Module - V
Lubricants

Definition:

→ A lubricant is a substance, usually organic, introduced to reduce friction b/w surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move.

Lubricity: The property of reducing friction is known as lubricity.

Characteristics

- A high boiling point and low freezing point.
- A high viscosity index.
- Thermal stability
- Demulsibility
- corrosion prevention.
- A high resistance to oxidation.
- Hydraulic stability

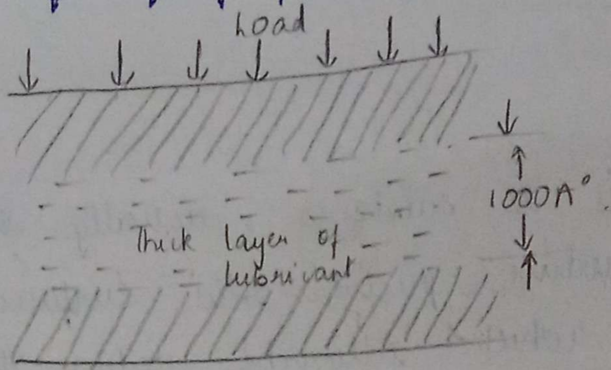
Mechanism.

~~Thick film~~

Lubrication film b/w the two contact surfaces is thick enough and two contact surfaces are separated completely by viscous oil film

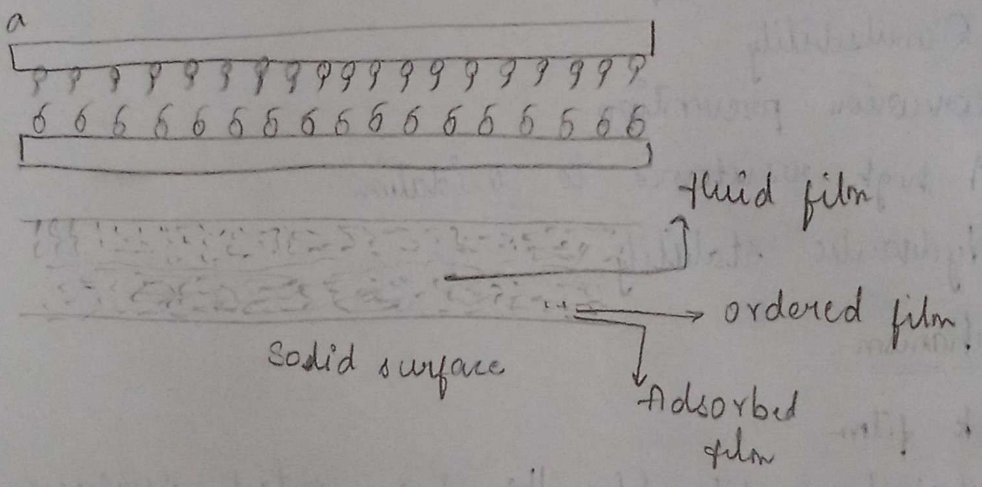
Types Of Mechanisms

Thick film mechanism (or) Hydro ~~car~~ dynamic lubrication occurs when non-parallel rigid bearing surfaces lubricated by a film-fluid slide over each other, forming a converging wedge of fluid and forming a ~~fl~~ lifting pressure.



2) Thin film mechanism:

It is formed where thick film lubrication fails, thin film lubrication is done. Thin film or boundary lubrication is done for those cases in which the continuous film of lubrication cannot persist and direct metal to metal contact is possible.

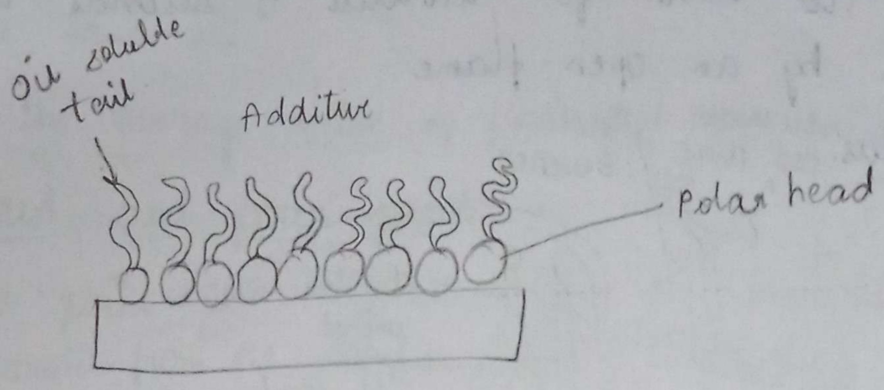


3) Extreme pressure film mechanism:

