LUBRICANTS.

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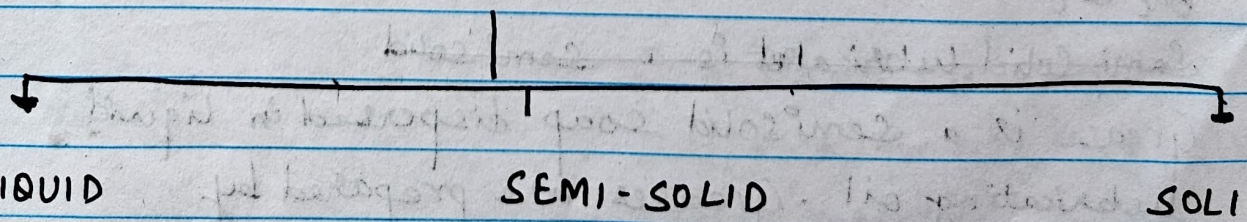
In a machine, the friction between metal to metal parts arises due to moving surfaces and machine experienced a resistance which retards their movement. Friction results in liberation of large amount of energy and reduces the efficiency of machine.

" Substances applied between moving or sliding surfaces to reduce friction between them are called LUBRICANTS and the process of reduction of friction is called LUBRICATION.

CLASSIFICATION OF LUBRICANTS



A. LIQUID LUBRICANTS : (also known as lubricating oils)

↓

Reduce friction between 2 moving / sliding metallic surface by providing a continuous fluid film between them.

They also acts as:

a) Cooling medium
b) Corrosion preventer
c) Sealing agent.

It include animal oil, vegetable oil, petroleum oil

Animal oil:

↓

Used earlier, before invent of petroleum industry. Now they are used as blending agents.

Petroleum oil: These are obtained by distillation of petroleum

B. Greases or Semi Solid lubricants

Semisolid lubricants are produced by emulsification of fat and oil with thickening agents at high temp.

Or Or.

~~Semi Solid lubricatet is a Semi Solid~~

Grease is a semisolid soap dispersed in liquid lubricating oil. Greases are prepared by saponification of ~~Soap~~ fat (tallow / fatty acid with alkali - Soda lime)

followed by adding hot lubricating oil while under agitation.

* Saponification: hydrolysis of ester to form alcohol and salt of carboxylic acid. / soap forming reaction of metallic alkali with fat

Classification

i) Calcium based grease: Calcium soaps are emulsified with petroleum oil. They are water resistant because they are insoluble in water.

$Ca(OH)_2$ + Hot oil (Tallow) $\xrightarrow{\text{agitation}}$ Calcium based grease.

- Cheapest
- Commonly used.

Above 80°C soap starts to separate out.

(ii) Soda based grease:
- Petroleum oil Thickened with Na soaps.
- Not water resistant. (because Na soaps are soluble in water.
- They can be used upto 175°C
- Suitable for used in parts which gets heated up.

(iii) Lithium based grease:
- petroleum oil + lithium soaps.
- Suitable for low temp (15°C).
- water resistant.

3. SOLID LUBRICANTS

These are used at places where lubrication through oil and grease cant be provided; or contamination of oil and grease by dust particles.

Graphite

Consist of layer structure. These layers are held together by vanderwaals forces which facilitate the easy sliding of one layer over another

- Soapy to touch
- Inflamable
- Used as powder form / mixed with ~~petroleum~~ water or oil.

* Doesnt gets oxidised in air.

Molybdenum disulphide.

Its a sandwhich like structure where hexagonal Mo lies between 2 hexagonal layer of sulphur.

Its used in high vaccum.
Used alongwith Solvent such as grease.

* Properties of lubricants

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Pour point depends on the trace of wax in oil and structure of oil.

lubricant should have flash point above the temp it's to be used.

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* The flash and fire point do not have any bearing with property of lubricant but its important to study because the lubricant gets heated up in machinery and its should be known how will the lubricant behave on exposure to temp.

(IV) fire point : Its an extension of flash point in a way that the condition is such that vapour burns continuously for 5 seconds when flame is brought nearer.

(V) Volatility : A good lubricant should have low volatility

How easily a substance vapourise or turn into gas or vapour.

VI. Viscosity : Viscosity is a property of liquid that offers resistance to its own flow. A liquid moves in layer fashion where one layer moves over the other

* A good lubricating oil should have viscosity that does not change rapidly

If the viscosity of oil is too low then the film of lubricant couldnt be maintained. Very high viscosity will offer friction.

