

Cement

- A cement is a binder, a chemical substance used for construction that sets, hardens & adheres to other materials to bind them together.
- Cement is an anhydrous powder obtained by burning a mixture of various metallic oxides (Ca, Al, Fe & Si etc.) at high temp of about $1500-1700^{\circ}\text{C}$

Cements are of 4 types

Natural Cement

↓
 produced by calcining & pulverizing naturally occurring argillaceous & lime stone at high temp.

Puzzolana Cement

↓
 oldest among all types.
 first made from volcanic ash from mount vesuvius situated around a place called pozzouli in Italy.

Slag Cement

↓
 hydrated lime & blast furnace slag (a mixture of calcium & aluminium silicates)

Portland Cement

↓
 'magical power'.
 It consists primarily of compounds of lime, alumina, silica & iron. It forms a paste when mixed with water.

Composition of Portland Cement:—

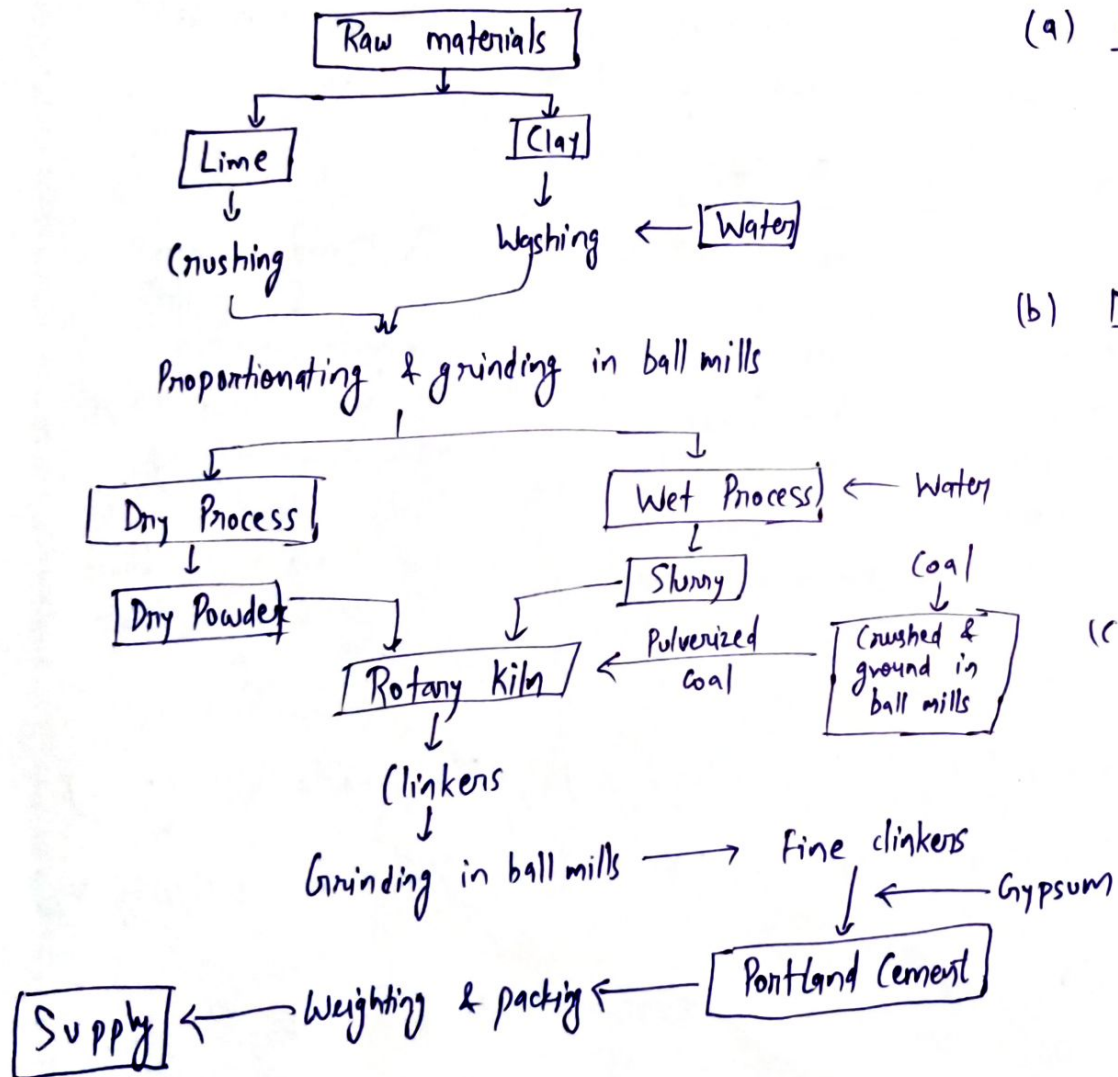
Lime (CaO) $\rightarrow$ (60-67%), Silica (SiO_2) $\rightarrow$ (17-25%), Alumina (Al_2O_3) $\rightarrow$ (3-8%),
 Iron Oxide (Fe_2O_3) $\rightarrow$ (0.5-6%), Magnesia (MgO) $\rightarrow$ (1-5%), Sulphur trioxide (SO_3) $\rightarrow$ (1-2%),
 Soda & Potash ($\text{Na}_2\text{O} + \text{K}_2\text{O}$) $\rightarrow$ (0.5-1.3%), Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