The fast moving or sliding metallic surfaces under very high pressure produce a large amount of heat and temperature becomes very high.

→ At high temp the ordinary liquid lubricants decompose or even vaporize at such a high temp and fail to stick over the metallic surfaces.

→ To face such conditions extreme pressure activities are added to the mineral oil.



Before load

Properties Of Lubricants.

1) Viscosity
2) Cloud and pour point
3) Flash and fire point
4) ~~Oilness~~ Oiliness of Lubricant.

Viscosity: (η)

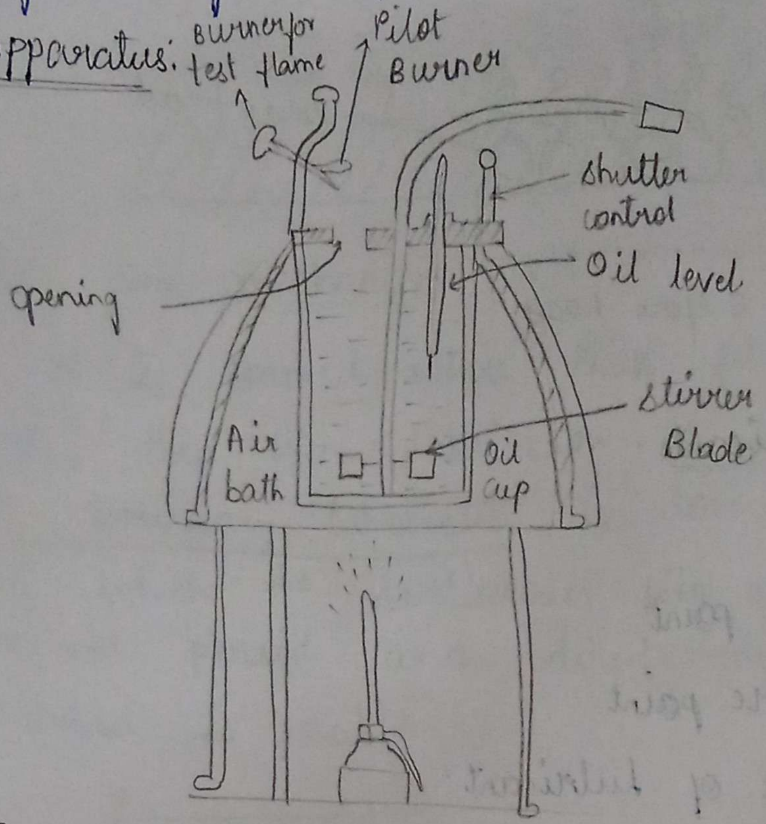
Viscosity ~~of~~ is the property of a fluid that determines its resistance to flow. It is an indicator of flow ability of lubricating oil. The lower viscosity greater than flow ability. If temp increases viscosity of lubricating oil decrease & pressure increases viscosity of lubricating oil increases

Flash & Fire point:

Flash point: The flash point of a volatile material is the lowest temp at which vapours of the material ~~with~~ will ignite, given a ignition source

Fire point: The fire point of a fuel is the lowest temp at which the vapour of that fuel will continue to burn for atleast 5 seconds after ignition by an open flame

Apparatus:



Determination of Flash & Fire points

Description

The apparatus consist of a brass cup and cover fitted with shutter mechanism without shutter mechanism (open cup), test flame arrangement, hand stirrer (closed cup), thermometer socket, etc.. heated with energy ~~or~~ regulator a thermometer socket made of copper.

Working or Procedure

Using the Energy regulator, control the power supply given to the heater and rate of heating. The oil is heated slowly when temp of oil rises, it is checked for the flash point for every one degree rise in temp.