* Mechanism of lubrication.

Lubricant is placed between the surfaces of two moving objects. The movement can be circular or linear.

The mechanism of lubrication could be carried out in 3 ways, which are:

a) fluid film / Hydrodynamic / Thick film lubrication :

This is known as thick film lubrication because the moving surfaces are separated from each other through a thick film of lubricant. This prevents the direct contact of two surfaces. The lubricant covers the entire surface of and it also covers the irregularities ~~found~~ by filling.

"HC Oils + LCP" VISCO

"Hydrocarbon lubricants" (oils) are considered good ~~example~~ for thick film lubrication. HC lubricants are blended with long chain polymer in order to maintain the viscosity for a long time. The lubricant chosen should have min viscosity and it should remain in the same place during the working condition. Eg: Sewing machine, clock, Scientific inst.

(Refer to diagram from book).

b) Boundary lubrication (Thin film lubrication).

Sometimes its difficult to maintain a thick film between the moving the objects. This happens ~~in the case of~~ when there is heavy load of weight which ~~exists~~

makes it difficult to have a continuous thick film. The thick film is adsorbed by physical or chemical forces on the metallic surfaces.
The thick film is not maintained when the moving part of machine has:

i) has very low speed
ii) Heavy load.
iii) low viscosity of oil
iv) Starts moving from rest.

the load is further

Preferably solid lubricants are used.

(III) Extreme pressure lubricants:

due to high Temp the lubricants fail to stick.

Moving surfaces are under very high Pressure and speed then they demand lubricants which must stick to the surfaces. Under high P or speed there develops a local temp. which makes it difficult for a lubricant to stay and in fixed place. The temp leads to decomposition / vaporisation

So, some additives are added to the lubricants i.e oils These additives are called extreme P. additives.
Organic compound with active radical group like Cl, S, P are considered good additive.

These compound react with metals and form metallic

X-15/19

which is a durable film. This film adheres to the metallic surface even under H.P. because they have high melting point. If by chance the layer is broken they get replenished quickly.

* Viscosity Index.:

The rate at which viscosity of a liquid changes with temperature is called VI.

* Small change in viscosity ⟶ High viscosity Index.

GLASS

Glass is an amorphous, hard, brittle, transparent or translucent supercooled liquid of infinite viscosity obtained by fusing a mixture of number of silicates mostly Na, K, Ca and Pb. It possesses no sharp melting point, definite formula or crystalline structure.

It maybe represented as:

$$xR_2O \cdot yMO \cdot 6SiO_2$$

R: monovalent alkali metal

x : ~~Al, Na,~~ K

y : ~~Ca, Pb, Zn~~

M: Bivalent metal:

Ca, Zn, Pb

x ~~and~~ and y = whole no.

SUPERCOOLED LIQUID

INFINITE VISCOSITY

METALLIC SILICATE

* Properties of glass

1. Amorphous: (something that lacks clearly defined shape)
2. No definite melting point
3. Can take high polish
4. Not affected by air water
5. Good Conductor
6. Affected by alkali
7. Brittle
8. Homogeneous internal structure.

Manufacturing of glass :

The manufacture of glass can be divided into 4 steps

(i) Melting (ii) Shaping (iii) Annealing (iv) finishing.

Melting of glass is carried out in furnaces which are of 2 types :

(a) Pot furnace
(b) Tank furnace.

} Both these furnaces can be regenerative type or recuperative type

Purpose of regenerator : To utilise the heat of waste gases for heating gas and air used for burning.

* Regeneration : The utilisation of the Δ of waste gases for heating the incoming gas and air used

Tank furnace: These are rectangular tank built of refractory bricks. (Refractory bricks are bricks that are kept around fire spaces. These are designed in a way to withstand high temperature.

→ Bricks kept around fire spaces..

This furnace is heated by producer gas (its a low grade fuel consisting of N and C monoxide). → produced by partial combustion of fuels (CO, N_2, H_2, CH_4)

Tank furnace are used to produce glasses on large scale.

Process:

Raw material (Sand, Na_2CO_3 and lime ($CaCO_3$) stone) + Cullets (broken / waste glass)

mixed and made into powdered form called the BATCH.

* Batch: Uniform mixture of raw materials for FRIT.

The tank is heated upto 1400°C. The materials melt and react to form glass.

its melted in tanks.

* Heating is done using producer gas.