↓
 added during grinding

Manufacturing of Portland Cement $\Rightarrow$ It can be performed by two methods:

(i) Rotary Kiln Method:- It involves following steps:-

(A) Crushing (B) Mixing (c) Burning (d) Grinding (e) Packing



(a) Crushing:- Raw materials are grinded in ball mills & passed to tube mill conveyed through means of screw driver. The material is mixed with 30-40% water before grinding.

(b) Mixing:- The muddy mixture thus formed is known as slurry, which is generally stored in big tanks. This slurry contains about 38-40% water. The slurry is then pumped into the rotary kiln where it is burnt.

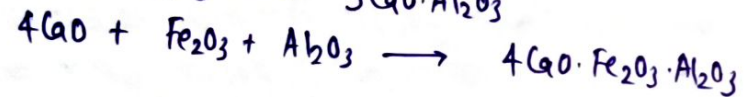
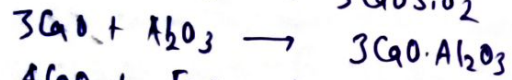
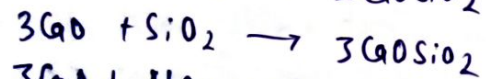
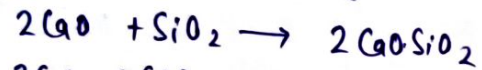
(c) Burning:- Actual chemical changes take place in rotary kiln. Heating of kiln is done by burning of pulverized coal & temp. maintained is $1400-1500^{\circ}\text{C}$. In fact, there are different zones in the rotary kiln viz.

(a) Drying Zone:- This is upper one fourth part of rotary kiln, here the temp. is moderate ($150-500^{\circ}\text{C}$). Here, water is driven out of slurry by means of hot gases.

(b) Preheating Zone:- Temp. in this zone varies from $500-700^{\circ}\text{C}$ where clay decomposes.

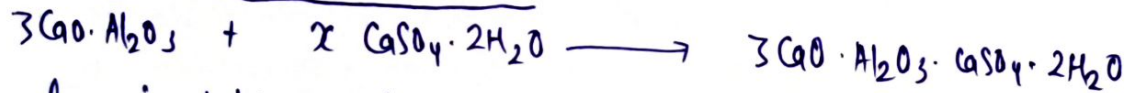
(c) Calcination Zone:- Its temp is about 1000°C & it is middle portions of the kiln.
 $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2 \uparrow$

(d) Burning / Clinker Zone:- Mixture melts & forms little rounded pasty masses about size of peas which are called clinks. The clinkers produced is greenish or black in color.



(e) Cooling of Clinkers:- Clinkers formed as pellets are very hot to handle, so they are allowed to cool very carefully.

(f) Grinding:- After cooling, clinkers are grounded to fine powder in ball mills. Finely ground clinkers set very quickly by absorption of moisture from the atmosphere. Therefore, a small quantity (2-3%) of gypsum is added which acts as retarder to prevent quick setting of cement.



Formation of insoluble product prevent too early further reactions of setting & hardening.

This mixture of ground Clinkers & gypsum powder is called 'portland Cement'.

(g) Packing:- The ground fine powder of cement is stored in silos from which packed by automatic machines into 50kg bag.