After determining the flash point, the heating shall be further continued.

→ Repeat the experiment 2 or 3 times with fresh sample of the same oil.

→ Take the average value of flash and fire points

3) Cloud and pour point

Cloud point: The temp at which the impurities being to separate from the solution and lubricating oil becomes cloudy or hazy in appearance is called cloud point

Pour point. The temp at which the oil ceases to flow and pour is called pour point.

Apparatus:

Determination of cloud point

Bring the sample to a temp of at least 15 °C above the approximate cloud point and pour it into the jar to a height of 51 to 57 mm and close the jar with the cork so that the thermometer bulb rests on the centre of the bottom of the jar.

Support the jacket and jar in a Vertical position in the bath so that not more than 25 mm projects from the cooling medium.

If the sample does not show a cloud when it has been cooled to −7°C: place the jar & jacket in another bath ~~to~~ maintained at a temp of −32°C to −35°C.

When an inspection of the sample first reveals a distinct cloudiness or haze at the bottom of the jar, record the reading of the thermometer as the cloud point after correcting the thermometer errors if necessary

Determination of pour point

→ The sample has cooled enough to ~~allow~~ allow the formation of the crystals. Maintain bath temp at $-1°C$ to $2°C$

→ As soon as sample ceases to flow when the jar is titled. hold the jar in horizontal position for exactly 5 sec. If the sample shows any movement replace the jar in the jacket and cool down the sample for another $3°C$.

→ If the oil shows no movement during the 5 sec, record the reading of the thermometer. Add $3°C$ to the temp recorded above and corrected for thermometer errors if necessary, and note down the result as pour point.

Nano Materials :-

Introduction :

The meaning of the word 'nano' is nanos, which indicates a person of very low height or a very small object that is a dwarf.

For instance, a nanometer is a billionth of a meter or a millionth of a millimeter, a nano leter is a billionth of a litre or a millionth of a millimeter, and a nano is a billionth of a Kelvin.

Difinition

Nanomaterials are substances that are b/w 1 and 100 nm in size, at least ~~or~~ in one of the three dimensions.

