 - 4% weight percentage by carbon and 1-3% weight% by silicon respectively.
* The melting point temperature closely from 1150°C to 1200°C

Classification

- Metals / Alloys
  - Ferrous
    - Steels
      - Low alloy
        - Low carbon
          - plain
          - High strength
        - Medium carbon
          - plain
          - Heat treatable
        - High carbon
          - plain
          - Tool
      - High alloy
        - Tool
        - Stainless
    - Cast Irons
      - Gray Iron
      - Ductile Iron
      - White Iron
      - Malleable Iron
  - Non-Ferrous

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PIG IRON

* Pig iron is the intermediate product of smelting iron ore with a high carbon fuel such as coke, usually with limeston as a flux, charcoal and anthracite have also been used as fuel.
* Pig iron has a very high carbon content typically 3.5 – 4.5% along with silica and other impurities.
* Pig iron produced in a blast furance is the first product in the process of converting iron ore into useful metal. the iron ore becomes pig iron when impurities are burned out in a blast furnace, although still containing some impurities, pig iron has a metal content
* Pig iron from the blast furnace has the following composition.

carbon = 3–4% | Phosphorus 0.3 – 1.7%
silicon = 1–3% | sulphur lessthan 1%
Manganese = 0.1 – 1% | Iron

* Pig iron is the raw material for all iron and steel product, from which wrought iron and steel are manufactured.

Based on chemical composition pig iron is classified into these groups.

1) Basics pig iron
2) Fondry pig iron
3) Ferro alloys.

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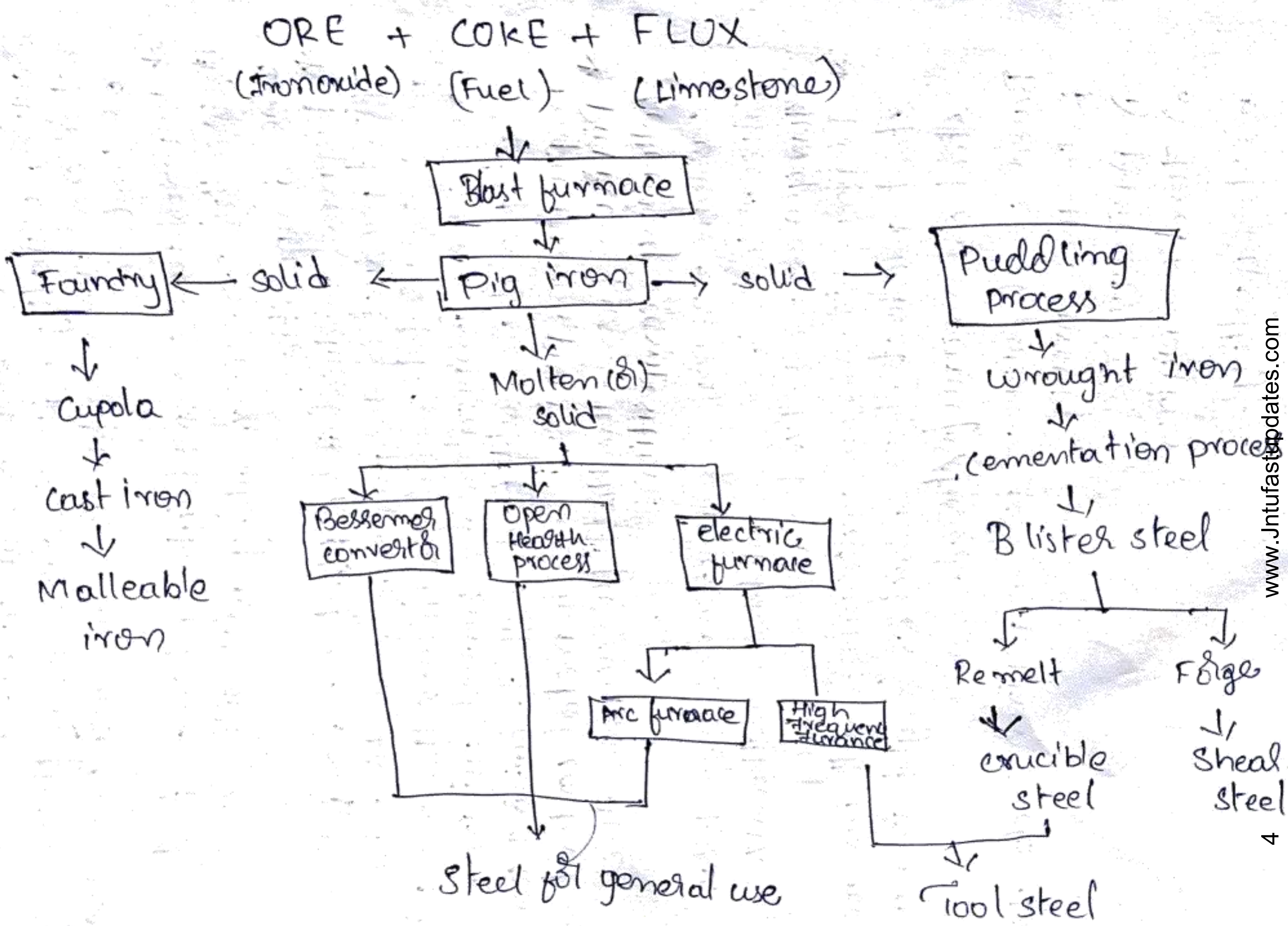
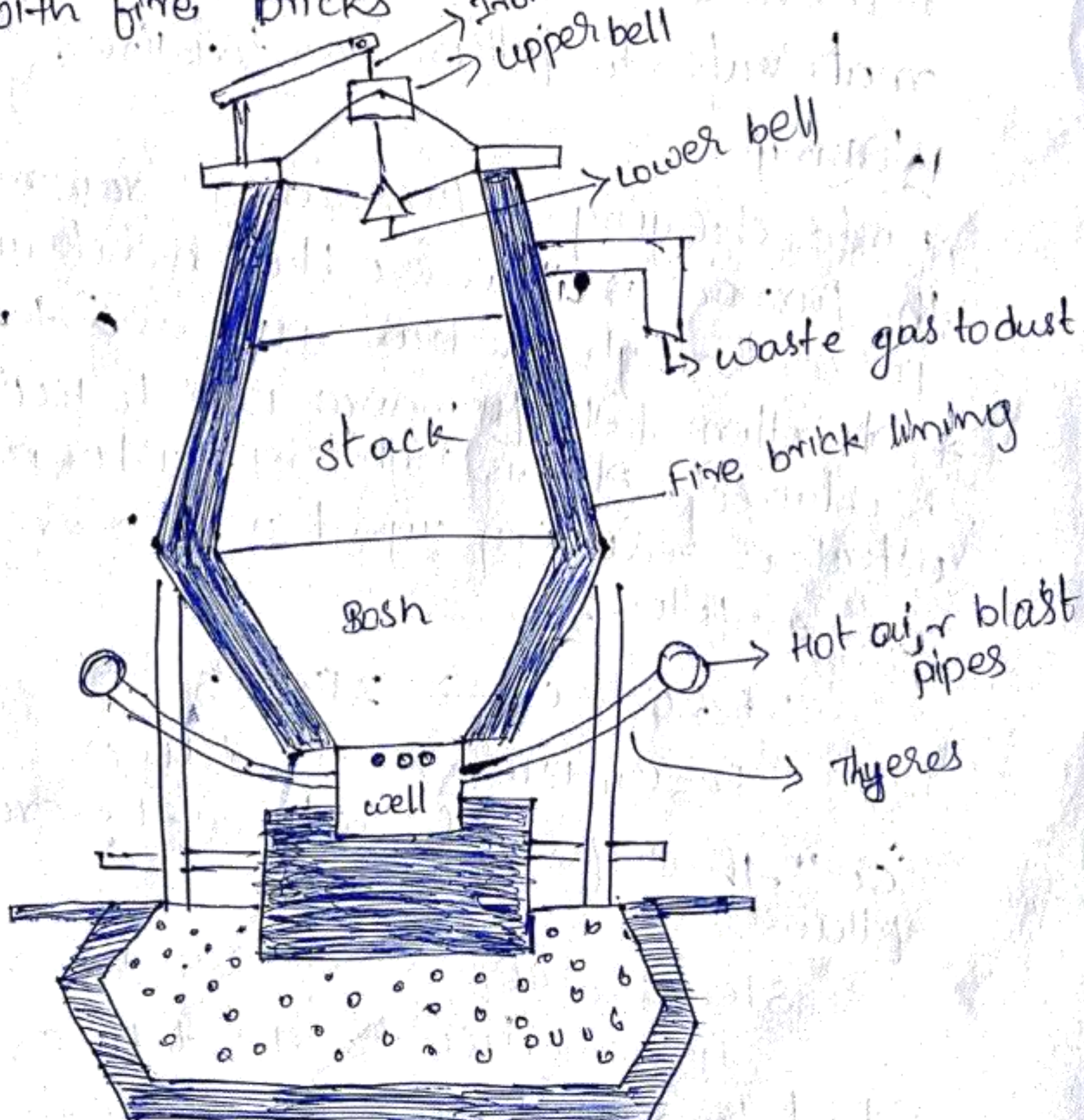

