LUBRICANTS

FRICTION

→ Static Friction
→ Kinetic friction
* Sliding friction (different hardness of two parties)

* ~~Heat effects~~ Disadvantages
  → Wear & Tear
  → Regular servicing required
  → Heat (thus expansion)
  → Low efficiency
  → Noise
  → More power consumptn
  → More fuel

LUBRICANTS

* Functions
  → Reduces wear & tear
  → Reduces maintenance cost
  → Reduces waste of energy / power
  → Reduces metal expansion (heat)
  → Avoids seizures
  → May act as seal (piston-cylinder)
* Types
*1 Thick - Film Lubrication / Fluid-film / Hydrodynamic
  → Most basic
  → > 1000 Å (thickness)
  → Frictional coff = 0.001 - 0.03
*2 Thin - Film / Boundary Lubrication
  → Varying speed - High load
  → Low viscosity
  → 10 - 20 Å

→ Frictional coeff. (0.05 - 0.15)

* Extreme Pressure
→ High pressure - high temp
→ eg: chlorinated esters, tricresyl phosphate

~~* Viscosity~~
* Classification: (physical state)
→ Liquid → Lubricating oils
(i) Animal / vegetable oil
(ii) Mineral / petroleum oil
(iii) Blended oils ((ii) added with additives)

→ Semi Solid → Greases
eg: Calcium-based, Soda-base, Lithium-base, anle.

→ Solid
eg: Graphite, molybdenum sulphide

→ Honourable Mentions: Synthetic lubes, Lubricating emulsions (polyalkyl. glycole etc.)

* PROPERTIES:
1) VISCOSITY: (unit = poise)
Too viscous → creates friction
Too less viscous → can't stand on the surface
∴ sweet spot

* Viscosity Index: Scale of change in viscosity with temp.
(Greater is its vulnerability to temp. lower is the VI.)
How to calculate?
There are 2 standard groups of oils.

(3) † Modifying VI: (i) polymeric molecules sensitive to temp.
eg: polyolefins, polyalkylmethacrylates etc.

†† VI Index: <35 (low grade); 35-80 (medium)
80-110 (High grade); >110 (very high)

(i) paraffin-base Pennsylvanian oils (H-oil) (VI = 100)
(ii) naphthanic-base gulf oils (L-oil) (VI = 0)

Step1) Take viscosity of test oil at 210°F and 100°F (as V and U)
Step2) Take the H-oil and L-oil with same viscosities as test oil at 210°F ~~(as H and L)~~
~~Step3) $VI = \frac{L-U}{L-H} \times 100$~~
Step3) Take the viscosity of selected H and L-oils at 100°F (as H and L)

$\therefore VI = \frac{L-U}{L-H} \times 100$

* Viscometers:
(i) Brookfield viscometer
(ii) Saybolt viscometer
(iii) Redwood viscometer. (Time of collection for 50mL, capilliary diameter = 1.62 mm)

2) Flash and Fire Points: (unrelated to lubrication)
> Flash point:- lowest temp. at which oil gives ignitable vapours
> Fire point:- lowest temp at which oil gives ignitable vapours that cause a flame afor > 5 sec (5-40° > flash pt.)
→ Apparatus: Abel Cup, Pensky Marten, Cleavelands cup (open)

3) Emulsification:
> Ability to mix with water
Demulsification number / Steam Emulsion Number (SEN)
How to calculate?
Step1) Take 20 ml oil and bubble it with 100°C steam till 90°C
Step2) Note the time till oil and water form layer while keeping temp. constant at 90°C.
This time in sec is SEN. (Lower the better)

Apparatus Functioning: 5), 6), 7)

4

4) Oiliness: Stickiness when subjected to heavy load. Vegetable oils have high oiliness while mineral oils don't. Can't be determined, just feel it on fingers. Eg: oleic acid

5) Cloud and Pour Points:

> Cloud point :- Temp at which oil becomes cloudy / hazy.

> Pour point :- Temp at which oil stops flowing / pouring, and paraffin wax starts separating out.

> Pour point depressants: phenolic polymers, alkylated naphthalene

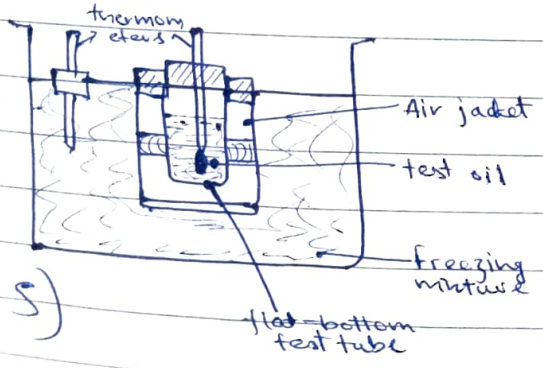
→ ~~Apparatus:~~

6) Volatility :- Vaporization of some portions. (lesser the better)

→ Apparatus. Vaporimeter

7) Carbon Residue :- Deposition of carbon after heating oil. (lesser the better)

→ Apparatus: Conradson Apparatus.



