UNIT-6 (R-16)

CHEMISTRY OF ENGINEERING MATERIALS and FUEL CELLS

1. REFRACTORIES

Q.1. What are refractories ? Give good refractories ?

A:- "An inorganic material that can withstand very high temparature without softening or deformation in shape is called refractory"

These are chemically inert, resistance to corrosion, abrasion etc These are used in furnace, retorts, Kilns, Crucibles etc.

Good refractories material characteristics

A good refractory material should.

1. be Infusible at the temparature
2. be chemically inert by the action of corrosive gases, slages etc
3. be resistant to the abrasion action of flames
4. not crack and sutter loss in size at operating temparature.
5. be able to withstand the Load
6. Expand and contract uniformly at high and low temparatures.

Q.2. Give the classification of refractories with examples.

A: Based on the chemical properties, refractories are classified into Three types.

(1) Acid (2) Base (3) Neutral refractories.

(1). Acid refractories :- These refractories are made of Acidic material like, Alumina (Al_2O_3), Silica (SiO_2) etc

Ex:- Silica, Alumina and fire clay refractories.

(2). Basic refractories :- These refractories are made of Basic materials like lime (CaO), Magnesia (MgO) etc

Ex:- Magnesite, dolamite etc

(3). Neutral refractories :- These are made of weak acidic/ basic materials like Carbon, chromate and zirconia.

Ex:- Carborundum, graphite and chromite.

Q.3. Write short note on the following ?
(a) Refractoriness (b) strength or RUL
(c) Dimensional stability (d) Thermal spalling
(e) Thermal conductivity (f) porosity

A:-

1. Refractoriness :- It is the ability of the refractory to withstand high temparature without deformation or softening is known as refractoriness.
The softening Temparature of the refractory material can be determined by the pyrometric cone test (PCT).

2. Refractoriness under Load (RUL) or Strength

Refractories should have high mechanical strength to withstand the load applied under operating temperature. Thus a good refractory should have high Load bearing capacity which can be measured by RUL Test.

3. Dimensional stability :-

A good refractory material should have high dimensional stability.

4. Thermal spalling :-

A good refractory should have high resistance to Thermal spalling even at high temparuture.

5. Thermal Conductivity :- Most of the refractories are lined inside of the furances, A good refractory should have high Thermal resistance.

6. porosity :- Refractories generally contain pores either due to manufacturing defects of saw dust etc. porosity is defined as the ratio of its porous volume to the bulk volume.

$$\text{porosity} = \frac{W - D}{W - A} \times 100$$

P = porosity, W = wt of saturated speciman in air
D = wt of dry speciman
A = wt of saturated speciman in water.

Q.4. Write notes on the condition leading to failure of a refractory material ? (2) pol

A: The efficiency of the refractory material mainly depends on its chemical constituents, processing and curing.

(i). An Acidic refractories should not used in basic fluxes, slag etc

(ii). porosity of refractory plays an important role. more porous, The greater will be the depth to which The slage will penetrate and destroy refractories

(iii). Fire clay refractories is failure in blast furnace because carbon monoxide.

(iv). As the temperature increases to failure of refractories

2. LUBRICANTS

Q.5. Define lubricant ?

A:- Any substance used between two moving or sliding surfaces to reduce frictional resistance between them is known as lubricant.

Ex:- Castor oil, olive oil, palm oil, Heavy oil, grease, graphite, MoS_2 etc.

Q.6. Write short note on functions of lubricants ?

A:-
1. It reduce frictional resistance
2. It reduce wear, tear and surface deformation
3. It act as coolant
4. Lubricant prevent rust and corrosion.
5. It reduce noise
6. It act as seal and avoid leakages.

Q.7. Give the classification of lubricants ?

A:- lubricants are classified into Three types

1. liquid lubricants or lubricating oil
2. Semi - solid lubricants or grease
3. Solid lubricants.

1. Liquid lubricants :- "A liquid lubricant is used to reduce friction and wear and as a sealing agent".

   Ex:- Castor oil, olive oil, palm oil, Heavy oil etc

2. Semi - solid lubricants :- "Semi solid lubricants are reduce friction by separating two moving surface under boundary conditions" it is also known as grease

   Ex:- Calcium based grease, Soda based grease, ~~graphite~~, ~~MoS2~~ etc.