ORE + COKE + FLUX
(Ironoxide) (Fuel) (Limestone)
Blast furnace
Pig iron
solid
Foundry
Cupola
Cast iron
Malleable iron
Molten (or) solid
Bessemer converter
Open Hearth process
electric furnace
Arc furnace
High frequency furnace
Steel for general use
Tool steel
solid
Puddling process
wrought iron
cementation process
Blister steel
Remelt
crucible steel
Forge
Shear steel

Blast Furnace:

1) It is named as a very high temperature is developed inside it by means of forcing a blast of heated air.
2) It's height is about 30 mts and dia is 8 mts.
3) To permit proper flow of material it is made narrow at the top and bottom.
4) The outside of the furnace is constructed of steel plates and these are lined on the inside with fire bricks



* The widest part of the furnace is at the top of the "bosh" and its diameter depends on the out-put.
* The raw material after weighing in the desired proportions are raised to the top of the blast furnace through mechanical charging equipment
* The material are charged first on the upper bell which is then lowered allowing them to fall on the lower bell. After closing upper bell the lower bell is lowered to enable the materials to fall on the stock line.

Working

* After charging the furnace with raw materials the furnace is lit and a blast of hot air is passed through the blast pipe and tuyeres.
* At bottom of the furmance 1350° to 1600°C temp is obtained. At this high temp. carbon present acts as a reducing agent and rexn on the ore as follows

$$3Fe_2O_3 + C \longrightarrow 2Fe_2O_3 + CO$$

$$Fe_3O_4 + 4C \longrightarrow 3Fe + 4CO$$

"CO" thus formed reacts on the ore as follows

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$

$$Fe_2O_4 + 4CO \rightarrow 3Fe + 4CO_2$$

Blast furnace slag has a composition with the following ranges.

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Silica = 28 to 30% ; Alumina = 12 to 20% (14)
lime = 30 to 48% ; Iron oxide = 1 to 2%
Mn = 2 to 14% ; Sulphur = 2 to 2.5%

Effects of impurities on iron

* The impurities (such as silicon, phosphorus, sulphur and magnesium) effect the iron in the following ways.

1) Silicon
→ increases the fluidity of Metal
→ Induces the softness of iron

2) Phosphorus
→ Brittleness at ordinary temp

3) Sulphur
→ Encourage the formation of blow holes

3) Manganese
→ Increase the hardness and brittleness.

—o—

CAST IRON

* The product of blast furnace i.e pig iron is unsuitable for castings as it contains impurities in high percentage to render it suitable for desired purpose it is refined in the furnace known as "cupola", the refined product is termed as cast iron.