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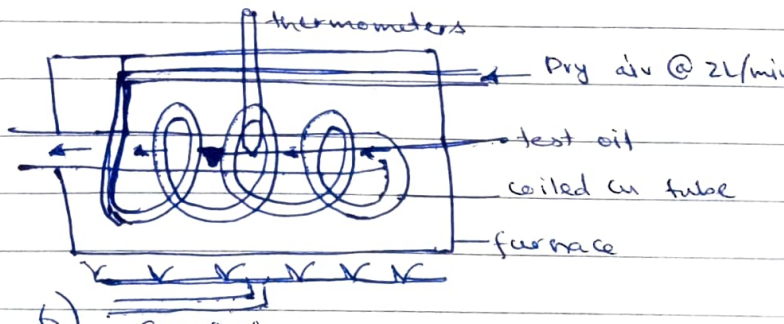

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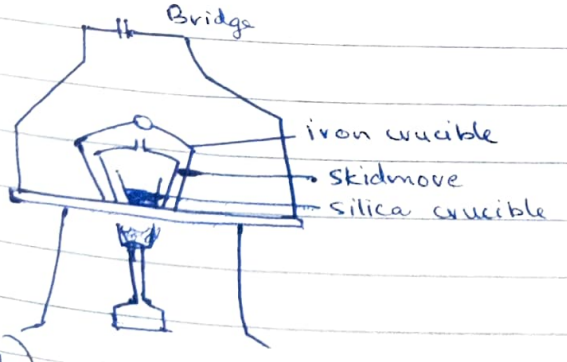


7)

8) Corrosion Stability: The effect of corrosion that the oil has on the metal (Lesser the better)
> Copper corrosion test → Cu strip in oil
> Inhibitors: organic compounds with P, As, Sb, Cr, Bi, Pb.

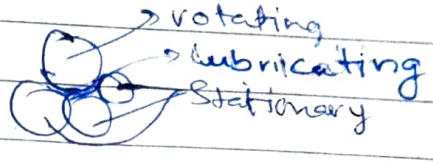
9) Decomposition Stability:
Sources of decomposition at operating temp.
(i) Oxidation: produces acids, sludges, and varnish
→ antioxidants - phenols, amines, organic alcohols etc.
(ii) Hydrolysis: ester oils hydrolyze to produce alcohols/fatty acids.
(iii) Pyrolysis: petroleum chains crack due to temp. and in turn deposit gummy & carbon residues in the lubricant.
* High oxidation test: 10g oil displaced with oxygen heated at 200°C for 2 hr, then cooled in petroleum naphtha for 1 hr. Precipitate formed is dried and weighed (Lesser the better).

10) Aniline Point: oil consits of aromatic hydrocarbons which dissolve rubber. Higher aniline pt. → lower aromatic hydroC → better.
How to measure: equal volume of oil and aniline is taken heated till homogeneous. Then cooled, time taken to separate out is aniline point.

11) Neutralization Number: No. of mg of KOH required to neutralize 1g of oil acids is acid value Should be < 0.1

12) Saponification Number: No. of mg of KOH required to saponify 1g of oil. (vegetable oil).

13) Mechanical Stability.



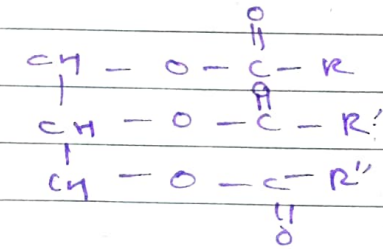
* CLASSIFICATION:
1> Vegetable / Animal - Based oils
2> Mineral / hydrocarbon oil
3> Blended oil
4> Synthetic oil

1) Vegetable / Animal oils

Plant: Rapeseed, castor, coconut, palm oil etc.
Animal: Lard, Tallow, Neatsfoot, cod-liver, sperm oil
(pigs) (farm animal) → (hooves) (cod fish) (sperm whale)

TRIGLYCERIDES:

3 fatty acids: $RCOOH$, $R'COOH$, $R''COOH$ + $CH_2(OH)-CH(OH)-CH_2(OH)$ (glycerol) $\xrightarrow{\text{catalyst}}$ triglyceride + $3H_2O$



Triglyceride

if R, R', R'' are same, simple triglyceride
else, mixed triglyceride

→ They are fat if solid at 25°C, oils if liquid.
→ Animal based are generally solids.