3. Solid lubricants :- "Solid lubricants to resist friction by separating of two moving surfaces"

   Ex:- graphite, MoS_2 etc

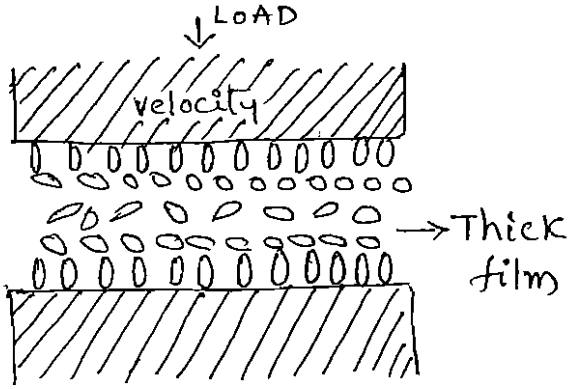
Q.8. Explain fluid - film mechanism of lubrication ?

A:- This is also called thick film lubrication. In this type of lubrication, two surfaces of moving surfaces are physically separated from each other by bulk of lubricant film with a thickness of at least 1000°A between them. This bulk lubricant film can prevent metal to metal contact and consequently it will reduce friction and prevents wear.

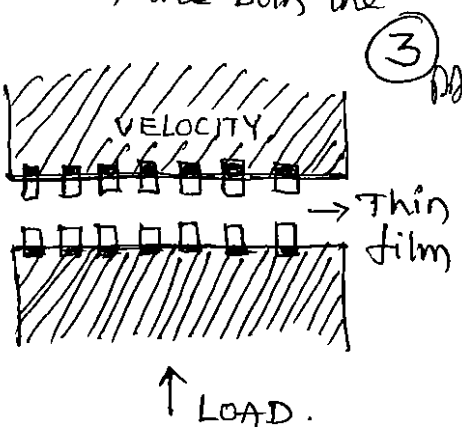
Q.9. Explain Thin film mechanism of lubrications ?

A:- In this case, lubricant is adsorbed on the metallic surface in this form of thin layer which avoid the metal - to - metal direct contact. The load

is carried by the Thin layer adsorbed on the both the metal surfaces.



Fluid-film lubrication



Thin film lubrication

Q.10. Write the properties of lubricants (Any Six)

A:-

(1.) Flash point :- "The Minimum or lowest temparature at which the oils give off enough vapour to ignite for a moment when a tiny flame is brought near it" is known as flash point.

* A good lubricant should have flash point above the temparature than the operating temparature.

(2) Fire point :- "The lowest temparature at which vapour of the oil burns continuously for at least 5 seconds when a tiny flam is brought near it" is known as fire point

* The fire point of an oil is about 5 to 40°F higher than its flash point.

(3) cloud point :- When an oil is cooled slowly, the temparature at which it becomes cloudly in appearance is called its cloud point

Cloud point indicate the suitability of lubricant in cold conditions.

(4). Pour point :- When an oil is cooled slowly, the temperature at which the oil cease to flow or pour is called its pour point.

Lubricants used in a machine at low temparature should possess low pour point, otherwise solidifaction of lubricant will cause Jamming of the machine.

(5). Aniline point :- The lowest equilibrium solution temperature at which equal volume of lubricating oil dissolves in equal volume of aniline

Lubricants with higher aniline points are preferred.

(6) Viscosity :- "Viscosity is the property of the fluid by virtue of which it offers resistance to its own flow"

* light lubricating oils have low viscosity are useful for heavy trucks.

Q.11. What are the Electrical Insulators ? Give examples

A: Insulators are the materials employed to minimize the loss of Electricity through certain parts in an electrical system.

* If Insulation is the main function, then called "Insulators"
* If charge storage is the main function is called "dielectrics"

Ex:- Insulators Examples

(a) Simple gases — Air, Nitrogen, SF_6
(b) Liquid Insulators — mineral oil, Flurinated fluid, vegetable oil
(c). Solid Insulator — cotton, Silk, asbestous, mica, Ceramics,

Q.12. What are the Thermal Insulators ? Give examples.

A:- Substance which possess extremely low Thermal Conductivities are known as Thermal ~~Conduct~~ Insulators.

These are used in refrigerators, cold storage rooms, ovens etc

Ex:- 1) Organic Thermal Insulators :- wood, cotton, wood pulp, paper, coke
2) Inorganic " " :- Asbestos paper, fibrous — glass etc.

PORTLAND CEMENT

(4)

It is defined as an extremely finely ground product. It is obtained by heating a mixture of argillaceous (clay containing) and calcareous (lime containing) raw materials to about 1500 c. It is then mixed with gypsum to increase the quick setting and hardening property.

CHEMICAL COMPOSITION OF PORTLAND CEMENT

1. 3CaO.SiO2 - Tri calcium Silicate
2. 3CaO.Al2O3 - Tri calcium Aluminate
3. 4CaO.Al2O3.Fe2O3 - Tetra calcium alumino Ferrate

Q. 13 Explain manufacture of Portland cement ?

A : MANUFACTURE OF PORTLAND CEMENT

Raw materials :

(i) Calcareous materials , CaO Ex: Limestone, chalk.