Cupola:-
* It is very similar to a blast furnace in principle i.e. it is a vertical shaft furnace, into which the raw material and fuel are charge at top
* Air from combustion of fuel is introduced

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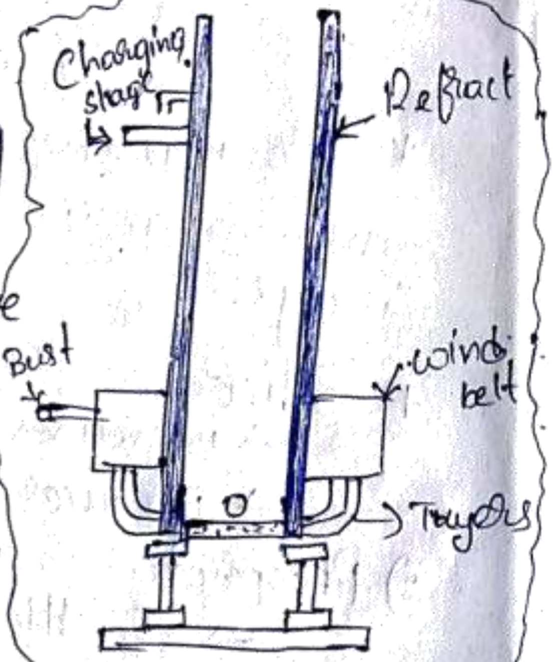
through one or more rows of thyeres a short distance above the bottom

In a cupola, the first operation is to let the fire at bottoming when the fire is burning strongly, coke is added gradually till the level above the tuyers is about 0.6 mts this coke serves as a bed for the alternative charges of metal and ~~choice~~ coke which follow when the shaft



of the cupola is filled with charging door to the blast is put on and combustion of the coke near the tuyers increases rapidly until a very intense heat is attained.

* The gases of combustion move upwards and pass on a portion of the heat to the metal and coke waiting to descend.
* In 9.5 to 10 min the first charge of metal starts melting and trickles down through the coke and finally collect at the bottom the cupola
* Since cupola is only concerned with the melting of the metal and it is not with the reduction of ores as in the blast furnace, and it is considerably smaller than a blast furnace of the same output

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* It diameter varies from 1 to 2 meters with a height of 4 to 5 times in diameter.

CLASSFICATION, COMPOSITION, PROPERTIES AND USES OF CAST IRON

Cast iron may be classfied as follows:

1) Grey cast iron
2) White cast iron
3) Mottled cast iron
4) Nodular cast iron
5) Malleable cast iron
6) Alloy cast iron

Grey cast iron

* Grey cast iron is characterised by presence of a large portion of its carbon in the form of graphite flakes
* Although grey iron is often defined as steel containing graphite its properties are far different from those of steel
* Owning to its low specific gravity, graphite occupies over three times as much space as an equal weight of metal
* From 6 to 10 percent of the volume of a typical grey iron is occupied by graphite

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* Grey iron is mostly used engineering material because of the ease with which it will be used its has excellent machinability and its good anti friction properties, vibration - damping properties and stress relieving properties.
* the strength properties of grey cast iron are improved by reducing the flake size and distributing the flakes uniformly
* Grey iron basically is an alloy of carbon and silicon with iron. It contains 2.5, 3.8% carbon ·0.1 – 2.8%. Si, 0.4 – 1% Mn, 0.15% P and 0.10% S
* When fractured a bar of grey cast iron gives gray appearance.

Applications

1) piston rings
2) Cylinder blocks and heads for I.C engines
3). Gas and water for underground purposes
4) Frames for electric motor
5) Rolling mills and general machinary parts.

WHITE CAST IRON

* The composition of white cast iron is as follows. graphite carbon 0.5% , iron 94% , combined carbon 3.5% and other impurities
* White cast iron derives its name from the fact that its freshly broken surface shows a bright white fracture.
* Unlike grey iron , white cast iron has almost all its carbon , chemically bonded with the iron - as iron oxide , Fe_3C (iron-carbide) is very hard and brittle constituent.
* Thus white cast iron possessess excellent abrassive wear resistance
* By using a fairly low silicon content cast iron may be made to solidty as white iron.
* The solidification range of white iron is 2550 - 2065 °F
* White iron is the first step in the production.

Properties

* Hard brittle
* Highly resistance to wear
* Tensile strength is good.

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* Obtained by rapid cooling of metal

Uses

1) used for parts subjected to excessive wear
   ex: rim of freight car wheel
   - Railway brake block
2) used for making malleable castings

MOTTLED CAST IRON

* The composition is iron 93.5%, graphite 1.75%, combined carbon 1.75% and remaining impurities

Properties

* It's a mixture of gray cast and white cast iron.
* Fluidity is good.
* Strength and hardness varies according to the ratio of free carbon to combined carbon
* hard and brittle
* Less tendency to rust than grey iron

Uses

→ used for man hole covers and pipes.

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NODULAR CAST IRON

* Unlike long flakes as in grey cast iron, graphite appears as rounded particles (or) nodules (or) spheroids in Nodular cast iron.
* Nodular cast iron contains 3.2 – 4.2 % carbon, 1.1 – 3.5 % Si, 0.13 – 0.8 % mn, 0.08 % P and 0.2 % S
* It posses excellent castability and wear resistance
* Ductile cast iron posseses very good Machinability
* It also called ductile cast iron and it is produced by nickel-mangesium alloy
* It behaves like steel.

Uses

1) Paper industries machinery
2) I.C. engine parts
3) Valves and fittings
4) Pumps and compressors
5) Construction machinery
6) Earth moving machinery

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MALLEABLE CAST IRON

Characterstics:-

1) Malleable cast iron is one which can be hammered and rolled to obtain different shapes.

2) Malleable cast iron is obtained from hard and brittle white iron through a controll-ed heat conversion process.

3) Malleable cast iron possess high yield strength

4) It can be used from -60 to 1200°F

5) It has solidification range 2550 - 2065°F

6) It contains 2-3% carbon, 0.6-1.3% si, 0.2 - 0.6% Mn, 0.15% P and 0.10% S

7) It is obtained by giving a long time annealing to cast iron. It is soft, tough and easily machined.

Procedure how to get malleable cast iron:-

* The white cast iron casting along with silica is packed in steel pot in heated mussle oven. The temperature is maintained at 870°C for 60 hours and casting is on cooling slowly in the furnace.

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Uses

1) Rail Road
2) Electrical line hardware
3) Gear case
4) Automotive industry
5) Crank shaft sprockets etc..

ALLOY CAST IRON

* Two examples of alloy cast iron
    1) Acicular
    2) Spheroidal

Acicular:

It has nickel and molybdenum as the leading constituent and is employed for crankshafts

Spheroidal cast iron:

It has graphite content in spheroidal form which is converted from flakes form by alloying with a small amount of mangnesium and cesium the change in graphite increases the tensile strength and produce atough metal and which can undergo bending and twisting.

STEELS

* Steel is an alloy of iron and carbon.