(Cullet melts first and helps in fusion of rest of material).

- As the charge melts, periodically the samples are drawn from the furnace.

(The mechanical process of introducing batch of new materials into melting process).

- When the charge becomes transparent and free from bubbles of CO_2 and SO_2 its called plain

→ decolourizer is also added.

High temp of 1500 - 1800°C is maintained to obtain homogeneous liquid.

The process of charging, melting, shaping continues.

The evolved gases are lead to the stack chambers via regenerative chambers. At the refining end the glass becomes free from all types of bubbles of gas called seeds.

↓

Melt → Transferred to → drawing chambers.

- These are surrounded by working pits.
- 980°C Temp is maintained.

The undecomposed impurities of Cl^- and SO_4^{2-} of Ca and other alkali metals and Al rise to top in form of scum called glass gall.

↓

Melt is drawn from working pits for shaping

* Reaction of Glass : (Processing of glass).

Manufacturing of glass is high temperature process which takes place through intermediate steps.

1. Melting → Shaping → annealing → finishing

Annealing:

The manufactured glass articles are cooled very slowly. This process of slow cooling which is used to reduce strain is known as annealing.

∵ glass is a bad conductor of ∆, there is uneven cooling. This uneven cooling causes internal strain and can result in breaking or cracking of glass.

Its ∴ necessary to anneal all types of glass

* **Shaping / forming:** manufacture of glass from molten glass either mechanically or by hands.

* **finishing:** Cleaning → washing →

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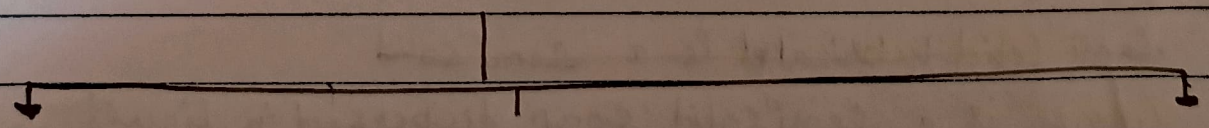

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Cement — material having adhesive and cohesive properties and capable of bonding material like stone and brick.

Concrete is widely used as a non-metallic material in construction of buildings, dams, bridges, high ways etc. In concrete, cement is a building material that possesses cohesive and adhesive properties and capable of bonding with stones, bricks, building blocks etc.

Portland cement → 1824 By Joseph Aspidin.

The name Portland cement is used because this powder on mixing with water gives a hard, stone like mass which resembles Portland rock (Leeds city UK). It is widely used as a non-metallic material in construction. It is a composition of calcium silicates, calcium aluminates and small amount of gypsum.

Composition of Portland cement:-

A sample of Portland cement contain following composition:

i)	Calcium Oxide or lime (CaO)	: 60-70%	Lime is the principal functional material. Excess of lime reduces the strength because it makes cement to expand and disintegrate.
ii)	Silica (SiO_2)	: 20-24%	
iii)	Alumina (Al_2O_3)	: 5-7.5%	
iv)	Magnesia (MgO)	: 2-3%	
v)	Ferric Oxide (Fe_2O_3)	: 1-2.5%	* Silica - Strength to cement
vi)	Sulphur trioxide (SO_3)	: 1-3%	* Alumina - makes cement quick setting.
vii)	~~Sulphur Oxide (Na_2O)~~	~~: 1%~~	
viii)	Potassium Oxide (K_2O)	: 1%	
	Alkali Oxides ($Na_2O + K_2O$)	0.3-1.5%	* Iron Oxide - colour strength and hardness.

Manufacture of Portland Cement:

The steps involve in the manufacturing process are as follows:

i) Crushing
ii) Mixing
iii) Burning
iv) Grinding

Wet Process

Raw materials are crushed, Powdered and stored in big tanks.

Clay → Clay is washed to remove any organic materials

Washed clay and powdered raw materials are led to grinding mills. → where they are mixed to form a SLURRY.

Contains upto 38-40% water.

* Slurry is stored in tanks → fed gradually to Kilns

Dry process

Raw material are crushed into roughly 2-5cm size pieces.

↓ ground to fine powder.

↓ Separate powdered indicator are stored in separately.

↓ Then they are mixed in required proportion to get dry mix.

↓ Stored in Bins.