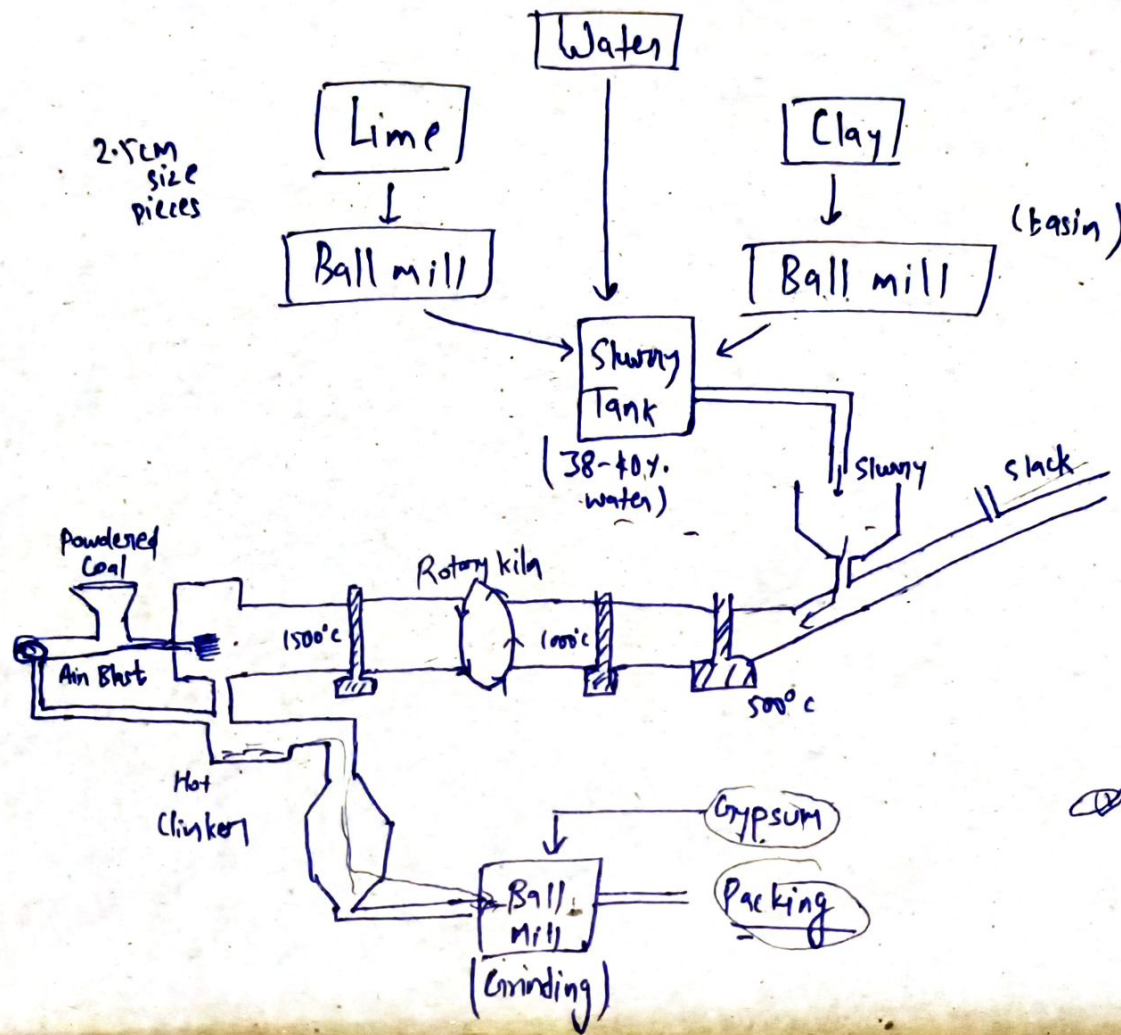


fig:- Rotary kiln for cement manufacturing

- (2) Vertical Shaft Kiln Method ⇒ Rotary Kiln Process is only used for large plants whereas V.S.K process can be used in mini cement plants.
- The capacity of mini cement plant may range from 40,000 to 1,50,000 tonnes/annum.
- In this process, the main set up of cement manufacture is vertical ~~based~~ instead of inclined.

Setting and Hardening of Portland Cement $\Rightarrow$

When water is mixed with cement, it forms a paste like mass, a hydration of compounds in cement takes place. This fluid like paste eventually becomes stiff & then hard. This action of change of mixture from a fluid to solid is known as 'setting of cement'.

During the process, gel is formed which adheres firmly to stones sand etc.

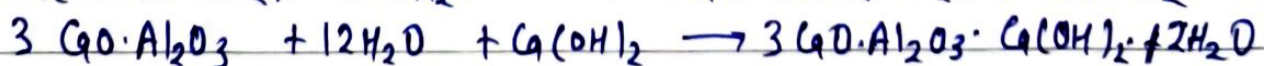
$\rightarrow$ The process of solidification comprises 3 stages:-

(i) Initial set $\Rightarrow$ When cement is mixed with water, a plastic mixture is formed which can be moulded as desired as the action of setting takes place gradually in 60 min & so.

(ii) Final set $\Rightarrow$ It takes place after few hours of mixing. Then, concrete mixture can neither be ~~moulded~~ moulded into any shape nor it can be remixed.

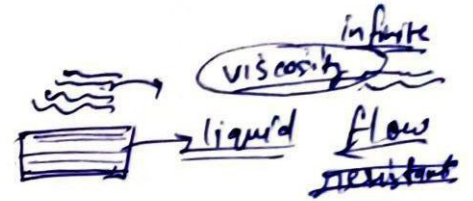
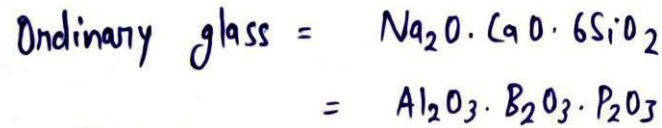
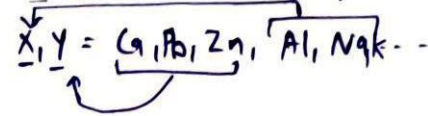
As the final setting of cement takes place, the mass attains such a stiffness that the standard needle can not penetrate in the cement mass at all.