(ii) Argillaceous materials, Al2O3 and SiO2 Ex: clay, slate etc

(iii) Powdered coal (or) fuel oil.

(iv) Gypsum (CaSo4.2H2O)

Manufacture of Portland cement involves the following steps:

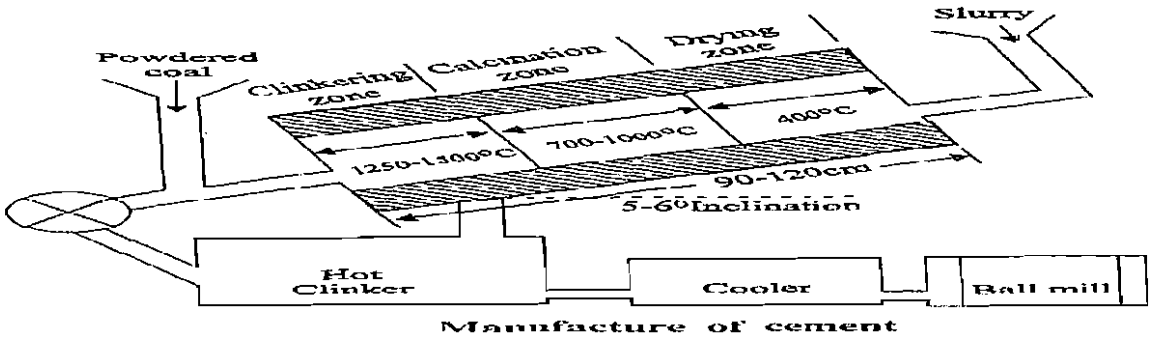
(i) Mixing of raw materials (ii) Burning (iii) Grinding (iv) Storage and Packing

(i) Mixing of raw materials:

(a) Dry Process (b) Wet Process

(a) Dry Process: In dry process, the raw materials like limestone and clay(3:1) are dried, and mixed in definite proportions

(b) Wet process : In wet process, the raw materials in definite proportions are finely ground with water and the slurry (past like) is fed at the top of the rotary kiln.



Manufacture of cement

(II) Burning

The slurry of raw materials is allowed to enter from the top end of the rotary kiln. Simultaneously the burning fuel (like powdered coal or oil) and air are introduced from the lower end of kiln . The slurry gradually comes down in the kiln into the different zones (Drying Zone at 400o :Calcination zone at 700 - 1000 o C and clinkering zone at 1250-1500 o C of increasing temperatures.

(a) Drying Zone: The upper part of the rotary kiln is known as drying zone , where the temperature is about 400 o C . Due to the presence of hot gases in this zone, water is evaporated from the slurry.

(b) Calcinations zone: The middle part of the rotary kiln is known as calcining zone, where the temperature ranges from 700 -1000 o C. In this zone lime stone is decomposed into CaO and CO2

$$CaCO_3 \longrightarrow CaO + CO_2\uparrow$$

(c) Clinkering Zone : The lowest part of the zone is called as clinkering zone, where the temperature is maintained about 1250-1500 o C. In this zone lime reacts with clay (Containing Al2O3, Fe2O3 and SiO2) and forms aluminates and silicates

$$2\,CaO + SiO_2 \longrightarrow 2\,CaO.SiO_2 \quad (C_2S)$$
$$3\,CaO + SiO_2 \longrightarrow 3\,CaO.SiO_2 \quad (C_3S)$$
$$3\,CaO + Al_2O_3 \longrightarrow 3\,CaO.Al_2O_3 \quad (C_3A)$$

The mixture is then finely powdered and fed into the top of the rotary kiln.

$$4\,CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4\,CaO.Al_2O_3.Fe_2O_3 \quad (C_4AF)$$

clinker is then finely pulverized with 2-6% gypsum acts as a retarding agent for quick setting of cement. Then the cement is packed in jute bags by automatic machines. Each bag contains 50kgs of cement.

Q.14 Chemical reactions involved in setting and hardening of cement:

A: When water is mixed with cement , hydration of tricalcium aluminate occurs rapidly and the paste becomes quite hard within a short time. This process is known as initial setting of cement.