Classification of steel

1) Plain carbon steel
2) Mild steel
3) Medium carbon steel
4) High carbon steel
5) Alloy steel
6) Prominent alloy steel

Plain carbon steel

* A plain carbon steel is an alloy of iron and carbon and it is malleable
* carbon steels are different from cast irons as regards the percentage of carbon
* Carbon steels contain 0.10 to 0.15% carbon whereas cast iron contains 1.8 to 4.2% carbon
* Carbon steels can be classified as
  1) Low carbon steel (8) Mild steel
  2) Medium carbon steel
  3) High carbon steel

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MILD STEEL

* Mild steel (or) low carbon steels may be classified as follows

1) Dead Mild steel

* Dead mild steel is used for making steel wire, sheets, rivets, screw, pipe and chain
* It has a tensile strength of 790 N/mm² and a hardness of about 115 BHN
* Mild steel containing 0.15 to 0.20% carbon.

2) Medium carbon steels

* Medium carbon steel containing carbon from 0.30 to 0.70%.
* It is used for key stock, connecting rods, Axels, Gear shafts, wires and rods.

3) High carbon steels

* High carbon steels contain carbon 0.7 to 1.5%.
* pneumatic drill bits, wrenches, jaws for vices, wire for structural work.
* Steel containing 0.8 to 0.9% carbon have a tensile strength of about 660 N/m² these steels are used for Rock drills, Railway rails, machines chisels etc..

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ALLOYS STEELS

* Steel is considered to be alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits:

Mn 1.65%, Si 0.6%, Cu 0.06% (or) in which a definite range of a definite maximum quantity of any of the following elements is specified (or) required within the recognized field of constructional alloy steel Al, B, Cr, upto 3.99%. Co, Mo, Ni, Ti W, V (or) any other alloying element added to obtain a desired alloying element ~~added to a~~ effect

* The composition of alloy steel is

C: 0.2 - 0.4%. Mn: 0.5 - 1.0%.
Si: 0.3 - 0.6%. Ni: 0.4 - 0.7%
Cr: 0.4 - 0.6%. Mo: 0.15 - 0.3%.
Fe: Balance

Advantages and Disadvantages of alloy steel

Advantages	Disadvantages
1) Greater hardenability	1) cost
2) Less distortion and cracking	2) special handling
3) Less grain growth	3) Brittleness
4) Higher elastic ratio	4) Tendency towards austenite retention
5) Greater ductility at high strength	

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Purpose of alloying

1) Strengthing of the Ferrite
2) Improved corrosion resistance
3) Better hardenability
4) Grain size control
5) Greater strength
6) Improved Machinability
7) Improved ductility
8) Improved Toughness.

Effect of alloying elements

Carbon:

Carbon content in steel affects

1) Hardness
2) Tensile strength
3) Machinability
4) Melting point.

Nickel:

→ increases toughness and resistance to impact
→ Does not unite with carbon
→ Strengthen steels

Silicon:

→ improves oxidation resistance
→ Strenthens low alloy steels
→ Act as a deoxidiser

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HADFIELD'S MANGANESE STEEL

It is an austenitic steel possessing excellent strength and toughness with high wear resistance under impact loads as experienced in material handling and earth moving machinary such as crushers, caterpillars showels, bulldozers, jaw crashers, plate coal grinding mills etc.

→ Hadfield Manganese steel contains
carbon 1·2 – 1·4 %, rest of the iron
Manganese 12 – 14 %.

→ Hadfield manganese steel is austenitized (i,e micro structure changed to austenite) by heating it to 1050° - 100°C, kept at that temperature for sufficient time and then quenched in water.

→ Before using this steel it is plastically deformed on its surface by hammering thus, a layer of austenite.

- **first stage graphitization:** cementite decomposes to the stable austenite and graphite phases
- **second stage graphitization:** slow cooling through eutectoid temperature to make *ferritic malleable iron*
- *when austenite is cooled in air or oil Pearlitic malleable iron is obtained (*pearlite or martensite.*)*

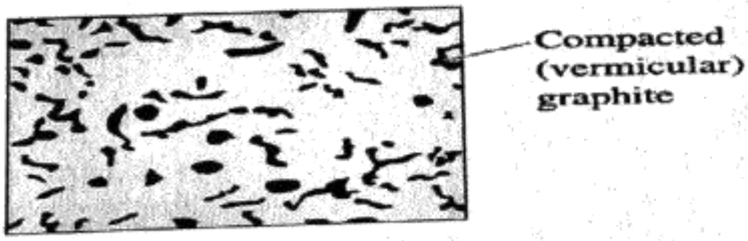
Drawing: is a heat treatment that tempers the martensite or spheroidizes the pearlite

Application

Connecting rods, transmission gears, and differential cases for the automotive industry, and also flanges, pipe fittings, and valve parts for railroad, marine, and other heavy-duty services

parts of power train of vehicles, bearing caps, steering gear housings, agricultural equipment, railroad equipment

- **Compacted graphite cast iron:**
- contains rounded but interconnected graphite also produced during solidification
- intermediate between flakes and spheres with numerous rounded rods of graphite that are interconnected to the nucleus of the eutectic cell.



- **vermicular graphite:**
- forms when ductile iron fades
- permits strengths and ductilities that exceed those of gray cast iron, but allows the iron to retain good thermal conductivity and vibration damping properties.
- **Ductile or nodular cast iron**

CAST IRON

Iron-carbon alloys with more than 2.11% carbon are called cast iron.

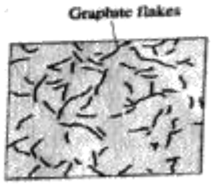
It pass through the eutectic reaction during solidification.

- Properties
  - Inexpensive
  - Have good fluidity
  - Have low liquidus temperature
  - Readily castable

Types of Cast Iron

- Depending on chemical composition, cooling rate, types and amount of inoculants that are used we can have
  a. Gray iron
  b. White iron
  c. Malleable iron
  d. Ductile iron
  e. Compacted graphite iron

- **Gray cast iron**



(a)

a. The least expensive and most common type

b. Characterized by formation of graphite

c. Typical composition ranges from 2.5-4.0% C, 1.0-3.0% Si, and 0.4-1.0% Mn.

d. contains small, interconnected graphite flakes that cause low strength and ductility.

e. It is the most widely used cast iron

f. It is named for the dull gray color of the fractured surface.

g. The gray irons are specified by a class number of 20 to 80.

- Properties

  a. high compressive strength,

  b. good machinability,

  c. good resistance to sliding wear,

  d. good resistance to thermal fatigue,

  e. good thermal conductivity, and

  f. good vibration damping.