(iii) Hardening:- After final setting of cement material begins to gain strength & this increase in strength which is known as hardening.



Glass

It is an amorphous, hard, brittle, transparent or translucent, super cooled liquid of infinite viscosity, obtained by fusing a mixture of a number of metallic silicates, most commonly of Na, K, Ca & Pb.



Manufacturing Process of Glass:-

Melting $\rightarrow$ Shaping $\rightarrow$ Annealing $\rightarrow$ Finishing

1. Melting $\Rightarrow$ The raw materials (sand, Na_2CO_3 & limestone) are ground and mixed with cullets & again ground to get finally powdered & intimate mixture called 'batch'.

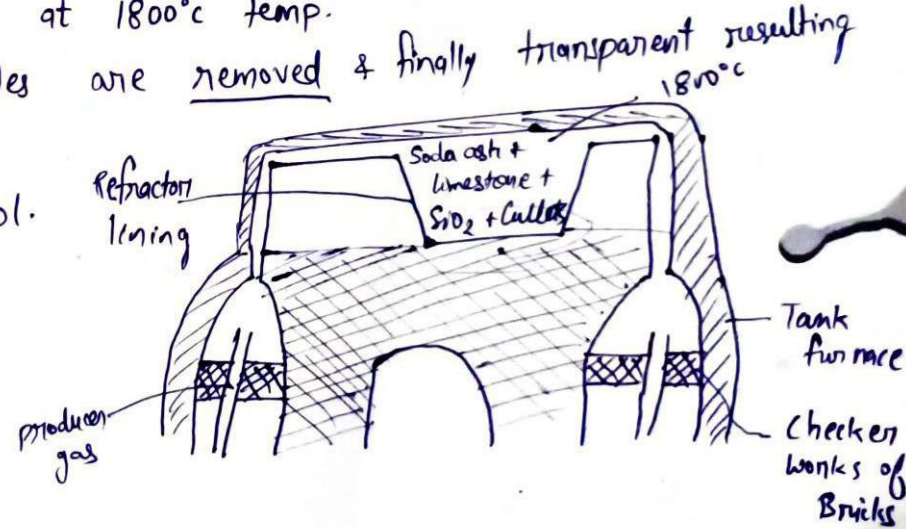
Melting of glass batch is done by either heating in pot or heating in tank furnace.

$\rightarrow$ Batch is heated in tank furnace by producer gas at $1800^\circ C$ temp.

Heating is continued till all the CO_2 & SO_2 air bubbles are removed & finally transparent resulting fused mass is obtained which is known as plain.

$\rightarrow$ Now heating is stopped & plain is allowed to cool.

The chlorides & sulphates of Ca, Al & alkali metals which are remained under composed with other impurities separate in form of sum called glass ball. & can be removed easily & then cooled to $800^\circ C$. The melt is drawn from working pits for shaping.



2. Shaping $\Rightarrow$ Molten glass is shaped into desired articles by either blowing or

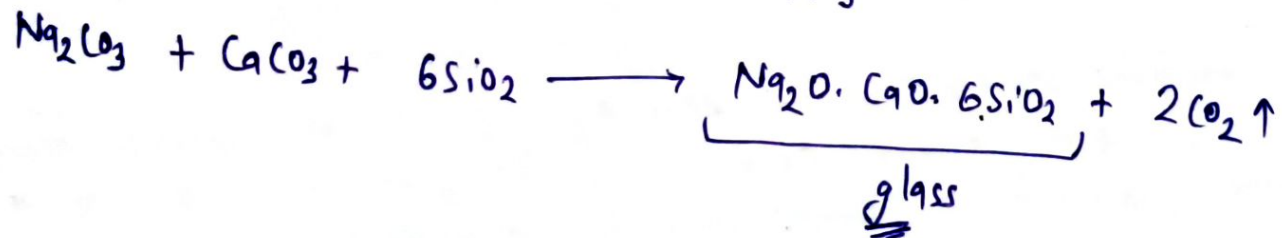
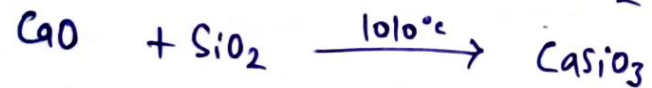
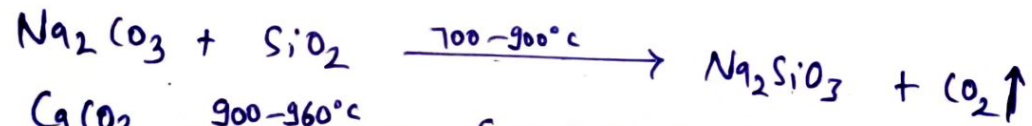
3. Annealing :- The glass articles are allowed to cool gradually at room temp. by passing through different chambers with descending temp., this is known as annealing.

The manufactured glass being a bad conductor of heat & if the glass materials are allowed to cool rapidly, the upper layers will cool down first, leaving the inner portions in a state of stress & strain. Due to this unequal expansion, the glass materials are much likely to crack to pieces. To avoid such problem, annealing is needed.