↓ Kept ready to be fed to Kiln.

i) Crushing:

In this step raw material of Portland cement lime, Silica, Alumina, Magnesia, Ferric Oxide, Sulphur trioxide, Sulphur Oxide, Potassium Oxide are crushed and ground to fine powder through ball mill.

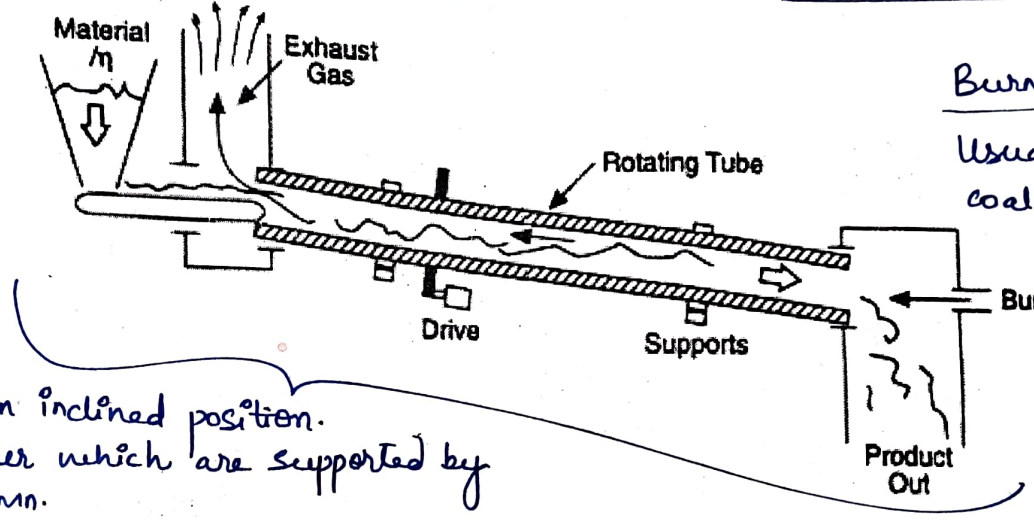
ii) Mixing:

In this step raw ingredients or fine powder are mixed in presence (wet process) or absence (dry process) of water to form slurry, then slurry is stored in storage tank.

iii) Burning:

Steel tube.
Diameter : 2.5 – 3.0m.
length : 90-100m.

The burning process is done in Rotary Kiln. The Rotary Kiln possesses three different temperature zone like drying zone, calcinations zone and Clinkering zone.



Burning fuel: Usually powdered coal or oil

Kiln is laid in inclined position. It rests on roller which are supported by masonary column.

Rotation capability : 1RPM.

Rotary Kiln

Drying zone: — UPPER PART — 400°C

It is the upper part of Rotary Kiln having temperature around ~~250~~ 400°C where the water from the slurry evaporates. —

Calcinations zone: Central – 700-1200°C

It is middle portion of Rotary Kiln where temperature ranges from 700°-1200°C. in this region limestone undergoes decomposition to form quick lime and carbon dioxide (escape out).

$$CaCO_3 \rightleftharpoons CaO + CO_2$$

Lime stone — Quick lime

1. Rotatory kiln. steel tube - diameter 2·5 m — 30 m.
Length 90 m — 100 m
Inside : Refractory bricks.

2. Rotatory kiln rests on an inclined plain and it rests on roller barrings.

3. Supported on masonary column.

4. Hot flame is produced which heats the inside of the kiln upto 1175°C.

5. Raw mixture ⟶ injected into kiln (through upper end) — temp here is 400°C. ⟶ Raw material moisture gets evaporated. (drying zone) ⟶

* Calcium ~~Aluminium~~ Silicates
→ Calcium aluminates and silicates are

Clinkering zone: Lower part

It is the lower part of Rotary Kiln where quick lime with clay to form calcium silicate, aluminates and ferrite.

1500-1700°C.

Lime and clay undergo fusion, yielding calcium aluminate and silicate

$2CaO + SiO_2 \longrightarrow Ca_2SiO_4$ (Ca_2S) Dicalcium silicate

$3CaO + SiO_2 \longrightarrow Ca_3SiO_5$ (Ca_3S) Tricalcium silicate

$3CaO + Al_2O_3 \longrightarrow Ca_3Al_2O_6$ (Ca_3A) Tricalcium aluminate

$4CaO + Al_2O_3 + Fe_2O_3 \longrightarrow 4CaO.Al_2O_3.Fe_2O_3$ (Ca_4AF) Tetracalcium alumino ferrite