- **Application;**

  a. Damping vibrational energy

     - Base structures for machines and heavy equipment

  b. High resistance to wear.

  c. High fluidity at casting temperature

     - Intricate shapes; Low casting shrinkage allowance.

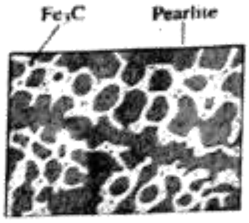
       - (strength is not a primary consideration)

       - Tensile strength 120 – 300 MPa

     - Small cylinder blocks, cylinder heads, pistons, liners, clutch plates, transmission cases.

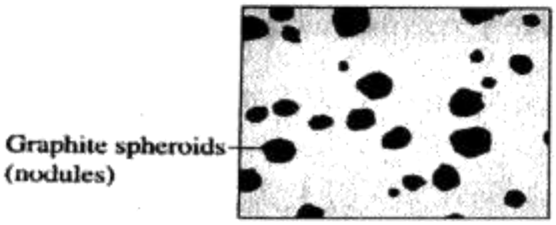
     - gears, flywheels, water pipes, engine cylinders, brake discs, Machinery beds

- **White cast iron**



(b)

a. is a hard, brittle alloy containing massive amounts of Fe_3C.



(d)

- contains spheroidal graphite particles.
- produced by treating liquid iron with a carbon equivalent of near 4.3% with magnesium

- Steps
  - **Desulfurization**: CaO is used to remove sulfure and oxygen from the liquid.
  - **Nodulizing:** Mg in dilute form (MgFeSi alloy) is added, a residual of 0.03%Mg must be present after treatment in order for spheroidal graphite to grow
- **inoculation:** heterogeneous nucleation of the graphite is essential
- **Fading:** occurs by the gradual, nonviolent loss of Mg due to vaporization and/or reaction with oxygen
- **Application:**
  - **valves, pump bodies, crankshafts, high-strength gears (heavy duty gears) and machine, rollers, slides, die material having high strength and high ductility.**

b. A fractured surface of this material appears white, hence the name.

c. Features promoting formation of cementite over graphite –

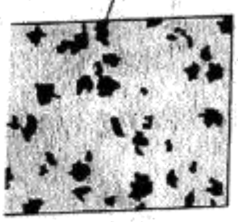
- A low carbon equivalent (1.8-3.6 %C, 0.5-1.9%Si, 0.25-0.8%Mn) and
- Rapid cooling

- A group of highly alloyed white irons are used for their hardness and resistance to abrasive wear.
- **Application:**

a. brake shoes, shot blasting nozzles, mill liners, crushers, pump impellers and other abrasion resistant parts.

b. wear-resistant surface, example, as rollers in rolling mills. Generally, white iron is used as an intermediary in the production of yet another cast iron, **malleable iron**

- White fracture surface
- No graphite, because carbon forms Fe_3C or more complex carbides
- Abrasion resistant
- Often alloyed
- **Malleable cast iron**



- (c)

a. formed by the heat treatment (in range of 900°C) of unalloyed 3%C white cast iron (carbon equivalent 2.5%C, 1.5%Si)

b. the cementite dissociates into its component elements (graphite clumps, or nodules)

c. It exhibits better ductility than gray or white cast irons. It is also very machinable.

- The production steps

(5)

(d)

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Types of Cast Iron

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  b. White iron
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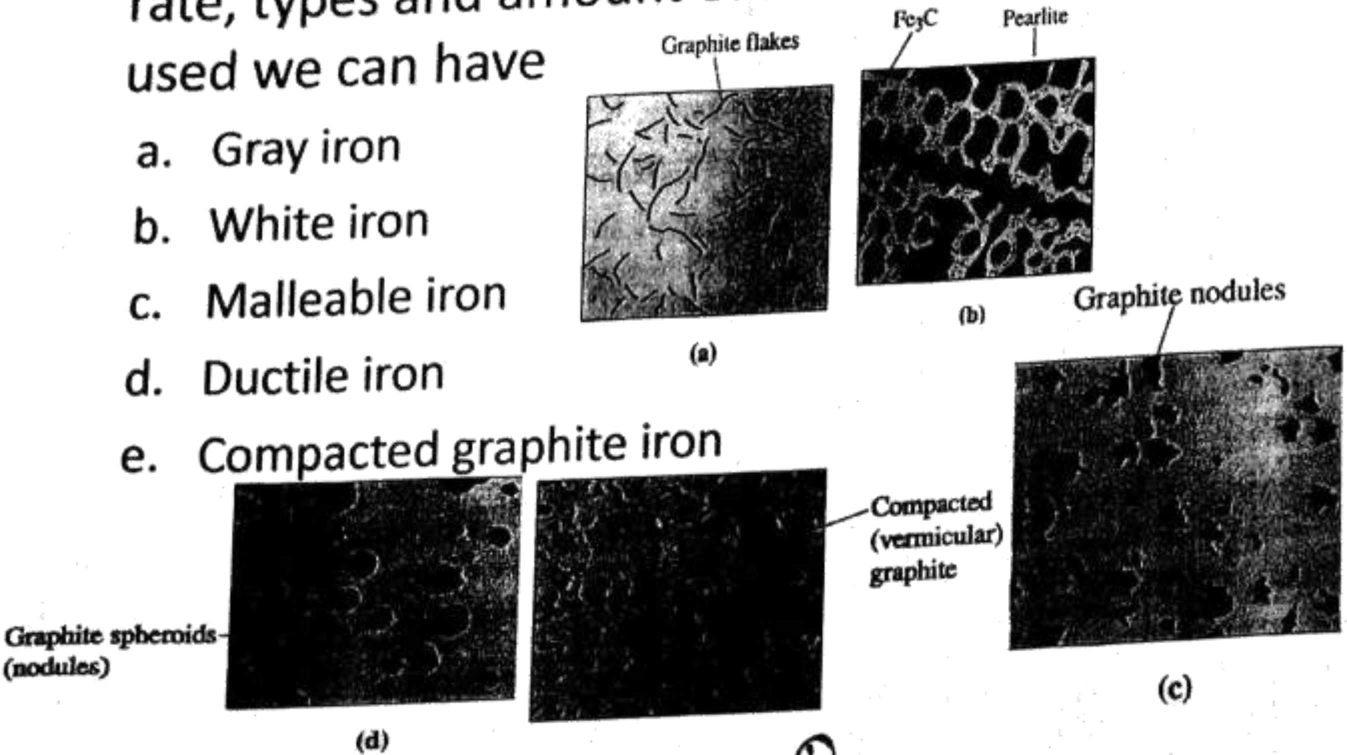
  e. Compacted graphite iron



- **Gray cast iron**
  - The least expensive and most common type
  - Characterized by formation of graphite
  - Typical composition ranges from 2.5-4.0% C, 1.0-3.0% Si, and 0.4-1.0% Mn.
  - contains small, interconnected graphite flakes that cause low strength and ductility.
  - It is the most widely used cast iron
  - It is named for the dull gray color of the fractured surface.
  - The gray irons are specified by a class number of 20 to 80.
- Properties
  - high compressive strength,
  - good machinability,
  - good resistance to sliding wear,
  - good resistance to thermal fatigue,
  - good thermal conductivity, and
  - good vibration damping.