→ Glass must be cooled gradually & slowly at room temp by passing through different chambers with descending temp. is called annealing process.

4. Finishing :- After annealing process, all types of annealed glass require finishing. It is carried out by cleaning, washing, grinding, polishing, blasting etc.

Chemical Rxn :-



Types of glass ✓

Types of Glass:-

- (i) Soda-Lime glass / soft glass (ii) Potash glass or hard glass (iii) Lead / flint glass
* (iv) Borosilicate glass / jena glass * (v) Alumino silicate glass * (vi) Optical or crooks glass
* (vii) Safety glass / laminated glass (viii) Toughened glass (ix) Wined glass * (x) Glass wool
(xi) Photo chromic glass

(i) Soda-Lime glass:- It is prepared by fusing Na_2CO_3 , CaCO_3 , SiO_2 [$\text{Na}_2\text{O} \cdot \text{CaO} \cdot 6\text{SiO}_2$]

- Used in manufacturing of window glass, cheap lab glass wares, kitchen wares etc.
→ Properties:- → Easily melts ✓ → Cheap glass, ✓ → Less resistant to heat,

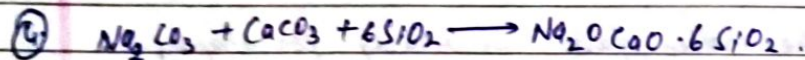
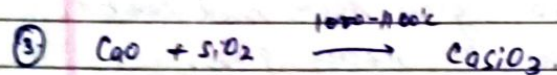
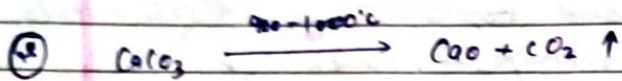
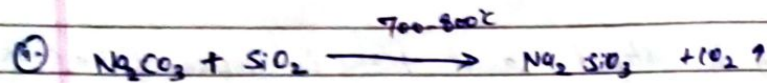
Borosilicate glass:- It contains boron trioxide (B_2O_3) & silica with a small amount of alumina & alkali-metal oxide.

80.5% SiO_2 , 13% B_2O_3 , 3% Al_2O_3 , 3% K_2O , 0.5% Na_2O

- Properties:- → Low thermal coefficient of expansion ✓
→ High chemical resistance ✓
→ Excellent shock-resistance. ✓

- Uses:- → Superior laboratory apparatus like flasks, beakers etc.
→ Television tubes, electrical insulators etc.
→ Industry for pipelines for corrosive liquids. ✓

chemical Rxn:-



Type of Glass:-

① Soda-lime glass (Soft glass) → It is prepared by fusing Na_2CO_3 , CaCO_3 , SiO_2 .
→ represented by $\text{Na}_2\text{O} \cdot \text{CaO} \cdot 6\text{SiO}_2$

Properties → 1) low m.p. easily melts 2) cheap glass
3) less resistant to heat & chemicals.

Uses → Used in manufacturing of window glass, cheap lab glass wares, cheap kitchen wares etc.

② Potash-lime glass (Hard glass) → It is prepared by fusing K_2CO_3 , CaCO_3 , SiO_2 .
represented by $\text{K}_2\text{O} \cdot \text{CaO} \cdot 6\text{SiO}_2$

Properties → 1) High melting point with difficulty 2) expensive
3) more resistant to heat & chemical.

Uses → Used in manufacturing of lab glass wares, combustion tubes, etc.

PAGE NO. Na₂O CaO 6SiO₂

③ Lead glass (flint glass) → It is prepared by fusing K_2CO_3 , Pb_3O_4 , SiO_2 .
(Lead potash glass)
represented by $\text{K}_2\text{O} \cdot \text{PbO} \cdot 6\text{SiO}_2$

Properties → 1) low m.p. 2) expansive ✓
3) more resistant to heat & chemical ✓
4) higher lustre with high refractive index ✓
④ Uses → used in manufacturing of optical devices, lenses, prism, neon tubes, mercury tubes.

⑤ Optical glass → It is prepared by phosphorus, (Crown's glass), cerium oxide, lead silicate which make the glass capable to absorbing U.V. lights.

Properties → 1) low m.p., low durability 2) expansive.

Uses → Used in manufacturing of lab glass wares, combustion tubes etc. ✓

Most Important

⑥ Borosilicate → (Pyrex, Jena glass) → It contains B_2O_3 & Al_2O_3 → alumina, with silica. $\text{Na}_2\text{O} + \text{K}_2\text{O}$ 12%
3.1% 80.5% 14.1%

Pro → high m.p., more durability, 3) expansive glass.
1) more resistant to heat & chemical.
4) low thermal expansion coefficient.

Uses → 1) Used in manufacturing of T.V. tubes, insulators, industrial pipe lines, lab apparatus, lab glass wares etc.