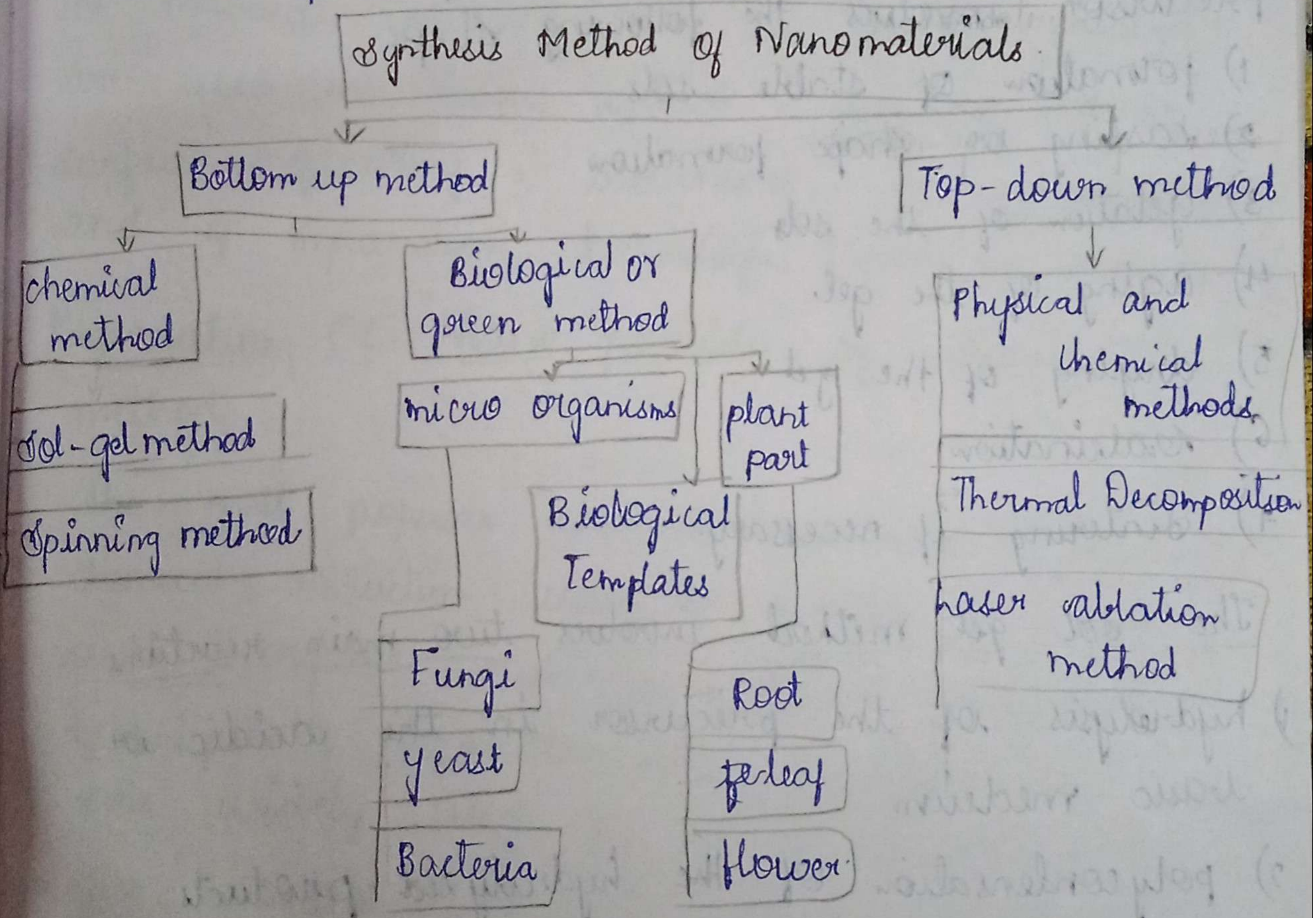
→ The field of study known as nanotechnology includes the synthesis, engineering, and application of nano materials.

Examples:

Agriculture, biomedicine, electronics, energy pollution abatement, food engineering, transportation, telecommunication, cosmetics, coatings, materials, and mechanical engineering are just a few of the industries that use ~~to~~ nanomaterials.

Synthesis:

In general, nanomaterials are synthesized using a variety of methods, which are categorized into two main categories: bottom-up and to-down methods.



The bottom up method also known as the constructive method, involves the building of material from atoms to clusters to nanoparticles

Sol-gel Method

It is the process by which a suitable chemical solution serves as a precursor. Metal oxide and chloride are common sol-gel method precursors.

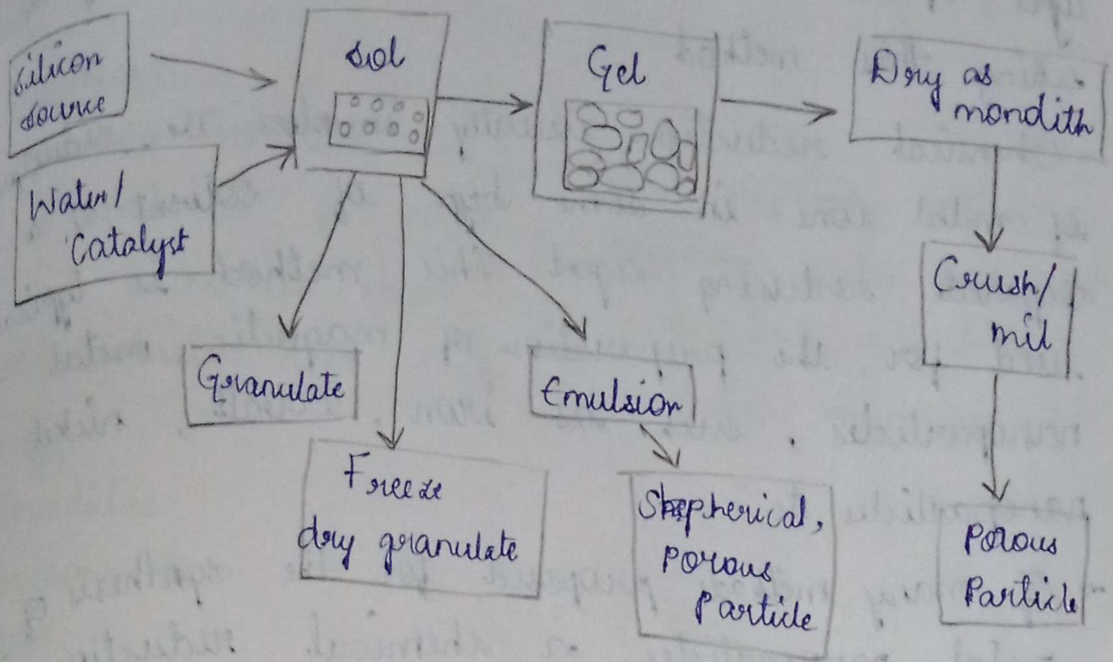
The sol-gel process is a more chemical method (wet chemical method) for the synthesis of various nanostructures, especially metal oxide nanoparticles.