Gray CI

- **Application;**
  - Damping vibrational energy
    - Base structures for machines and heavy equipment
  - High resistance to wear.
  - High fluidity at casting temperature
    - Intricate shapes; Low casting shrinkage allowance.
      - (strength is not a primary consideration)
      - Tensile strength 120 – 300 MPa
    - Small cylinder blocks, cylinder heads, pistons, liners, clutch plates, transmission cases.
    - gears, flywheels, water pipes, engine cylinders, brake discs, Machinery beds

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UNIT - 5

Non Ferrous Metals and alloys

Copper (Cu)

→ Copper is a chemical element with symbol "Cu"

→ It's atomic number is 29

→ It is a soft malleable, and ductile metal with very high thermal and electrical conductivity.

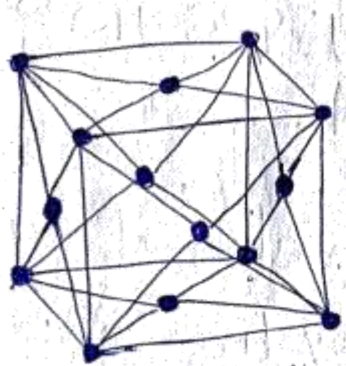
→ It has a melting point 1085°C

Alloys of copper

1) Bronze
2) Brass

Structure of copper

→ Copper has Face centered cubic structure. (FCC)



FCC structure

→ copper and its alloy have a range of yellow / red / gold colour and when polished develop a bright metallic lustre.

→ A freshly exposed surface of a pure copper has

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reddish - orange colour.

Properties of copper

→ copper has good ductility and malleability because of its FCC structure.

→ It has good electrical and thermal conductivity

→ It is non magnetic and has pleasing reddish colour.

→ It has an ability of getting alloyed with many other metals which helps in improving its properties.

→ It has ~~an~~ fairly good corrosion resistance to general atmospheric conditions.

→ It has melting point of 1085°C and boiling point of 2562°C

→ It has density 8.96 g/cm3

1) Bronze

→ Bronze is an alloy of copper

→ copper with 12% tin gives bronze.

Bronze is classified into different types

1) Aluminium bronze
2) Tin bronze.
3) Phosphor. bronze.
4) Beryllium Bronze.
5) Manganese bronze.

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1) Aluminium Bronzes

fig: Aluminium bronze structure

→ Aluminium bronzes are the alloys of copper and aluminium.
→ Here aluminium is the alloy element in the copper base.
→ The maximum solubility of Al in Cu is 9.4%.
→ Eutectoid transformation occurs at 11.8% Al.
→ Certain properties of bronze can be improved by adding elements like Fe, Ni, Mn and Si.
→ In general aluminium bronze has 4–11% aluminium.

Properties

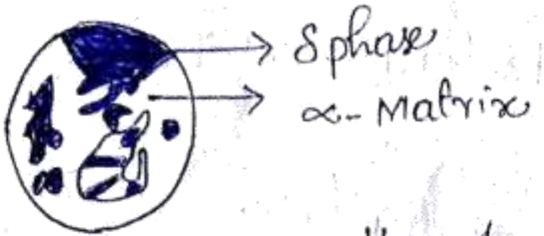
1. Good strength
2. Good heat resistance
3. High corrosion resistance
4. Good cold working properties etc..

Applications

used in making of bearing, gears, slide valves, pump parts, cams, valves seats etc..

Tin bronze

structure



→ Tin bronze is the alloy of copper and tin.
→ Solubility of tin in copper is 13.5 % at 798 °C and 15.8 % at 586 °C remains constant at 520 °C and 11 % at 350 °C and 1 % at room temperature.
→ There are different bronzes based on the tin content
They are
i) Alloys upto 8 % tin
ii) Alloys ~~upto~~ between 8-12 % tin
iii) Alloys between 12-20 % tin
iv) Alloys between 20-25 % tin

Properties
1. Good affinity toward oxygen.
2. Oxide layer on solidfied metal reduces ductility, so they are mechanically weak and porous.
3. single phase α solid solution has good ductility and malleability.

Applications
1. used to form sheets & wires & coins
2. used for bearings, pumpes, heavy load bearings gears, marine fittings.
3. Alloys with (20-25 % tin) are used for making bells hence called bell metal.

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Phasphour Bronze

These ~~are~~ is the alloy of copper and tin containing phosphorus. (3)

phosphorous bronze is devided into two types

1) Wrought Phosphorous Bronze.

→ It has 2.5 to 8% tin and 0.1 to 0.35% phosphorous

→ These are single phase α solid solutions.

2) cast phosphorous Bronze

→ It contains 5-13% tin and 0.3-1% phosphorous

→ As ph increases the fluidity of metal increases and hence general sound~~ing~~ness of casting.

→ The formation Cu_3P compound makes casting more brittle and makes it unsuitable. Therefore the ph content should not exceed 1%.

Properties

1. It has high strength and toughnes

2. It is resistance to corrosion.

3. It has low friction co-efficient

4. It has good load bearing capacity.

Application

1. used in making gears, bellows, clutch discs, pump parts, lining, springs, diaphragms etc.

2. used in bearing which is used as a self lubricant.

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4) Beryllium Bronzes

-> These are produced by in cast and wrought forms.

-> As temp ↑ solubility of beryllium ↓.

-> Alloy is heated at around 800°C and quenched in water and then heated at 300-320°C for 2 hours. This is called precipitation & aging treatment.

Structure of beryllium Bronze.