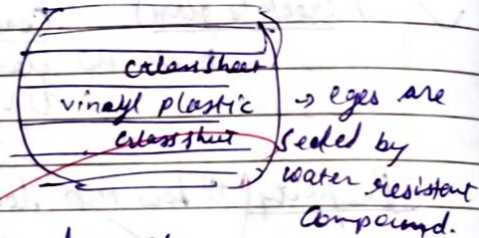
→ (i) Alumina Silicate glass → It contains SiO_2 and alumina with

Silica				
SiO_2	Al_2O_3	$\text{Na}_2\text{O} + \text{K}_2\text{O}$	MgO	CaO
85%	3.5%	3.5%	1.1%	9%

Properties → Same as previous ✓✓

Uses → Used in manufacturing TV, Combustion & High pressure lab apparatus & domestic equipments ✓

most important
⑥ Safety laminated
or layered glass
Bullet proof glass



→ A glass which when breaks does not allow its broken pieces fly apart.

Preparation :- A safety glass is prepared by placing a thin layer of vinyl plastic in between 2 glass sheet. These sheets are pressed together under heat so that vinyl plastic is sandwiched in b/w glass sheet.

The edges are sealed by water resistant compound to make tough glass.

Uses → Three layer glass is used as a wind shield in automobile and aeroplane industry. 5 layered is used in building construction.

and 7 layer laminated are used in for making bullet proof jacket and in automobile wind screen.

most important
⑧ Glass wool → It is a fibrous wool like glass.

Preparation → It is prepared by forcing molten glass through small holes (0.003-0.005 mm) diameter continuously to get thread like glass. The glass thread are thrown over rapidly revolving drums to get material like glass.

Properties → ① This glass is resistant toward heat fire and chemical.

② Its density is very low but tensile strength is very high.

Uses → ① Used in manufacturing for making fire man costume,

② in domestic appliances like vacuum cleaner, fan & motors.

③ Used in making for electrical insulator wires.

★ Fuel Numerical :-

① Dulong's formula (Q1) A coal sample contains 60% Carbon, 3% O_2 , 1% H_2 , 0.5% Sulphur, 0.2% Nitrogen, & 0.3% Ash.

Q2 Calculate H.C.V. & L.C.V of Sample. :-

$$\text{H.C.V} = \frac{1}{100} [8080 \cdot C + 34500 \left(H - \frac{O}{8} \right) + 2240 \cdot S] \text{ Cal/gm}$$

$$= \frac{1}{100} [8080 \times 60 + 34500 \left(6 - \frac{3}{8} \right) + 2240 \times 0.5] = 5514.70 \text{ Cal/gm}$$

Safety Glass / Laminated Glass:-

A glass which when breaks does not allow its broken pieces to fly apart.



Safety glass is prepared by placing a thin layer of vinyl plastic b/w two sheets of glass. Then plastic & glass sheets are pressed together under heat, so that plastic thin layer is sandwiched in b/w glass sheets. The edges of combined sheets are sealed with some water resistant compound. The glass becomes quite tough.



Properties:- (i) Shatter proof (ii) Quite tough

Uses:- (i) 3 Layer laminated glass is used as wind shields in automobile & aeroplane industries

(ii) Five-layer laminated glass is used in building construction.

(iii) Several layer laminated glass is bullet proof & used for making looking windows automobile wind screens.

Glass wool:- It is a fibrous wool like form of glass. It is composed of intermingled fine filaments of glass.

It is prepared by forcing molten mass of glass through small holes of average diameter of 0.005 to 0.007mm continuously. The fibers of glass so obtained are thrown over a rapidly revolving drum to get material in wool like form.

Properties:- Non combustible, fire proof, heat proof
Thermal & electrical conductivity are low.
Its tensile strength is about eight times that of steel.
Resistant to moisture & chemicals
Its density is quite low.

Uses:-

- filtration of acidic liquids
- oven, motors, vacuum cleaners
- costumes of fire men
- sound insulation.

Lubricants

Any substance introduced b/w moving or sliding surfaces to reduce friction in order to avoid or reduce the wear & tear is known as lubricant.

Functions:-

- Prevents direct metal to metal contact
- Prevents loss of energy
- Prevents seizure of machines
- Act as coolant in engine
- Absorb shocks b/w bearing & engine parts
- Reduces maintenance cost of machines

[Viscosity
Viscosity index
SEN (Steam Emulsion Number)]

* Classification of Lubricants:-

1. Liquid lubricant or Lubricating oils
2. Semisolid lubricants or Greases
3. Solid lubricant

* Types of Lubricant:-

1. Thin layer mechanism or boundary lubrication
2. Thick layer lubrications
3. Extreme pressure lubrications

Classification of Lubricants :-

1. Liquid Lubricants $\Rightarrow$ It is also known as lubricating oil. Lubricating oils reduce friction & wear b/w two moving metallic bodies by providing a continuous fluid film in b/w them.

A good liquid lubricant must possess:

- (i) Low vapour pressure or high boiling point.
- (ii) Adequate viscosity for particular service conditions
- (iii) Low freezing point
- (iv) High oxidation resistance & heat stability
- (v) Non corrosive properties.