ADVANTAGES:

→ High → oiliness, viscosity, VI
Low → SEN, volatility.
→ Biodegradable, Non-toxic

DISADVANTAGES:

→ Expensive → Not producable in high amount
→ Poor corrosion stability → Solidity at low temp.

2) Mineral / Hydrocarbon oil.

Four main types of hydrocarbon oil in crude oil

- paraffins (15-60%)
- naphthalenes (30-60%)
- aromatics (3-30%)
- asphaltics (remainder)

* Fractionating Column

- Height = 60m
- Diameter = 1.2 - 2 m

Refinery Gas (C_{1-4})	20°C
Petrol (C_{5-9})	70°C
Naphtha (C_{9-10})	120°C
Kerosine (C_{10-16})	170°C
Diesel (C_{10-18})	270°C
Lubricating oil (C_{17-30})	
Fuel oil (C_{23-30})	
Bitumen ($C_{>30}$)	340°C

* Refining of lubricating oil

- Dewaxing - solvent used: methylethylketone, toluene
- Solvent refining - separate impurities from product steam by dissolving / precipitation
  - solvent used: phenol.
- Acid refining - fuming H_2SO_4, clay treatment purification

ADVANTAGES:

→ Available in bulk, cost effective, solubility of additive.

DISADVANTAGES:

→ Non biodegradable, Highly toxic, cannot be replenished.

3) Blended Oil (volume: 0.1 - 30 % of additives)

Use: Mineral oil can't satisfy all criteria of machinery.

Basic roles of additives: ~~to enhance basic existing oil properties~~

Function	Additives
1) Enhance basic existing properties of oil	antioxidants, corrosion inhibitors, antifoam reagent, demulsifying agent.
2) Suppress undesirable base oil property	Pour and point depressant, VI improvers
3) Impart new properties to base oil	Extreme pressure additive, detergent, metal deactivator

4) Synthetic Oil

> Man made

> Prod High molecular wt. as a product of low molecular wt. reactants.

> High price for good performance.

ADVANTAGES:

→ Longer oil life, safer operation, easy disposal

DISADVANTAGES:

→ High production cost, toxic, high disposal cost.

Eg: Silicones, silicate esters, halogenated hydrocarbon, Dibasic acid, polyalphaolefins.

* Dibasic acid esters

ADVANTAGE:

→ Non toxic, non-corrosive, low volatility

DISADVANTAGES:

→ Limited biodegradability, incompetable with sealing material, low hydrolytic stability

APPLICATIONS:

→ Engine oil, gear oil, bearing oil.

* Poly alpha olefins

ADVANTAGE:

→ High VI, Non-toxic, low volatility

DISADVANTAGE:

→ Limited biodegradability, seal shrinking risk, limited additive solubility.

APPLICATIONS

→ Engine oil, gear oil, bearing oil.

* Silicones (polysiloxanes)

* Silicones (polysiloxanes)

ADVANTAGE :
→ Very high VI, low volatility, water resistant.

DISADVANTAGE:
→ High cost, poor additive response, poor load carrying ability.

APPLICATIONS:
→ Cooking utensils, electric induction, sealant.

* GREASES

Lubricating greases = 70-95% Base Oil (Mineral / Synthetic oil) + 3-30% Thickener (metal soap / non-soap thickener) + 0-10% Additive &

→ Conditions for Use : ~~ADVANTAGES :~~
> Extreme pressure / temp.
> Infrequent machine usage
> Dripping of oil is intolerable
> Sealant
> Too many jerks during movement.

DISADVANTAGE:
> Higher coefficient of friction
> Tough to clean
> Does not ~~clean~~ cool quickly.

+ Importance of consistency for grease:
Lower the consistency the more readily will the grease lose the lubricant oil.
Thus, - - - .

→ Types of Grease:

> ~~Fatty~~ Natural ~~Color~~

Temp Range	Name	Color	Properties
< 65°C	Calcium - based	yellow / reddish	smooth, cheap, common, insoluble in water.
upto 175°C	Sodium - based	yellow / green	spongy, not water resistant
around 150°C	Lithium - based	brownish red	buttery, water resistance, high cost, non-corrosive
< 90°C	Aluminum - based		waterproof, 5% oil more than other grease.
(-40) - 400°C	Silicon - based	white paste (translucent)	viscous, waterproof, used for preserving rubber part, plumbing industry, dental equipment usage.

→ Properties

> Consistency
> Drop-point
> Base oil viscosity
> Ash content
> Water stability
> Neutralization number.

* Consistency: (in terms of penetration)
Apparatus: Penetrometer
→ Distance (in 1/10th mm) penetrated for 150g load at 25°C for 5 sec.
→ It is the ability of grease to oppose applied force and resist deformation.