-> It has nominal 1.92 % beryllium and 0.20-0.30% cobalt.

Properties

1. Good corrosion resistance
2. Good fatigue resistance
3. Has low elastic hysteresis and non-sparking characteristics.
4. High resilience.
5. Good bearing properties.
6. 2% beryllium content alloy have 130-140 kg/mm² tensile strength and 350 BHN hardness.

Applications

1. Used for gears, bearings, flexible bellows, diaphragms, springs and some tools.
2. Used as moulds for forming plastics
3. Used in electrical contacts

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5) Manganese bronze

→ Manganese bronze contains a composition of copper, zinc, lead and small amounts of manganese.

Properties

→ Manganese bronze is stronger and harder.

→ It has excellent corrosion resistance.

Applications

→ It is used in manufacturing of bushes, rods, feed pumps, plungers, worm gears etc.

2) Brass

→ It also alloy of copper.

→ copper with zinc makes out brass.

Brass is classified into two types

1) α - brasses (cold working)

2) (α + β) brasses (hot working)

1) α - brasses

→ They are soft, ductile, malleable and have fairly good corrosion resistance in annealed condition. All the α - brasses are suitable for cold rolling, wire drawing, press work, and such other operations.

Some important α - brasses are as follows

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i) Cap copper

→ It contains zinc between 2 to 5%. Zinc is used as a deoxidiser for the deoxidation of copper.

Applications

→ It is used for caps for detonators in ammunition factories.

Properties

→ It is very ductile

ii) Gilding metals

→ They contain zinc 5 to 15%.

→ They have different shades of colours from reddish to yellowish according to zinc content.

Applications

→ They are used for bullet envelopes, drawn container, condenser tubes, coins, needles, emblems, dress jewelry because of colour like gold.

iii) Cartridge brass

Structure of cartridge brass

→ It contains about 30% zinc.

→ It is also known as 70-30 brass

Properties

→ It has maximum ductility and malleability

Applications

→ It is used for forming by deep drawing, stretching, trimming, spinning and press work operations

→ It is used for cartridge cases, radiator fins, lamp fixtures, rivets and springs.

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iv) Admiralty brass

→ It contains about 30% zinc and 1% tin

Properties

→ It has good corrosion resistance.

Applications

→ It is used for condenser tubes and heat exchangers in steam power plants.

→ A typical ~~brass~~ admiralty brass contains about 22% Zn, 2% Al and 0.04% As and is widely used for marine application.

2) α-β-Brasses

→ Commercial α-β brasses contain zinc between 32-40%. They are hard and strong when compared to α-brasses and are fabricated by hot working processes.

α-β Brasses classified as follows.

i) Muntz metal

→ It contain copper of 60% and zinc - 40%.

→ It is also known as 60-40 brass (or) Yellow brass.

~~Prop.~~

Structure of Muntz metal

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Properties

1. Muntz metal have good machinability
2. It has high strength and excellent hot working properties.
3. Tensile stregth is 480 ~~N/mm²~~ Mpa
4. Elongation upto 50 % for cast and 40 % for hot rolled.

ii) Leaded brass

→ It contains Cu - 62.5 % Zn - 36 % Pb - 1.5 %.

Properties

→ It prossess good machinability and resistance to corrosion.

→ It has low ductility and impact values.

Applications

→ used in making of plates, keys, clock parts etc...

→ It is used in automotive parts suchas gears, valve parts etc...

iii) Naval brass

→ It cotains Cu - 60 % Zn - 39 % Sn - 1 %.

~~→ It has~~

Properties

→ It has good resistance to corrosion.

→ It is more suitable for hot rolled forging and castings.

Applications ⑥

→ used for structural applications and forgings.

→ Making of valve stems, propeller shafts, pump impellers etc....

iv) High Tensile brass

→ Alloy elements such as Al, Fe, Mn, Sn and Ni are frequently added to 60-40 brass to increase its tensile strength. Brasses containing one or more of the above elements are called high tensile brasses.

Properties

→ It has good resistance to sea water corrosion

→ It has tensile strength 40 to 55 kg/mm² and elongation between 20 to 30%.

Applications

→ It is widely used for marine engine pumps, ships propellers, gears, valves bodies and other applications.

Brazing brass

→ It contains zinc about 50%.

→ It is known as 50-50 brass.

Properties.

→ It is brittle due to the presence of γ phase

Applications

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→ Has no application due to brittle nature.

ALUMINIUM

(AL)

→ Aluminium is a chemical element with symbol "AL" and atomic number 13.

→ It is a silvery white, soft, non magnetic, ductile metal in the boron group.

→ It has FCC structure and ductile & malleable

Properties of aluminium

→ It has Melting point 660°C and boiling point 2470°C

→ It has density of 2.70 g/cm3

→ It has very good thermal and electrical conductivity

→ It has good corrosion resistance.

→ It has high strength to weight ration

→ It has high specific strength, good formability and high reflectivity.

→ It is very ductile and non-magnetic.

→ It is light weight (specific gravity - 2.7gm/cm3

Applications of Aluminium

→ It used for making of cooking utensils, combs, collar buttons, toasters, mixers, electrical conduct or, foodcontainers, paint, name plates, ashtrays, flower pots, coins etc...

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LM Series for Cast Aluminium Alloys

Sr. No.	Trade name	Composition, per cent. Si	Cu	Mg	Mn	Others	
1	LM–1	3.0	7.0	–	–	Zn	3.0
2	LM–2	10.0	2.0	–	–	–	–
3	LM–4	5.0	3.0	–	0.5	–	–
4	LM–4	5.0	3.0	–	0.5	Fe Ti	0.8 0.2
5	LM–5	–	–	5.0	0.5	–	–
6	LM–6	11.5	–	–	–	–	–
7	LM–8	5.5	–	0.6	0.5	Ti	0.15
8	LM–9	11.5	–	0.4	0.5	–	–
9	LM–10	–	–	10.5	–	Ti	0.2
10	LM–11	–	4.5	–	–	Ti	0.15
11	LM–12	–	10.0	0.25	–	–	–
12	LM–13	12.0	0.9	1.2	–	Ni	2.5
13	LM–14	0.3	4.0	1.5	–	Ni Ti	2.0 0.2
14	LM–16	5.0	1.2	0.5	–	Ni	0.3
15	LM–17	11.5	–	–	–	Ni	3.0
16	LM–18	5.0	–	–	–	–	–
17	LM–23	2.5	1.8	0.2	–	Ni Fe Ti	1.2 1.0 0.2
18	LM–24	8.5	3.5	–	–	–	–
19	LM–25	7.0	–	0.3	–	–	–

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→ It is used in transportation industry in the manufacture of bicycles, motorcycles, trucks and buses, aeroplanes and marine vessels.