Liquid lubricants also act as:-

- (a) Cooling medium (b) Sealing agent (c) Corrosion preventors

They are further classified as-

- (a) Animal & Vegetable oils (b) Mineral oils or Petroleum oils (c) Blended oils
(d) Synthetic oils.

2. Viscosity $\Rightarrow$ Viscosity is the property of lubricant or fluid by virtue of which it offers resistance to its own flow. It is mainly due to forces of cohesion b/w fluid molecules.

(a) → Animal & vegetable oil are obtained from animals & plants. These lubricating oil having good oil film. These oil are very expensive and stable up to extreme condition (high temperature & pressure) but can undergo oxidation to form gummy products. These oil cannot be used in pure form always used as additive.

(b) → Mineral Oil → These oil are obtained from fractional distillation of petroleum.
 → They are low molecular weight hydrocarbon with about 11-12 carbon atom.
 → They are cheap and available in abundance.
 → They are quite stable under service condition.
 → These oil having poor oxidation stability that animal and vegetable oil are mixed into these type of oil to improve their oiling.

(c) → Blended oil (Additives) → Blended oil are capable of giving desired quality of lubricant and which is required for specific machinery.
Anti oxidant → Aromatic phenol or aromatic amine are used as a antioxidant in oil.

Anti foaming → Glycerol & glycols are anti foaming agent in oil.

Corrosion inhibitors → Organic phosphorus & organic antimony are used as corrosion inhibitors in.

Diluent carrier → Animal & vegetable oil & fatty acid are used as a diluent carrier compound.

→ Viscosity Index improver → Relationship b/w temperature & viscosity both are inversely proportional to each other as the temperature increases viscosity will decrease. → viscosity means internal resistance which is offered by the liquid or oil against to its own flow.

Low VI	High VI
→ Rapid change in viscosity with respect to temp.	→ Slow change in viscosity w.r.t. temp.

→ A lubricating oil should have high viscosity index.
 → Emulsified → alkali metal salt of Carboxylic & Sulphonic acids.

(d) → Synthetic oil :- These lubricant which will not only work under extreme conditions but also bear wide range of various operational conditions.
 → ~~It is not~~ They are synthesised by the help of inorganic & organic chemical in laboratory.

→ Semi-solid lubricants → They are prepared by combining liquid lubricant with thickening agent (soap based).

→ The thickeners are higher molecular weight fatty acids of lithium sodium & potassium.

→ Semi solid lubricant are used when lubricating oil cannot remain in place due to high pressure temperature and high speed.
 → Grease are used at high temp. in gears & ball bearing.

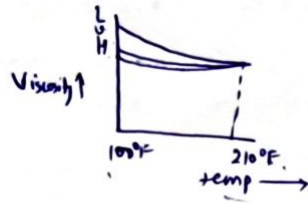
Determination of viscosity index:-

The viscosity index represent the average decrease in viscosity of an oil per degree rise in temperature blw 100°F to 210°F

$$V.I. = \frac{L - U}{L - H} \times 100$$

where U = Viscosity at 100°F of an oil whose V.I. is to be determined
 L = Viscosity at 100°F of an oil of zero V.I. having same viscosity at 210°F as the oil

H = Viscosity at 100°F of an oil of 100 V.I. having the same viscosity at 210°F as the oil.



(2) Semi-Solid Lubricants $\Rightarrow$ Obtained by combining lubricating oil with a thickening agent. Lubricating oil is principal component & it can either petroleum oil or synthetic hydrocarbon of low to high viscosity. They improve heat resistance. The fibrous structure of thickeners traps the oil & enables lubricant to cling to moving parts.
Greases have following uses:-

1. Where lubricating oil can't remain in place due to high load, low speed, intermittent operation, etc.
2. Grease works at high temp in bearings & gears.
3. In machines used for textile, edible materials, paper etc.

(3) Solid Lubricants $\Rightarrow$ Where oils & greases are either undesirable or inadequate. Then, solid lubricants are used in dry power form or mixed with water/oil, solid lubricants are preferred over oils & greases due to following reasons: where operating temperature, conditions ---, combustible can't be used

- Characteristics:-
- (a) Good thermal conductivity
 - (b) Low shear strength
 - (c) Chemical inertness
 - (d) Strong adhesion to applied surface
 - (e) Stability at operating temperature.

Flash point & Fire point →

Flash point is the lowest temp at which the lubricating oil gives off enough vapours that is ignited for a moment, when a test flame is brought near it.

The fire point is the lowest temp at which the vapours of lubricating oil burn continuously for at least 5 seconds when a test flame is brought near it.

SEN :- (Steam Emulsion Number)

The time in second in which oil & water emulsion separate out in distinct layers is called 'steam emulsion number' or demulsification number.

A good lubricant possesses low steam emulsion number.