A typical sol-gel process using an alkoxide precursor involves the following steps.

1) formation of stable sols
2) casting or shape formation
3) gelation of the sols
4) aging of the gel.
5) drying of the gel
6) calcination
7) sintering if necessary.

The sol-gel method involves two main reactions

1) hydrolysis of the precursor in the acidic or basic medium
2) polycondensation of the hydrolyzed products.



Applications:

The materials obtained from the sol-gel method are used in various optical, electronic, energy, surface engineering, biosensors, and pharmaceutical and of separation technologies (such as chromatography)

Preparation Of Nano particles by chemical Reduction method.

The most popular chemical approaches, includes chemical reduction using a variety of organic and inorganic reducing agents electrochemical techniques, physicochemical reduction and radiolysis are widely used for the synthesis of silver NPs.

→ The chemical reduction method consists of three essential stages, namely the reduction of metallic salts by reducing agents, stabilization of ionic complexes and controlling of the size by the capping agent. Many different types of metallic nanoparticles have been synthesized using this method.

→ Chemical reduction usually involves the reduction of metal ions in some type of solvent & a separate reducing agent. This method is typically used for the preparation of magnetic metal nanoparticles, such as iron, cobalt, nickel, nanoparticles etc.

→ Of many methods proposed for the synthesis of metal nanoparticles, a chemical reduction is usually preferred because it is easy to perform cost effective, efficient and also allows control of structural parameters through optimization of synthesis conditions.

→ Nanoparticles are traditionally synthesized using wet chemistry methods, which involve first generating the particles in soln, drop casting the wet particles onto a substrate and removing the solvent surfactants and other materials from the particles.

→ In general different reducing agents such as sodium citrate, ascorbate, sodium borohydride ($NaBH_4$) are used for reduction of silver ions (Ag^+) in aqueous or non-aque solns.

Applications:

Electronics:

Carbon nanotubes are close to replacing silicon as a material for making smaller, faster and more efficient microchips and devices, as well as lighter more conductive and stronger quantum nanowires.

- Energy.
- Biomedicine.
- Environment.
- Food.
- Textile.

Shape memory materials

Shape memory materials are also called stimuli-responsive material. There are several types of shape memory materials, such as metals, ceramics, gels & polymers.

→ A shape ~~of~~ memory alloy is a metal with unique Properties that allow it to be trained to move on its own. It can be strechted, bent, heated, and Cooled and still return its original shape

→ The most common memory metal is called NiTinol, consisting of equal parts of nickel & titanium.

Uses:

→ They are used as wires and tubes in applications with hot fluids flowing through them.

→ Another application of SMAs (Shape Memory Alloys) in civil engineering.

→ Shape memory alloys are used in a wide variety of applications, from actuators, and dampeners in the aerospace & automotive sectors.

→ SMA's can go through solid-state phase transformations, meaning they can be stretched, bent, heated & cooled & still remember its original shape

Poly L-lactic acid: (PLLA)

This is a biodegradable (polymers) thermoplastic polyester belonging to the class of poly hydroxy alkanoates, derived from renewable sources. Such as starch tapioca or sugar cane.

Properties of PLA:

→ The glass transition temp of PLA is 60-65°c

→ PLA pooses melting point is 173-178°c

→ PLA is a chiral compound existing as poly l-lactic acid (PLLA).

Applications of PLA:

→ PLA is widely used for making medical implants like anchors, screws, pins, mesh etc.

→ For making compostable packing material, disposable garments, food packing etc.

(Thermo response materials).

Smart materials.

→ Smart materials are defined as materials that sense and react to environmental conditions or stimuli (e.g. mechanical, chemical, electrical or magnetic signals).

→ Smart materials are materials that can change their properties or behaviour in response to external stimuli, such as temp, pressure, electric field or light.

Types of smart materials

→ piezoelectric
→ shape memory
→ chromoactive
→ magnet orheological
→ photoactive.

Properties:

→ potential applications for this include sporting equipment such as helments and gum-shields or car bumpers, which can be heated to return to their original shape after a minor collision. In addition, medical stiches can self tighten as a wound heals.

→ It aims to minimize waste and increase efficiency in the use of natural resources. That is why smart materials play a key role in the circular economy.

→ These materials are designed to be durable, efficient and resistint. making them ideal for making products, that can be effectively reused or manufactured.

Applications:

→ Smart materials are materials that respond to changes in their environment and then undergo a material property change.

These property changes can be leverged to create an actuator or a sensor from the material without any additional control or electronics required.

→ smart materials offer a wide range of uses in technology, industry, science and medicine, but their most common and wide scale usage remains in civil engineering because of their ability to adjust to the their properties. construction projects frequently use concrete as a material.

Thermo response materials:

Introduction:

→ Temp:- responsive polymers or thermo responsive polymers are polymers that exhibit drastic and discontinous changes in their physical properties with temp.

→ The thermo-responsive properties in the LCST-type and / or USCT-type PBSCs arise from differences in the solubility response (in a particular solvent) of materials with temp.

working:

→ The most widely studied thermo responsive polymers exhibit a lower critical solution temp (LCST) in water. Upon heating above the LCST, such polymers undergo an entropically driven phase seperation that coincides with a coil-to-globule transformation.

Ex (Applications).

→ They have stimulated researches' attention in the biomedical field, taking into consideration that specific infections show temp. changes.

Advantages and Disadvantages.

→ Thermo-responsive polymers are smart materials that have many applications in various fields of science.

→ Thermo responsive hydrogels use temp. as external stimulus to show sol-gel transition and most of the thermo responsive polymers can form hydrogels around body temperature.

Preparation polyacry amides:

→ polyacryl amide gels are made by chemical polymerization of a mixture of acryl amide and bisacrylamide (a cross-linker) in the presence of a catalyst and an initiator of the polymerization reaction.

Properties:

polyacrylamide is an important water-soluble polymer, and has many soluble polymer, and has many valuable properties, such as flocculation, thickening, shear resistance, resistance reduction and dispersion. These properties vary with the ion of the derivative.

Applications:

1) Measuring molecular weight.
2) Peptide mapping.
3) Estimation of protein size.

poly vinyl amides:

preparation:

→ poly(N-vinylacetamide) (PNVA) is a polymer having affinity for both water and alcohol made primarily from N-vinylacetamide (NVA) monomer. the homopolymer of NVA is called GE191 grade.

copolymer of NVA and sodium acrylate called GE167 grade.

properties:

→ Resistance to acids and alkalis

→ water-soluble.

→ Adhesion and pressure sensitive adhesion.

→ Resistant of heat.

Applications:

→ PVA is used in packing and as optical polarizer.

→ This polymer is also applicable in other industries, including polymer recycling, binding and coating and adhesives.

Cement

Composition of Cement:

- portland cement gets its strength from chemical reactions b/w the cement & water. The process is known as hydration. This is a complex process that is best understood by first understanding the chemical composition of cement
- portland cement is made up of four main compounds like tricalcium aluminate, tetra-calcium aluminoferrite, dicalcium silicate and tricalcium silicate.

compound	formula	short hand form	% by weight
Tricalcium aluminate	$Ca_3Al_2O_6$	C_3A	10
Tetracalcium aluminoferrite	$Ca_4Al_2Fe_2O_{10}$	C_4AF	8
Belite or dicalcium silicate	Ca_2SiO_5	C_2S	20
Alite or tricalcium silicate	Ca_3SiO_4	C_3S	55
Sodium oxide & Potassium oxide	Na_2O & K_2O	N & K	upto 2
gypsum	$CaSO_4 \cdot 2H_2O$	CSH_2	5

→ Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients.

→ Common materials used to manufacture cement include limestone, shells & chalk combined with shale, clay, slate, blast furnance slag, silica sand, and iron ore

Portland Cement

- It is most widely used non-metallic material of construction. It is a mixture of calcium silicates and calcium aluminates with small amount of gypsum.
- The name portland cement is used because this powder on mixing with water gives a hard, stone like mass which resembles portland rock.
- All portland cements are hydraulic in nature.

Composition of portland cement :- A good sample of portland cement

- Calcium Oxide or lime (CaO): 60 - 70%.
- Silica (SiO_2): 20-24%.
- Alumina (Al_2O_3): 5 - 7.5%.
- Magnesia (MgO): 2-3%.
- Ferric Oxide (Fe_2O_3): 1-2.5%.
- Sulphur trioxide (SO_3): 1-1.5%.
- Sodium Oxide (Na_2O): 1%.
- Potassium Oxide (K_2O): 1%.

Setting and Hardening of Cement :

- Cement when mixed with water forms a plastic mass called cement paste. During hydration reaction, gel and crystalline products are formed.
- The inter - locking of the crystals binds the inert particles of the aggregates into a compact rock like material.
- This process of ~~s~~ solidification comprises of Setting then Hardensing.
- Setting is defined as stiffening of the original plastic mass due to initial gel formation. Hardening is development of strength, due to crystallization.
- Due to the gradual progress of crystallization in the interior mass of cement, hardening starts after setting.
- The setting & hardening of cement is due to the formation of inter locking crystals reinforced by rigid cells formed by the hydration and hydrolysis of the constitutional compound.

→ When cement is mixed with water, the paste becomes rigid within a short time which is known as initial setting. This is due to the hydration of tricalcium aluminate and gel formation of tetra calcium alumino ferrite.

$$C_3A + 6H_2O \longrightarrow C_3A.\,6H_2O + 880\ KJ/Kg.$$

- tricalcium aluminate hydrated tricalcium aluminate (crystalline)

$$C_4AF + 7H_2O \rightarrow C_3A.6H_2O + CF.H_2O + 420\ KJ/Kg.$$

tetracalcium alumino ferrite (crystalline) gel

- Dicalcium silicate also hydrolysis to tobermonite gel which contributes to initial setting.

$$2C_2S + 4H_2O \longrightarrow C_3S_2 \cdot 6H_2O + Ca(OH)_2 + 250\ KJ/Kg.$$

dicalcium silicate to be monite gel

- Final setting and hardening of cement paste is due to the formation of to be monite gel and Crystallisation of calcium hydroxide and hydrated tricalcium aluminate.

$$2C_3S + 6H_2O \longrightarrow C_3S_2 \cdot 6H_2O + 3Ca(OH)_2 + 500\ KJ/Kg$$

- tricalcium silicate to be monite gel calcium hydroxide
- During setting and hardening of cement, some amount of heat is liberated due to hydration and hydrolysis reactions. The quality of heat evolved during complete hydroxide of cement is 500 KJ/Kg

<u>Function of gypsum in cement:</u>

Tri calcium aluminate (C_3A) combines with water very rapidly.

$$C_3A + 6H_2O \longrightarrow C_3A.6H_2O + heat.$$

- After the initial setting, the paste becomes soft and added gypsum retards the dissolution of C_3A by forming insoluble calcium sulpho aluminate.

Scanned with ACE Scanner

$3CaO \cdot Al_2O_3 \times CaSO_4 \cdot 7H_2O$

This reaction prevents the high concentration of alumin in the cement soln and hence retards the early initial setting of cement.