Aluminates and silicates of calcium fuse together to form HARD, GREYISH, STONES called CLINKERS

The aluminates and silicates are mixed with CaO to form stone like structure, known as clinkers. → These are very hot (about 1000°C)

iv) Grinding:

The cooled clinkers are ground to a fine powder in ball mill. At this time 2-3% of gypsum is added to prevent the early setting of cement. * Imp

Setting and hardening of cement

When water mixed with Cement, form a plastic paste. The past is subjected to hydration and gel and finally crystalline products are formed.

$$3CaO.Al_2O_3 + 6H_2O \rightarrow 3CaO.Al_2O_3.6H_2O + Heat$$

$$2(2CaO.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.6H_2O + Ca(OH)_2 + Heat$$

$$4CaO.Al_2O_3.Fe_2O_3 + 7H_2O \rightarrow Ca_3Al_2O_6.6H_2O + CaO.Fe_2O_3.H_2O + Heat$$

final setting of Cement

Tobermonite gel, calcium hydroxide crystallization and hydrated tricalcium aluminate are responsible for final setting and hardening of cement.

$$2(2\ CaO.SiO_2) + 6H_2O \longrightarrow \overbrace{3CaO.2SiO_2.3H_2O}^{\text{Tobermonite}} + 3Ca(OH)_2 + Heat$$

$$3CaO.Al_2O_3 + 6H_2O \rightarrow 3CaO.Al_2O_3.6H_2O + Heat$$

Role of gypsum: Act as Retarding agent for early setting of cement

2-3% of gypsum is added to prevent the early setting of cement.

$3CaO.Al_2O_3 + xCaSO_4.2H_2O \longrightarrow 3CaO.Al_2O_3.xCaSO_4.2H_2O$

Tricalcium aluminate gypsum Tricalciumsulphoaluminate

After the initial set, the paste becomes somewhat stiff. However the added gypsum retards the dissolution of Tricalcium aluminate (C_3A) by forming insoluble calcium sulpho Aluminate.

(ii) Final Set :- This takes place after few hours of mixing.
- This concrete mixture can neither be moulded again nor remixed.
↓
Gradually the mixture is hardened to an extent that even the std needle cant be penetrated.

Change from fluid → SOLID — SETTING.
(Plastic mass)

The process of solidification comprises of (i) Setting (ii) Hardening.

* Setting: It is defined as stiffening of original plastic mass due to initial gel formation.
↓
Hardening: "Development of strength" due to crystallisation.

* The strength developed by cement paste at any time depends on the amount of gel formed and extent of crystallization.

(i) Initial setting: Initial setting of cement paste

Initial Set: Cement + Water → plastic mass → can be moulded as desired.
Action of setting takes place. → But with time the mixture begins to lose its plasticity.
↓
marked by jellyfying of cement paste
↓
It shouldnt be disturbed untill it hardened.

Plaster of Paris (POP)

Plaster of Paris is Calcium sulphate hemihydrates having molecular formula $2CaSO_4.H_2O$ or $CaSO_4.1/2H_2O$.

Preparation:

When gypsum is heated about at 150°C then plaster of Paris is formed.

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow{150^\circ\text{-}160^\circ} \underset{\text{plaster of Paris}}{2CaSO_4.H_2O + 3H_2O}$$

Properties:

i) When plaster of Paris reacts with water, large amount of heat is release. It absorbed water and convert into gypsum. This process is known as setting of plaster of Paris.

$$\underset{\text{Plaster of Paris}}{2CaSO_4.H_2O + 3H_2O} \longrightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

ii) Plaster of Paris is a fine white powder. When heated at 200°C it first convert into *gamma*- $CaSO_4$ and on further heating at 600°C it changes into *beta*-$CaSO_4$.

$$2CaSO_4.H_2O \xrightarrow{200^\circ C} \textit{gamma}\text{-}CaSO_4 \xrightarrow{600^\circ C} \textit{beta}\text{-}CaSO_4 \xrightarrow{1100^\circ C} CaO + SO_3$$

When *beta*-$CaSO_4$ is heated about 1100°C, then it converted into quick lime (CaO) and SO_3. The quick lime is used in formation of cement.

Uses of Plaster of Paris:

i) It is used in making casting and in surgical bandage.
ii) Used in making plaster wall and for making plaster boards
iii) Used in making statue, toy, models etc.
iv) Used in formation of gypsum and cement.
v) Used in the formation of calcium sulphate.