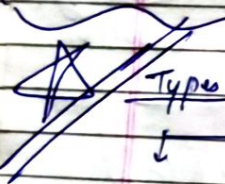
Type of semi-solid Lubricant

lithium based - $17^{\circ}\text{C} - 150^{\circ}\text{C}$ lab eqs.
 Na based - $170^{\circ}\text{C} -$ gear & ball bearing
 K based - $80^{\circ}\text{C} -$ water pumps

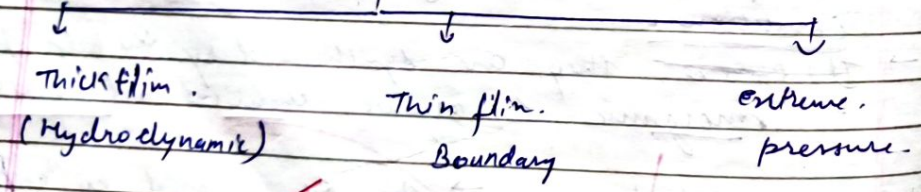
Solid Lubricant $\rightarrow$ when operational temp. pressure & load is extremely high such that condition lubricating oil or greases cannot remain in plain. So that solid lubricants are used.

Gr $\rightarrow$ Graphite $\rightarrow$ used in food stuff industries and air compressures.

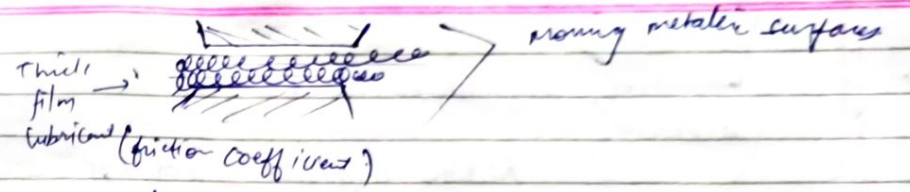
MOS₂ $\rightarrow$ Stable up to 400°C temp. used in extreme temp, pressure, condition



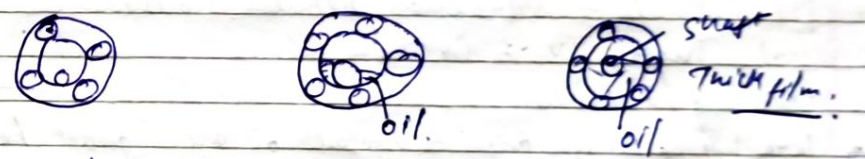
Type of Lubrication:



① Thick film $\rightarrow$ In this type the metal surfaces are separated from each other by thick films of lubricant so that the direct contact of metal surfaces is avoided & reduces friction and wear.



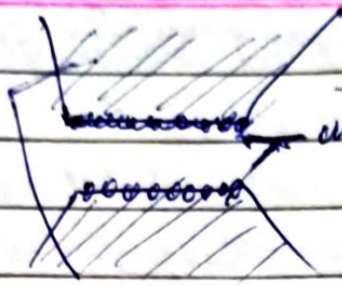
- $\rightarrow$ The resistance to movement of metallic surfaces is only due to the internal resistance between the lubricating particles moving over each other. So, that lubricant should have minimum viscosity under service condition.
- $\rightarrow$ It should remain in place and separate the metallic surfaces. Hydrodynamic lubrication occurs in a case of a shaft moving at a fast speed in ball bearing.



- $\rightarrow$ Thick film lubrication occurs in delicate machinery watches, clocks, scientific instrument, sewing machine etc.
- $\rightarrow$ Thick film lubrication is effectively done by hydrocarbon oil, blended with long chain polymer with antioxidants.

- ② Thin film lubrication $\rightarrow$ Under heavy load and a very low viscosity of oil, a thick film cannot be maintained in between moving metallic surfaces and direct metal to metal contact is possible than thin film lubrication is done.
- $\rightarrow$ when the speed is very low.
 - $\rightarrow$ The load is very high.
 - $\rightarrow$ low viscosity of oil.
 - $\rightarrow$ The shaft start moving from rest.

moving
metallic
surfaces.



chemically absorbed thin film.

friction coefficient = $0.05 - 0.15$.

→ Thin film lubrication is achieved by chemical absorption of lubricant on the metal surface.

→ For good boundary lubrication the lubricant should have

- (i) Long hydrocarbon chain.
- (ii) Active functional group.
- (iii) Capable to form bond with surface.
- (iv) lateral attraction between the chain.
- (v) high V.I. (Viscosity Index).
- (vi) good oiliness.

→ Graphite, MoS_2 , animal & vegetable oil are good boundary lubricant.

③ Extreme Pressure Lubrication :-

Under heavy load and high speed of operational condition of high temp. develops at the metal surface.

In that situation, liquid lubricant fail to stick the metal surface and get decomposed or vaporised. under such condition a special type of lubricants are used these are known as extreme pressure additives.

These are stable and capable of with standing at very high load and pressure & high temp. Metallic compounds of phosphorus, chloride and Sulphides. (mp. $650 - 1200^\circ C$) are used as extreme pressure additives.