3CaO.Al2O3 +6H2O-------3CaO.Al2O3.6H2O

Role of gypsum in cement:

(i) In initial setting process gypsum is added during grinding of cement clinkers to retard the rapid Hydration of C3A. Gypsum reacts with C3A to form insoluble calcium sulphoaluminate complex.

$$3\,CaO.Al_2O_3 + H_2O \longrightarrow 3\,CaO.Al_2O_3.6H_2O$$
$$4\,CaO.Al_2O_3.Fe_2O_3 + 7H_2O \longrightarrow 3\,CaO.Al_2O_3.6H_2O + CaO.Fe_2O_3.4H_2O \quad (Gel)$$

(ii) After the hydration of C3A, C3S begins to hydrate to give tobermonite gel and crystalline Ca(OH)2. The hydration of C3S takes place within 7days.

$$2CaO.SiO_2 + 4H_2O \longrightarrow 3CaO.2SiO_2.6H_2O + Ca(OH)_2$$
Tobermonite gel.

(iii) Dicalcium silicate reacts with water slowly and gets finished 7-28days.

(iv) Hydration of tetra calcium aluminoferritetakesplace initially, the hardening takes place finally through crystallization along with C2 S.

$$2(2\,CaO.SiO_2) + 4H_2O \longrightarrow 3\,CaO.2SiO_2.3H_2O + 3\,Ca(OH)_2$$
Tobermonite

Thus the final setting and hardening of cement is due to the formation of tobermonite gel plus crystallization of Ca(OH)2 and hydrated tricalcium aluminate.

Q.15 Write notes on Environmental effects on concrete / cement?

Ans:1. Acid attack: Concrete contains free calcium hydroxide, so in acidic water lime dissolves making the concrete weak.

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$$

2.Sulphate attack: Sulphates are present in soil, ground waters and marine water environment. Sulphates react with C_3A to give bulky material causing cracks due to expansion.

3.Carbon Dioxide Attack: Diffusion of CO2 into concrete and conversion of Ca $(OH)_2$ to $CaCO_3$ is called as carbonation, Carbonation depends on the porosity of concrete. Good quality of concrete is less porous and diffusion of concrete is less,

(5) PDL

$$Ca(OH)_2 \rightarrow CaCO_3 + H_2O$$

Q. 16. Explain Hydrogen- Oxygen Fuel cell / [H2 - O2] Fuel cell.

A : Fuel Cell: It is a device in which the chemical energy of the fuel hydrogen is directly converted into electricity without combustion.

Anode : Hydrogen

Cathode : Oxygen (oxidizer)

Electrolyte : 25% KOH or NaOH

Two porous electrodes – Made of compressed carbon containing a catalyst like pt / pd.It consists of two porous electrodes anode and cathode. In between two electrodes an electrolytic solution 25% KOH or NaOH filled. When H2 is bubbled through the anode compartment, where it is oxidized. The O2 is bubbled at the cathode compartment where it is reduced.

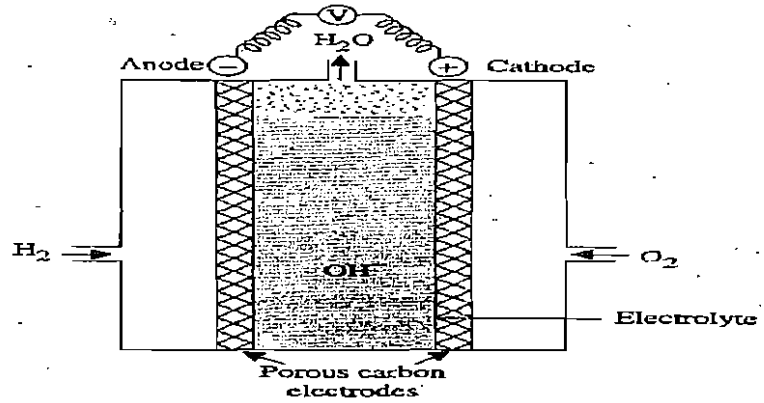


Fig. $H_2 - O_2$ Fuel cell

The emf of the cell = 0.8 to 1.0 V. Merits:

i. High efficiency. ii. No unwanted noise and less maintenance. iii. Nopollution

iv. No need to change electrode often.

Uses:

i. Used in military vehicles and space vehicles.

ii. H2 – O2 fuel cell, the product is water, so no need of fuel because fuel is water

Q.17. Explain the construction and working of Methanol – Oxygen fuel cell.

Ans: It consists of two electrodes made up of platinum in between the electrodes H2SO4 is placed as a electrolyte. Methanol and H2SO4 is supplied at the anode and pure oxygen gas is supplied at the cathode. The ethanol is oxidized to CO2 & H2O with the liberation of electrical energy. The cell delivers an emf of 1.20v. The cell reactions are as follows.

Uses:

1) Used in Military applications.

2) Used for large scale power production stations

Composite material

✓ **Fiber Reinforced Plastics**

The two components are the fiber and the resin combined in a suitable manner will gives Fiber Reinforced Plastics (Resins).

Applications: