Unit-3 Lubricants

Tribology is the science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication, and wear.

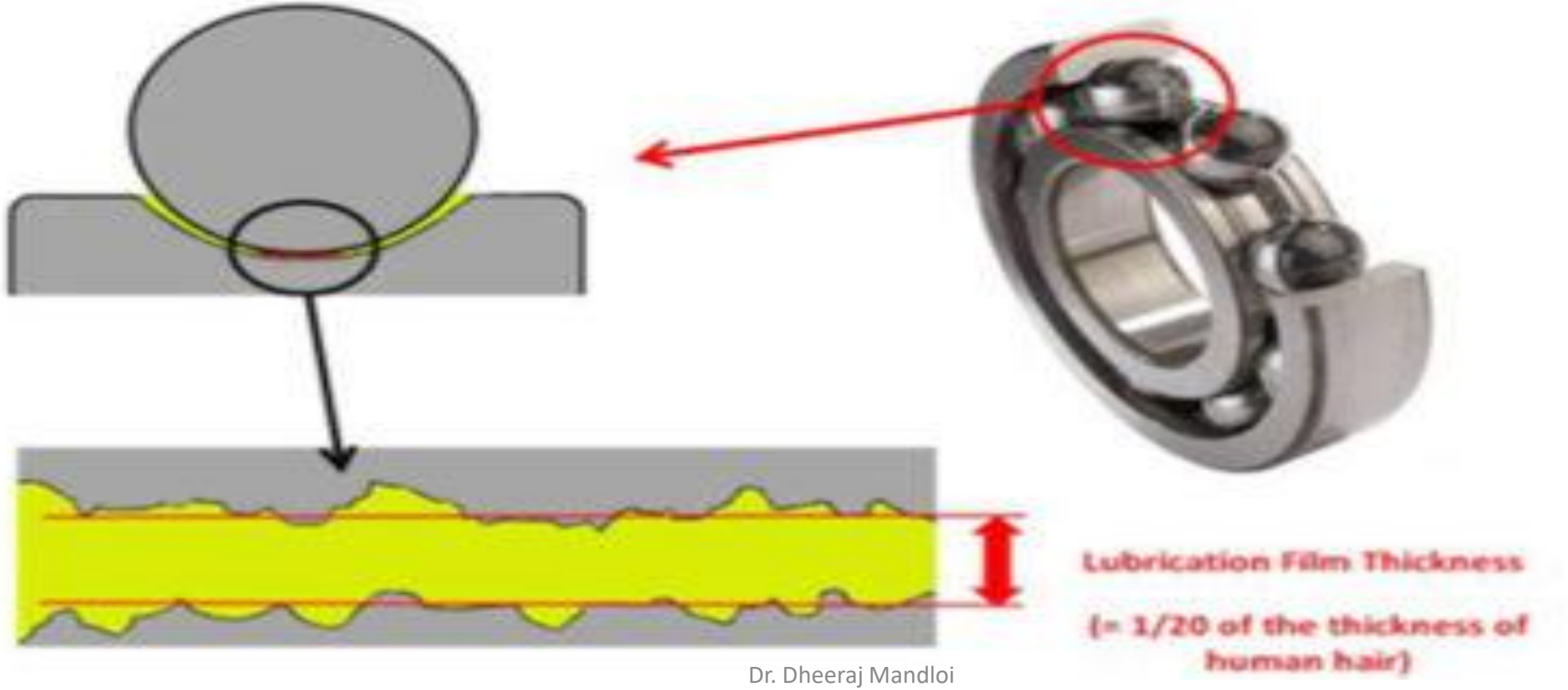
Lubricants word in English means **slippery**.

Q. Explain Lubricants. List various functions of Lubricants.

Any slippery material introduced in between two relatively moving surfaces, in order to reduce friction between them is called lubricant and this phenomenon is called lubrication.

Lubricant work (reduces friction) by forming a slippery, continuous, stable film between two moving surfaces.

How Lubricant work? Every surface have some degree of roughness (shown as peaks and valleys, ……rubbing, stress concentration, friction…..)
https://www.youtube.com/watch?v=u5RA3zHLIdM 4.43 mins



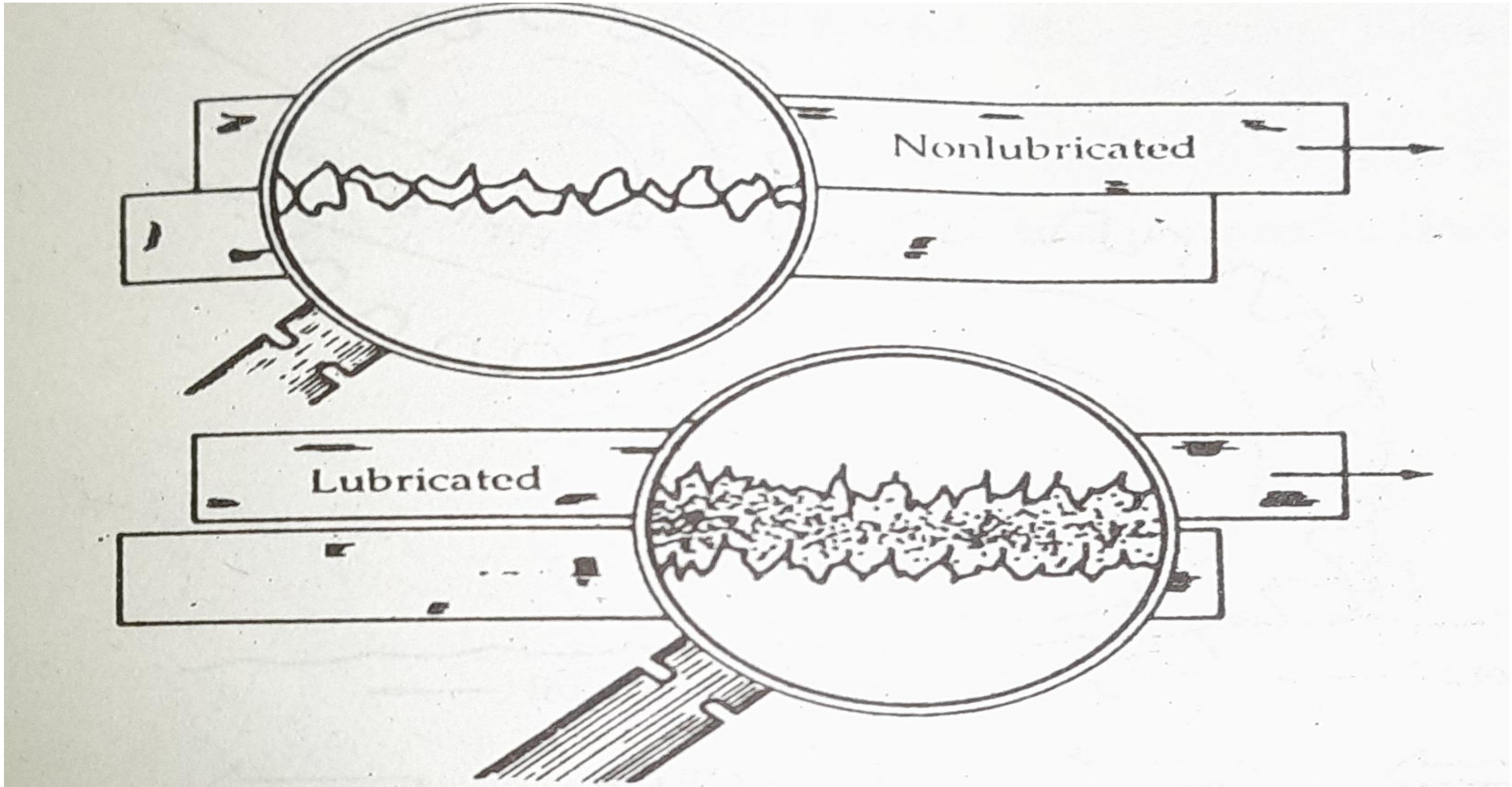
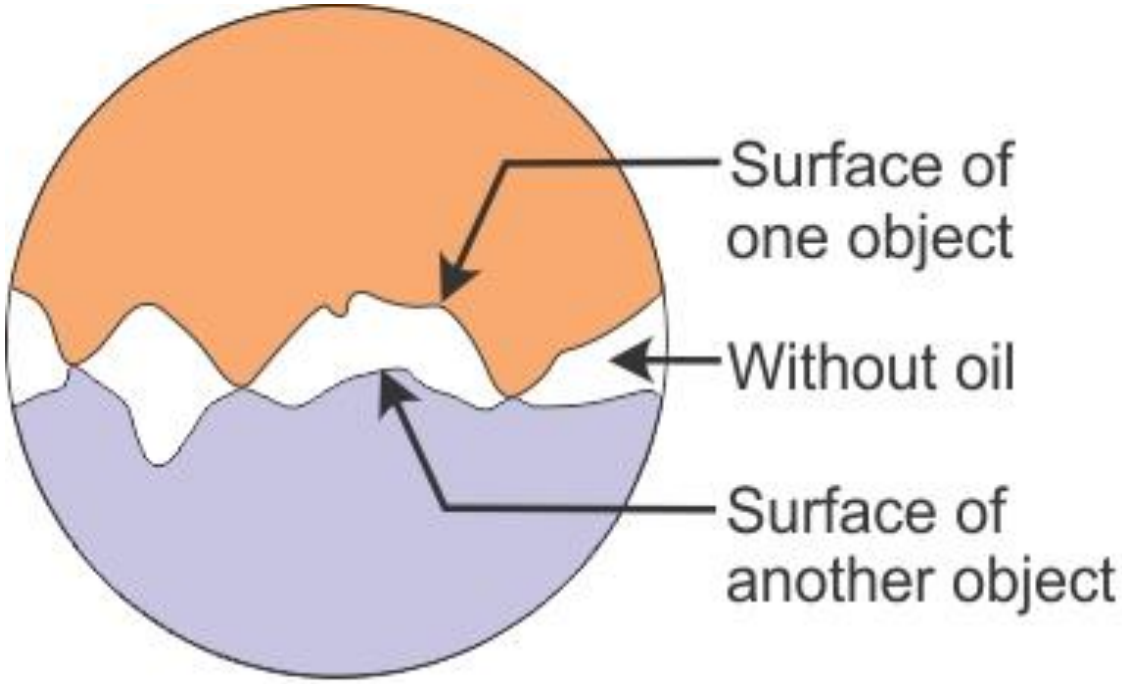
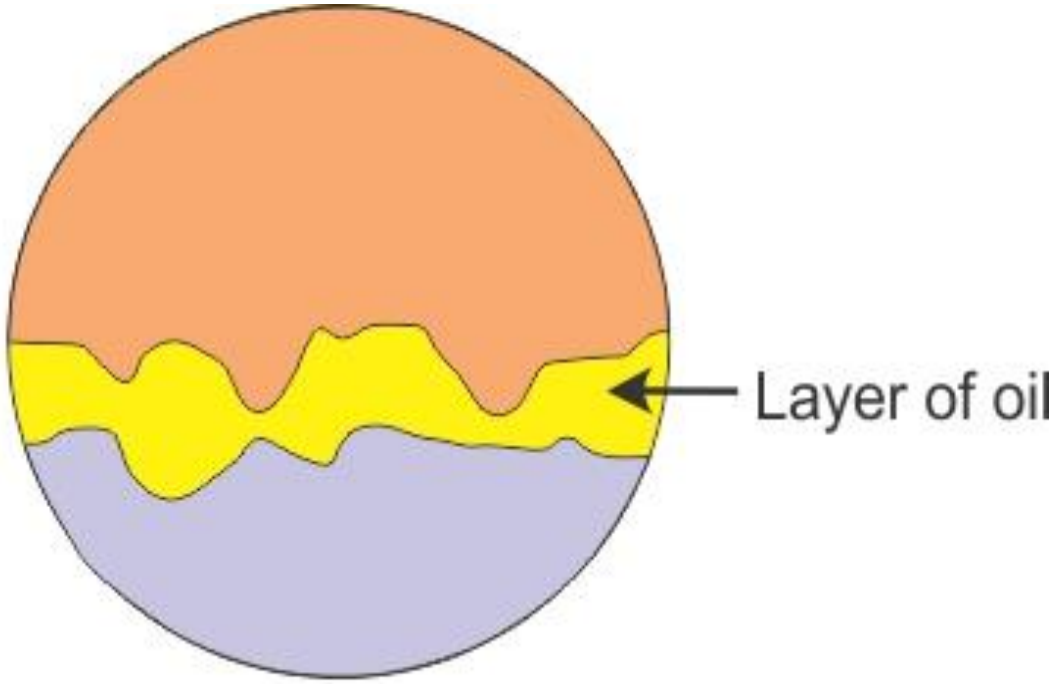


Fig. 1. Lubricants reduce friction.



Two rubbing surfaces when no oil is present between them



A layer of oil separates the two rubbing surfaces a little and reduces friction

Functions of lubricants

- Reduces friction between two relatively moving surfaces
- as coolant, helps in running machine cool
- Reduces wastage of energy, increases efficiency
- Reduces wear and deformation of rubbing parts
- Noise reduction by film (cushion) formation
- Corrosion preventer
- Cleaning agent (bike engine oil change)
- used as sealing agent (along with lubrication)
- Increases life of machine

Classification of Lubricants (by physical state)

1. Liquid lubricants (Oils, emulsions)- most widely used
2. Semi solid lubricants (Greases)
3. Solid lubricants – used under special conditions

I. Liquid Lubricants (Oils) - most widely used lubricants

Further classified on the basis of their chemical nature-

1. Fatty oils- Tallow (animal fat) is oldest lubricant used by humans

Fatty acid derivatives, Vegetable oils, animal oils, give examples…….

oiliness (ability to stick to the surface) is maximum, but thermal resistance is poor. So limited applications as lubricants.

- Used in various other fields like soaps, body oils/lotions, ointments, Cooking oils, pharmaceuticals etc.

2. Hydrocarbon oils, Mineral oils, Petroleum oils- Oiliness is good, thermal resistance is high, so suitable for heavy machines.
Obtained from fractional distillation of crude oil (India imports 95% of total requirement)
Hydrocarbon oils have wide variation in their structures, wide variation in properties, so wide range of HC oils is available (selection of oil is optimized as per requirement of machine)
Social, commercial, economic importance of HC Oils is very high

3. Blended oils – *its more than just oil, its liquid engineering*

Also called tailored oil, engineered oil (R&D)

Consisting of a base oil and different blending agents/ additives

Different blending agents/ additives are added to tailor (improve) various properties of base oil.

Commonly used additives are- thickeners, Viscosity index improvers, high pressure additives, oiliness carrier, anti-corrosive agents, anti oxidants, anti foaming agents, pour point depressants, carbon busters etc. (subject of R&D)

Lubricating oil is chosen as per working conditions and requirement of the machine.

Mechanism/ Theories of Lubrication

Lubricant work (reduces friction) by forming a slippery, continuous, stable film between two moving surfaces.

Mechanism depends on the nature of lubricating film formed (machine design and machine working conditions) **3 types**

1. Thick film/ Hydrodynamic Lubrication-

Oils are often used, light machines, clearance space is more, Viscosity and Viscosity index plays important role

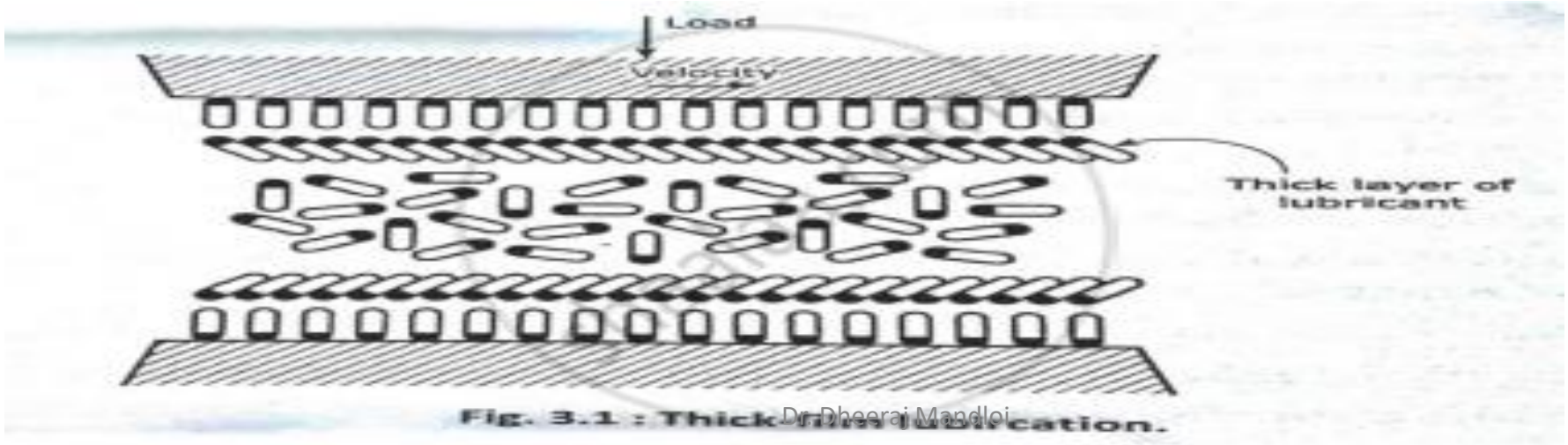
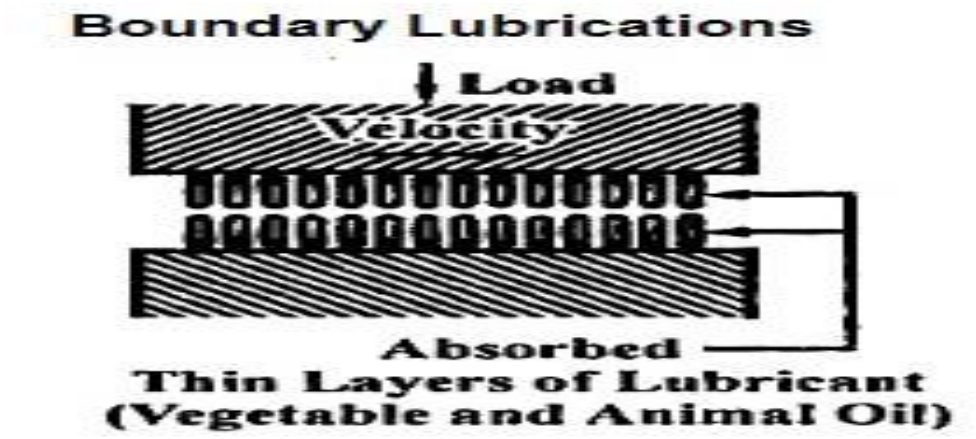


Fig. 3.1 : Thick film lubrication.

2. <u>Thin film/ Boundary Lubrication-</u>

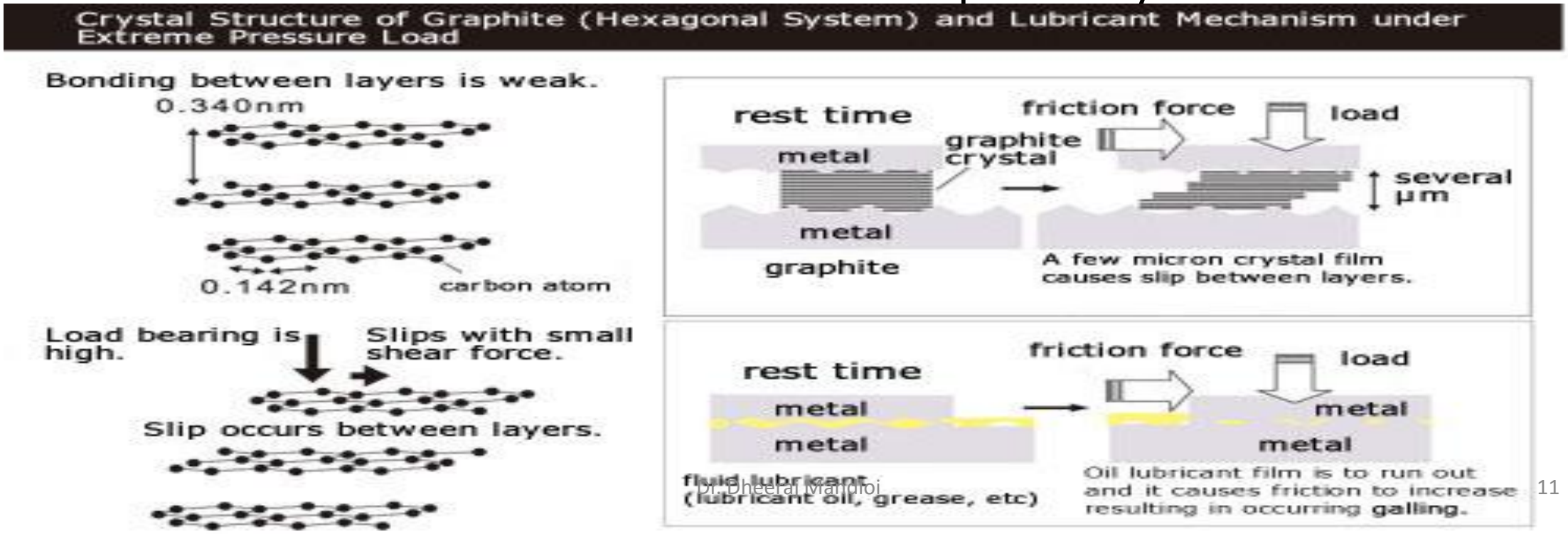
in heavy machines, clearance space is much less, a thin but very effective (high oiliness) film is present between two surfaces performing lubrication.

Oiliness plays important role.



3. Dry or Solid (Extreme pressure) Lubrication-

Not very common. Under extreme pressure, load conditions.
Used where properties of oil like viscosity, viscosity index, oiliness, flash point, thermal/decomposition stability may cause problem.
Soild lubricants like graphite, MoS_2 etc. are used OR Blended oils containing extreme pressure additives are used. Solid (slippery) film
Life of lubrication under such conditions is comparatively less



5 PROPERTIES AND TESTING OF LUBRICATING OILS

PROPERTIES AND TESTING OF LUBRICATNG OILS

- Viscosity
- Viscosity Index
- Flash Point
- Fire Point
- Cloud Point
- Pour Point
- Aniline Point
- Steam Emulsion Number
- Neutralisation Number
- Saponification Number
- Iodine Value
- Carbon residue

Properties of Lubricating Oils

A good lubricating oil should be slippery, required flow ability, thermal resistance, corrosion stability, mechanical stability, high bp, low fp etc.

1. **Viscosity**- property of liquid to resist its own flow.

Higher viscosity will offer its own internal friction. Lower viscosity will adversely affect stability of oil film. So, Viscosity should be moderate.

Viscosity of oil is measured as flowability (in seconds) by Redwood Viscometer No. 1 and No. 2.

Redwood viscosity is time required in seconds for flow of 50 ml of oil through Redwood viscometer under standard conditions. It is reported in seconds (not Poise).

Q. Explain construction, working and applications of Redwood Viscometers. Differentiate between Redwood Viscometer No. 1 and No. 2. (Refer Lab manual)

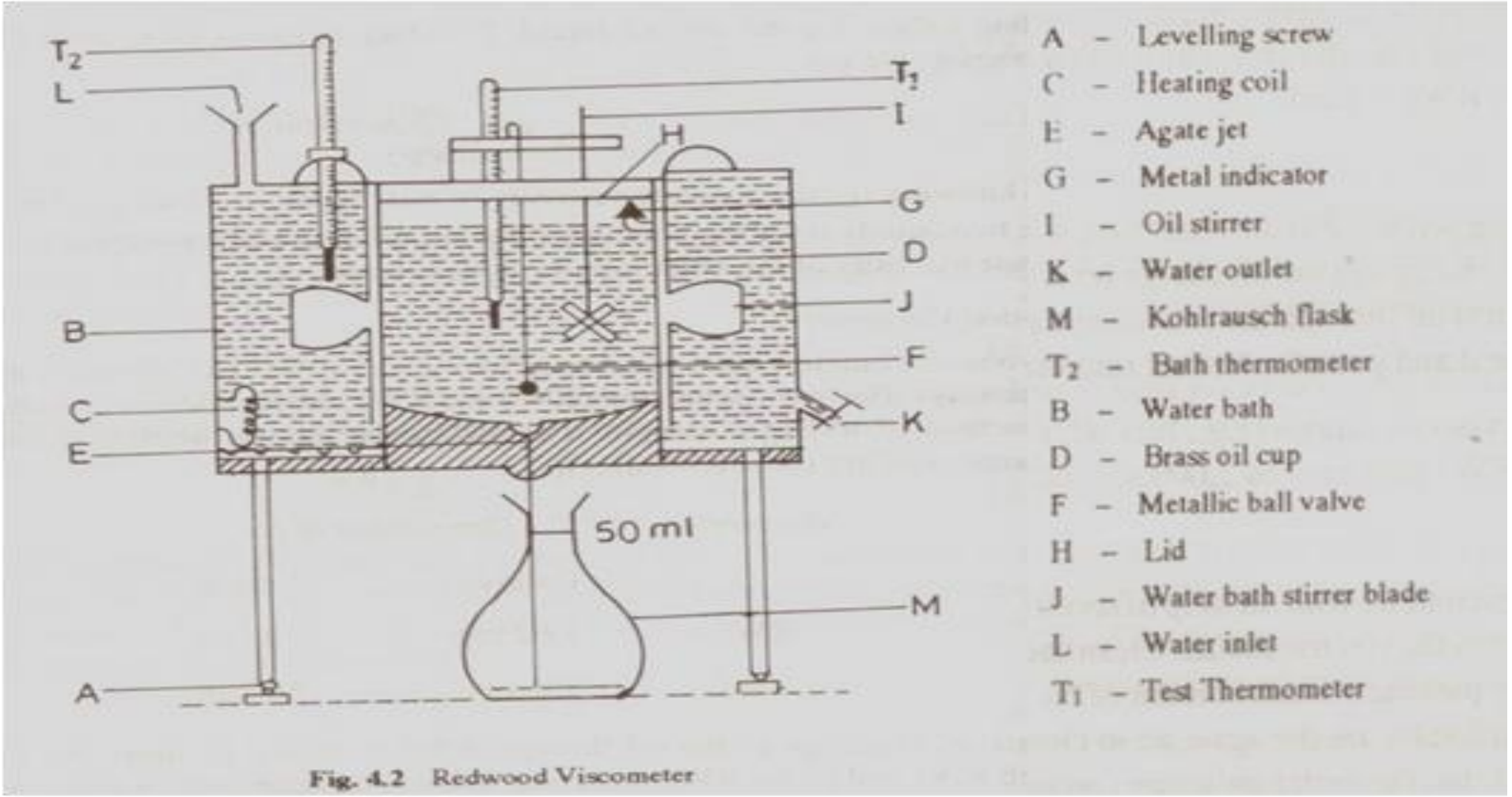


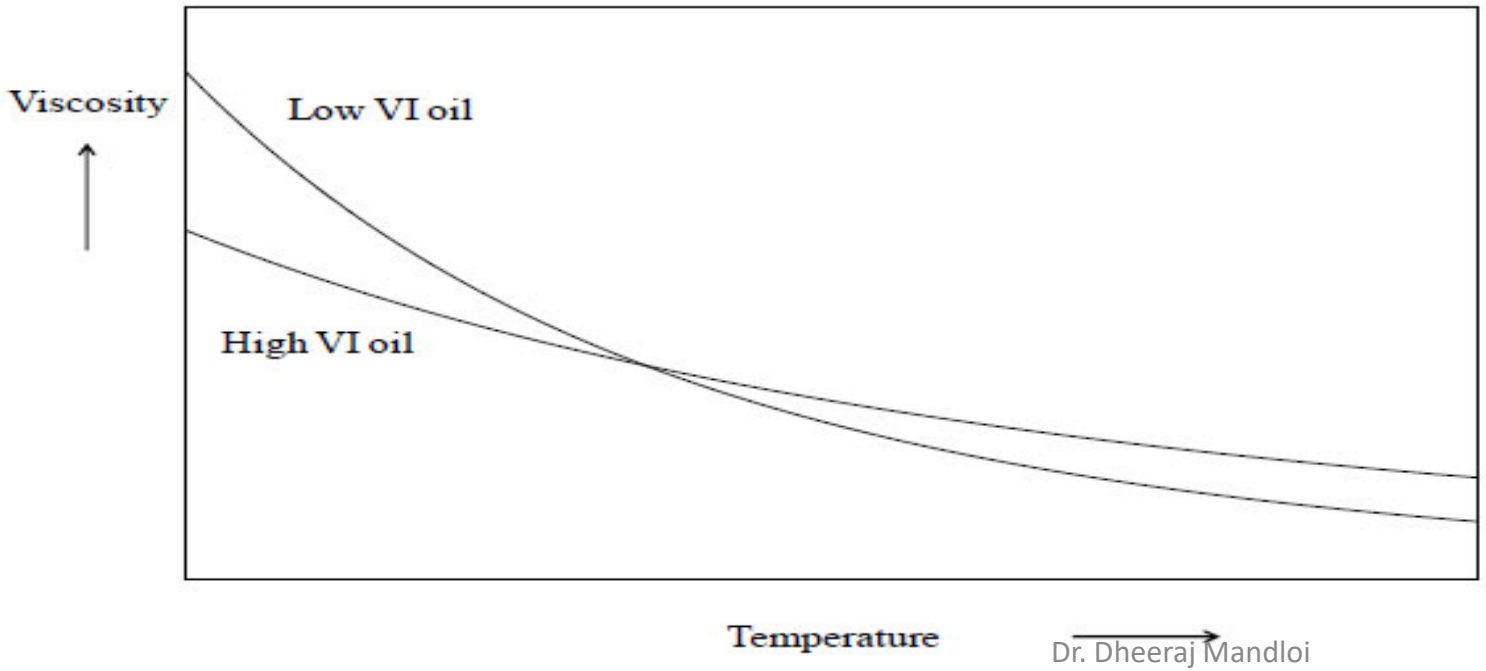
Fig. 4.2 Redwood Viscometer

2. **Viscosity Index** – It is experimental data based mathematical calculation, tells about rate of change of viscosity with temperature.

High VI oils- rate of change is slow

Low VI oils- rate of change is fast.

Good oil should have high Viscosity Index. (Refer Lab manual)



3. **Flash Point and Fire point**- **Flash point** is the minimum temperature to which oil is heated to produce a flash when a small test flame is brought near to it. (Refer Lab manual)
Oil start continuous burning at **Fire point**.
Pensky- Marten apparatus OR Abels apparatus is used.
For safety, Flash point is more significant.
A lubricating good oil should have high flash and fire point.

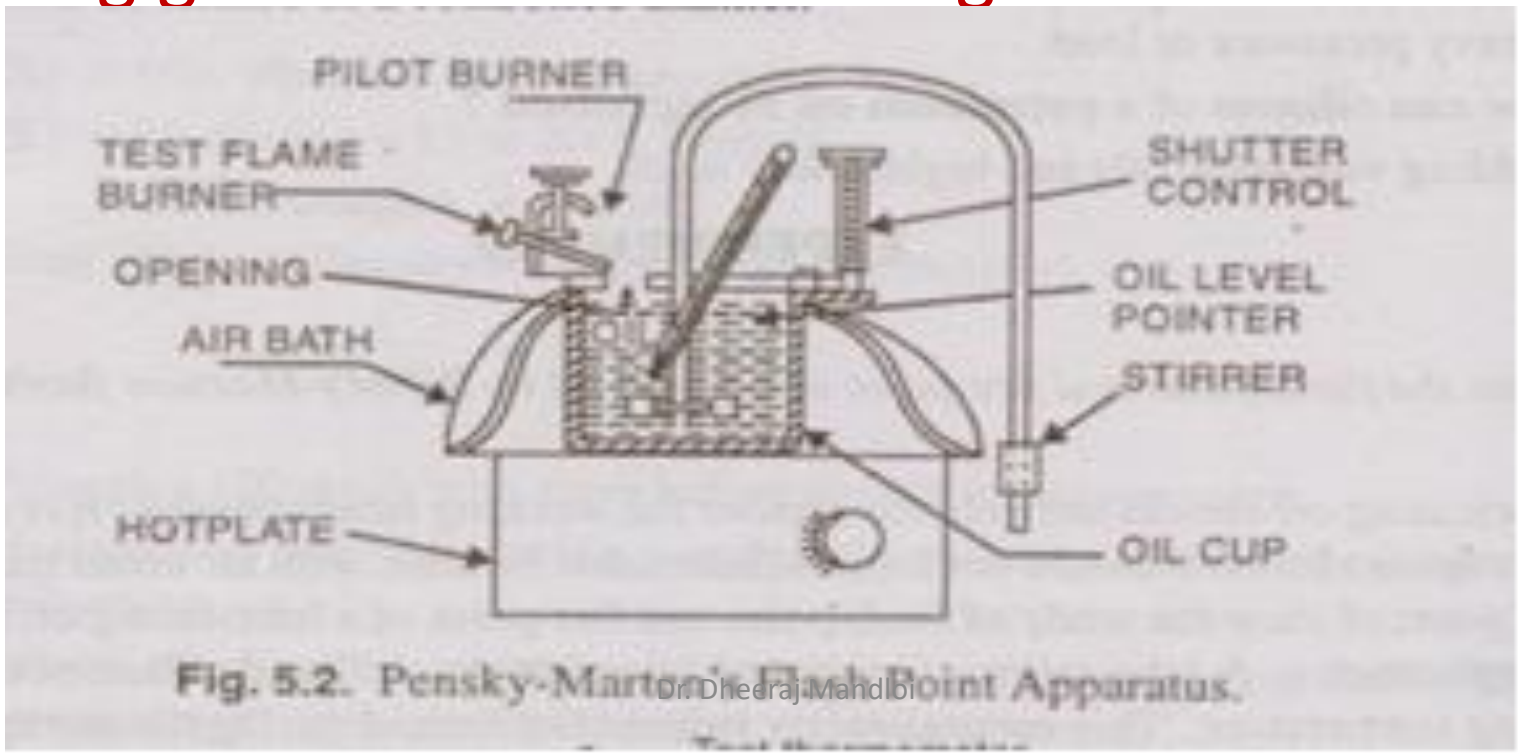


Fig. 5.2. Pensky-Marten's Flash Point Apparatus.

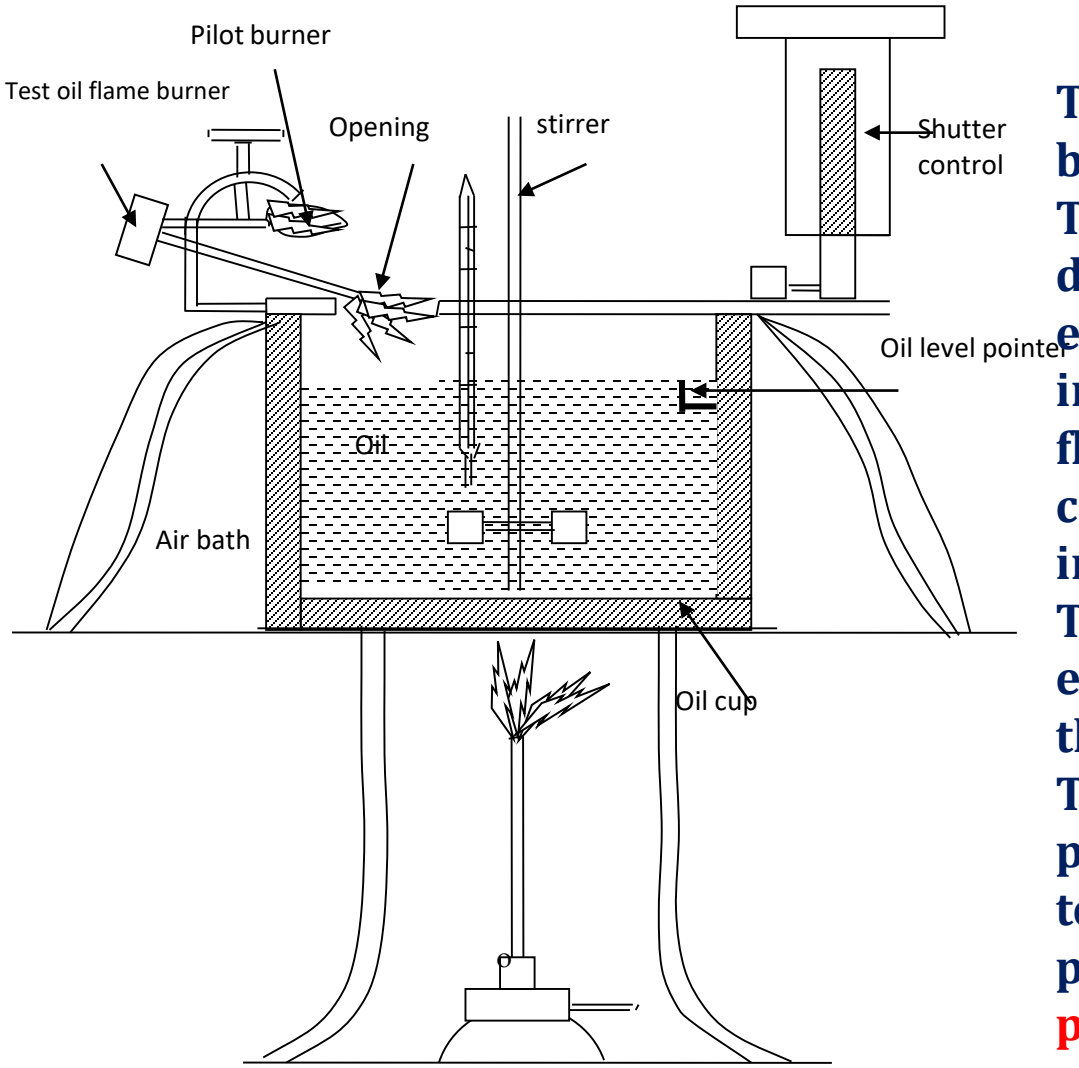


Fig 3.8 Pensky-Marten's Flash-point apparatus

The flash and fire point are determined experimentally by using Pensky-Martens apparatus.

The apparatus consists of a small cup with 5cm diameter and 5.5 cm height which is closed at the top except at few places where gaps are provided for inserting the thermometer, stirrer and introducing flame. A shutter which can be moved on the top of the container by lever mechanism and can open the lid for introducing the test flame.

The container is gradually heated using a burner. For every 1^0C rise, the test flame is introduced by opening the lid with the removal of shutter.

The temperature at which the introduced test flame produces flash is noted as the flash point. Similarly the temperature at which the introduced test flame produces fire at least for 5 seconds is noted as the fire point.

4. **Aniline Point** – It is minimum temp at which equal volumes of oil and aniline mixture get completely miscible in each other.

Oil contains mixture of hydrocarbons (aliphatic/aromatic).

Higher aromatic content will lead to corrosion, dissolve rubber etc.

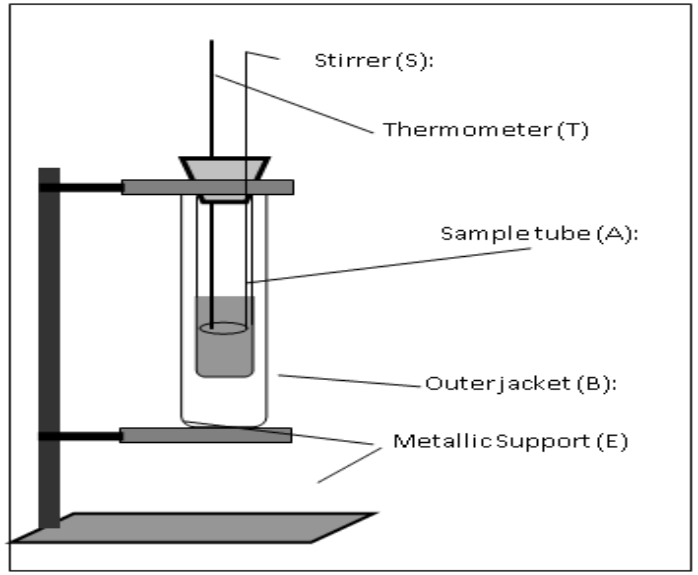
A good lube oil should have low aromatic content, so Aniline point should be high.

Oil A - Aniline point is 60 Degrees C

Oil B – Aniline point is 70 Degrees C

Which is better and why?

(Refer Lab manual)



5. **Steam Emulsification Number SEN** – It is minimum time required in seconds for complete separation of oil- water emulsion.

It tells about affinity of oil with water.

A good lube oil should have low SEN. (Refer Lab manual)

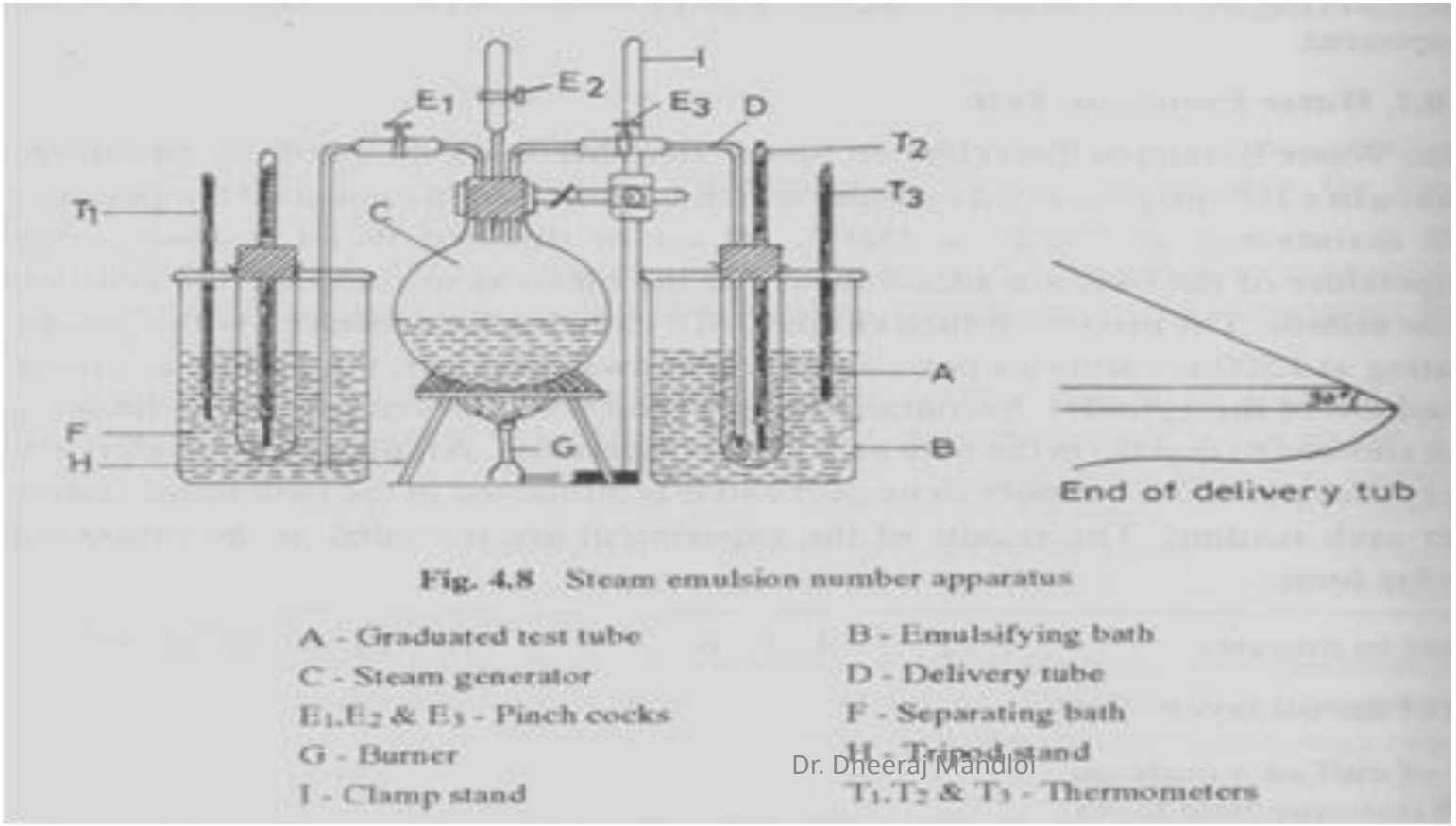


Fig. 4.8 Steam emulsion number apparatus

A - Graduated test tube
B - Emulsifying bath
C - Steam generator
D - Delivery tube
E1, E2 & E3 - Pinch cocks
F - Separating bath
G - Burner
H - Tripod stand
I - Clamp stand
T1, T2 & T3 - Thermometers

6. **Oiliness** – ability of oil to stick with the surface.
Good lube oil should have high Oiliness. It increases stability, efficiency and life of lubrication.

7. **Carbon deposits** – It measures ability of oil to deposit C during prolonged working.

A good oil should have low Carbon residue.

8. **Corrosion stability** – Oil should not induce corrosion during working.

Tested using both lab test and field test.

A good oil should have high Corrosion stability.

9. **Acid Number/ Acid Value/ Neutralization Number** – It is number of milligrams of KOH required to completely neutralize up to phenolphthalein end point free acids present in 1 g oil sample.
Test performed using volumetric acid-base titration.
Oil should not contain acids (highly corrosive)

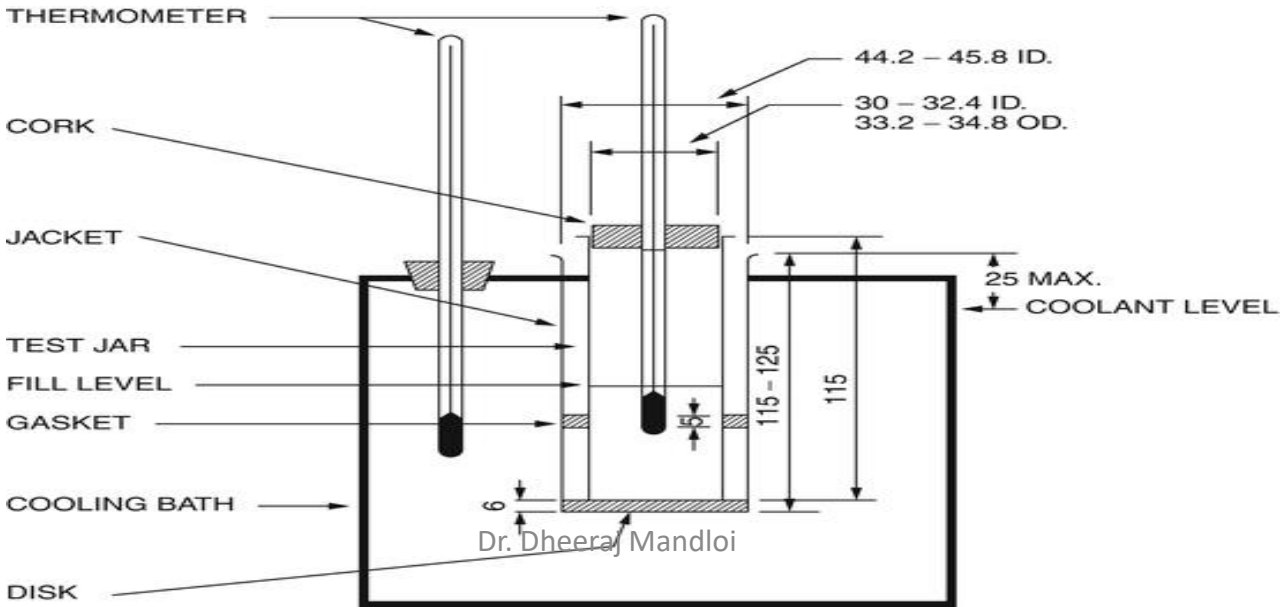
10. **Saponification Number** – It is number of milligrams of KOH required to completely saponify fatty acids contents present in 1 g oil sample.

This test is generally used for fatty oils to identify unknown oil or to check adulteration in fatty oil.

11. **Cloud and Pour point** – This test is useful for oil to be used at low temperatures. Tells about lower temp suitability and working of lube oil.

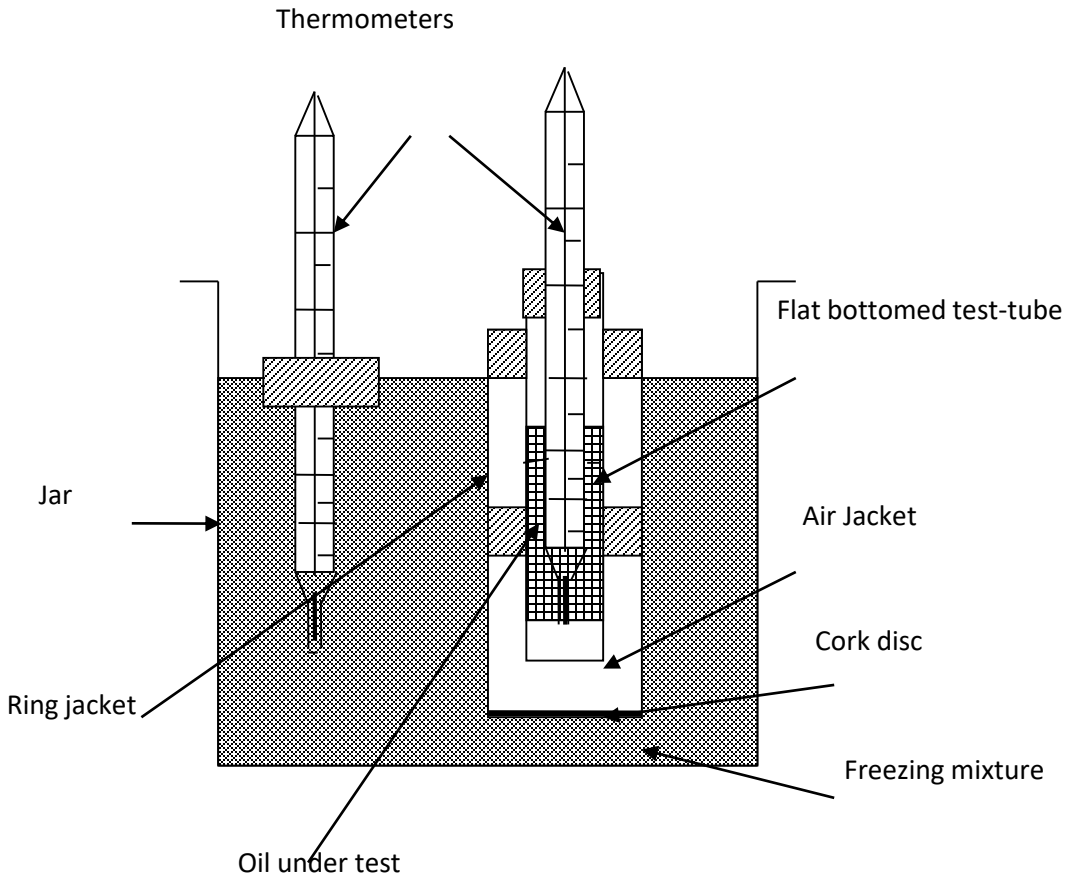
Cloud point is temp on cooling, at which cloudiness/ fogginess/ haziness appears on cooling oil sample under standard conditions, due to separation of heavy HC from oil.

On further cooling, **Pour point** is temp at which oil stops to pour (flow, now oil will jam the machine)



To determine the cloud point and pour point, the pour point apparatus shown in Fig is used. The apparatus consist of a flat bottomed glass tube containing the lubricating oil at a standard height. This is placed inside an air jacket flat bottomed bigger glass tube. In the centre of the main glass tube , a thermometer is introduced for noting the temperature of the lubricating oil. The test tube along with the outer air jacket test tube are placed inside a beaker containing ice and salt ($CaCl_2$).

The middle test tube containing oil is withdrawn from the ice mixture and outer jacket for every 1^0C fall of temperature (approximately) and noted for any change in state. The temperature at which cloudiness is noticed is recorded as the cloud point. Similarly after some time, the temperature at which the lubricating oil solidify and resist to flow is recorded as the pour point.

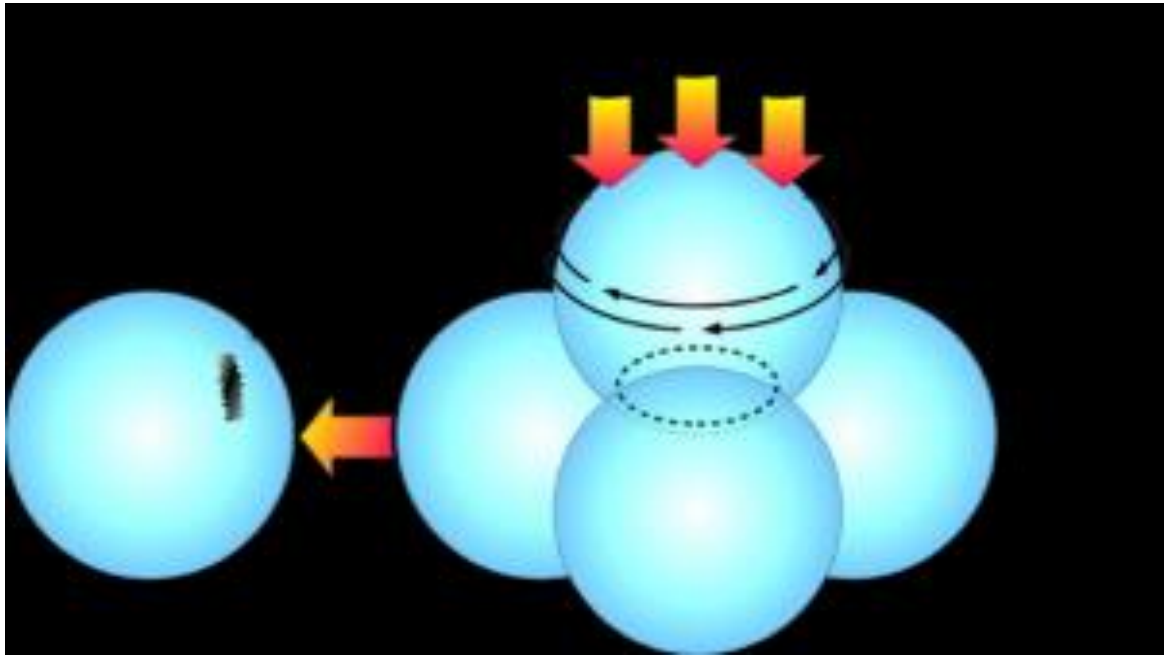


Cloud and pour-point apparatus

12. **Mechanical strength/ stability** – It tells about up to what extreme conditions of speed and load, oil can perform lubrication.

It is tested in lab using Four balls extreme pressure lubrication test.

Lube oil is selected as per working conditions and requirement of Machine.



II. **Semi Solid Lubricants**

Greases are semi-solid lubricants consisting of soap dispersed in oil.

We have already discussed a lot regarding Oils.

Soap is used as thickening agent and it also affects other properties of Grease like Thickness of grease (Consistency by Penetrometer), water resistance and temperature resistance (Drop point of Grease).

Greases are used mainly because of their semi-solid nature (thickness, consistency).

Coefficient of friction of greases is higher than oils.

Greases are classified on the basis of soap present

Eg. Ca, Na, Si, Li Grease

Types of Greases

1. Calcium Grease – Ca soap, water resistance is very good, Drop point is 80 degrees C.

Most commonly used and cheapest of all grease.

General purpose grease for ordinary applications.

2. Sodium Grease – Na soap, water resistance is poor, Drop point is high (so suitable for heavy machines). Cost is higher than Ca Grease.

3. Silicon Grease – Si soap, also called Adhesive Grease, used for effective sealing along with lubrication.

4. Lithium Grease – Li soap, also called Low temp Grease. Suitable for working at very low temp, working temp range is wide.

Very costly also (used for specific/extreme applications)

Conditions suitable for use of Grease

Used due to its heavy consistency (semi-solid nature)

1. In open systems
2. stable oil film is difficult to maintain
3. spurting of oil is problem
4. Sealing is required
5. Less maintenance, More life
6. To lubricate high loads with low speeds

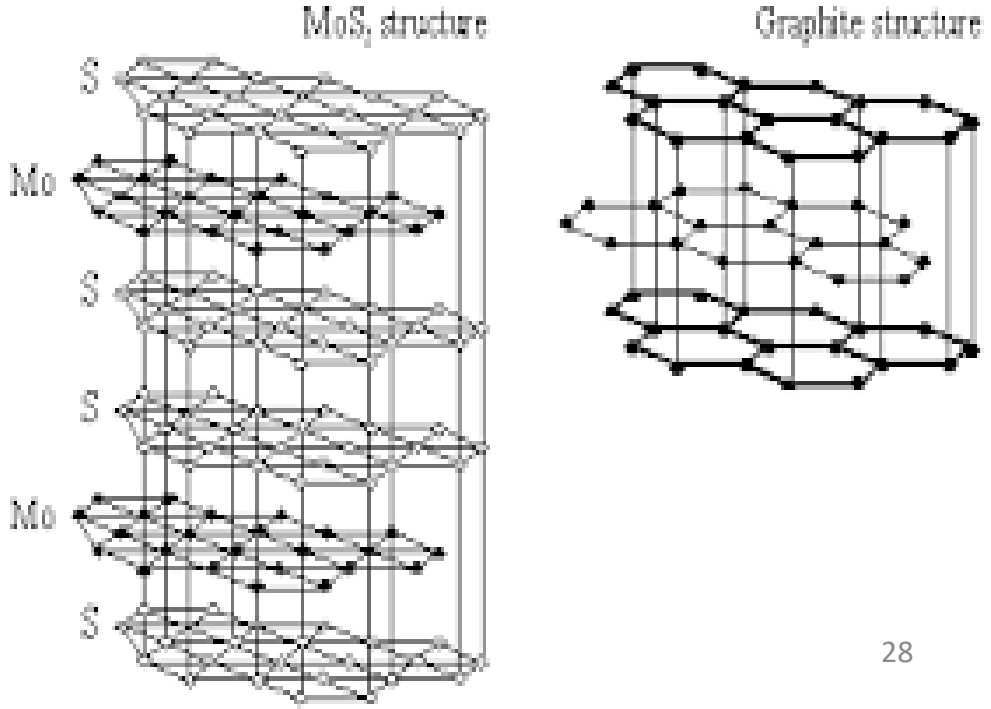
III. **Solid Lubricants**

Solid lubricants (slippery) reduce friction by separating two moving surfaces under boundary conditions. They are used in the dry powder form, coatings, or mixed with oil.

Solid lube possess lamellar structure preventing direct contact between the sliding surfaces even at high loads.

Used where-

- Carrom board
- Rifle barrel
- Teflon tape (plumber-water line tap)
- Operating temp and load is too high
- Contamination of lube oils or grease
- Moon surface



Cutting Fluid

Fluid used as coolant and lubricant for cutting purpose (hard objects)

(to cool and lubricate both tool and workpiece, carries debris away, increases tool life, dimensional accuracy, good surface finish).

Used during cutting of hard metals/ ceramics.

Ceramic tiles cutting - water is used,

oil-water emulsions

Properties of good Cutting fluid

- Good cooling and lubricating property
- Flash point is high
- Non-corrosive
- Chemical stability (long life)
- Non-toxic, non-allergic (resistance to rancidity)
- Viscosity is low (continuous flow, also to wash away cutting chips)
- Light/transparent in color (so cutting operation is visible)
- SEN is high
- Availability and cost