Alloys of Aluminium

→ For engineering applications, large number of alloys have been developed for satisfying the specific service requirments.

→ The most common alloying elements are Cu, Mg, Zn, Mn, Si, Ni, Fe and Ti.

→ Strengthing of some of the alloys can be done by such processes as work hardening and precipitation hardening or both. The various Aluminium alloys are designated by LM series (BS 1490/1949). The detailed list of LM alloys is given in table

i) Aluminium - silicon alloys:

structure

(a) LM-6 (Si - 11.5 %)

(b) LM-8 (Si - 5.5 %)

(c) LM-9 (Si - 11.5 %, Mg - 0.4 %)

ii) Aluminium - copper - Sillicon Alloys

structure

(a) LM-1 (Cu - 7% , Si 3%)

(b) LM-2 (Cu - 2% , Si - 10%)

(C) LM-4 (Cu - 3% , Si - 5%)

iii) Aluminium - magnesium Alloys

(a) LM-13 (Mg - 1.2% , Si - 12% , Cu - 0.9%)

(b) LM-14 (Mg - 1.5% , Si - 0.3% , Cu - 4%)

(c) LM-10 (Mg - 10.5%)

(d) LM-25 (Mg - 0.3% , Si - 7%) etc ..

structure

iv) Duraluminium

structure

→ It contains Al - 94% , Cu = 3.5 to 4.5% , Fe-0.5 % , Si - 0.5% , Mg - 0.4 to 0.7% , Mn = 0.5%

Properties

→ Tensile strength is high (400 MPa)

→ Hardness is 56 - 95 BHN

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3. It can be easily forged and stamped. (8)

4. It has high electrical conductivity.

v) Y- alloy

→ It is composition of AL - 92.5% ; Cu - 4% ; Ni - 2% ; Mg = 1.5%.

Properties

→ It is strengthened at 200°C

→ At elevated temperatures, it retains high strength and hardness.

→ It is easy to cast and hot working process.

Applications

→ It is used for components such as piston heads, cylinder heads and crank case of I-C engines.

→ It is also used for die castings, pump rods and in sparking chisels.

vi) Magnelium

→ It is composition of AL - 85% to 95% , Cu - 0% to 25% , Ni - 0% to 1.2% ; Sn - 0% to 3% , Mg - 1% to 5.5% ; Mn - 0% to 0.03% ; Si - 0.2% to Fe - 0% to 0.9% ; 0.6%

Properties

→ It possess high tensile strength, machinability and less weight.

→ This alloy can be welded and elongated.

Applications

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→ It used in aircrafts and automotive ~~automobiles~~

industries to manufacture components like gear box housing, luggage racks, ornamental fixtures, handles of door etc..

vii) Hindumimium – RR 350

→ It contains about 5% Cu and 1.5% Ni with small amounts of Mn, Ti, Sb, Co and Zr.

~~→ It is su~~

Properties

→ It is superior to Y-alloy at elevated temperature service particularly in respect of creep resistance.

Applications

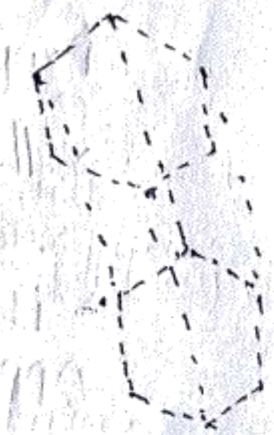
→ It is used in Aero engines and other continuous elevated temperature service applications upto 300°C.

TITANIUM

→ Titanium is a chemical element with symbol "Ti" and atomic number 22.

→ It is a lustrous transition metal with a silver colour, Low density and high strength.

→ It has hexagonal close-packed structure (hcp)



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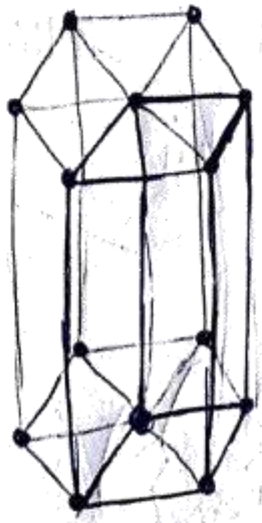

HCP structure

Properties of Titanium

→ It has melting point of 1668°C and Boiling point of 3287°C

→ It has low density 4.506 g/cm^3

→ It has high strength.

→ It has excellent corrosion resistance upto 1000°F

→ It the 4th abundant element in the earth's curst

→ It is expensive to obtain it from its ores.

Application of Titanium

→ Because of excellent strength to weight ratio it is widely used in air crafts.

→ It is also used in armor plating, naval ships, spacecraft and missiles.

Titanium alloys exists in three different forms

They are

1) α - Titanium alloys
2) α-β - Titanium alloys
3) β - Titanium alloys.

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These are processed by casting, terming and also by powder metallurgy.

1) α - Titanium Alloys

Structure

→ It is composed fully an α - phase of 92.5% titanium and 5% aluminium and the remaining 2.5% constitutes of tin.

→ Aluminium and tin are α - stabilizers

Properties

→ These alloys have the properties of weldability and are strong and can retain their strengths at high temperatures also.

Applications

→ These alloys are used for steam turbines.

2) α-β Titanium Alloys

structure

→ These alloys are composed of sufficient amount of β- stabilizing elements. The alloys of this type

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have 90% titanium, 6% aluminium and the remaining 4% is vanadium. The α-stabilizer and β-stabilizer is due to is due aluminium and vanadium. (10)

Properties

→ The α-β alloys can be increased in strength by heat treatment quenching.

→ This can also be welded, forged and machined.

β-Titanium Alloys

Structure

→ These alloys are composed sufficient amount of β-stabilizers elements. The structures can be made entirely β at room temperature.

→ ~~This is~~ The composition for this alloy is 77% titanium, 13% vanadium, 11% chromium and remaining 3% is aluminium.

Properties

→ These β-alloys are readily cold worked in solution treated, quenched conditions to give very high strength.

→ It have low ductility

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