

Tribology

Module4: Lubricants & Lubrication

Q.1. What is fluid film lubrication? What is the difference between hydrostatic and hydrodynamic lubrication?

Ans: Fluid film lubrication is a generic term used for full film lubrication, in which solids surfaces are completely separated by fluid and wear is negligible. Fluid may be gas or liquid. Liquid lubrication is more common compared to gaseous lubrication. Hydrostatic and hydrodynamic lubrications are two mechanisms of liquid lubrications. In hydrostatic lubrication external pressure is supplied to separate two surfaces, while relative velocity between two surfaces is used to generate liquid pressure between two surfaces. Hydrostatic lubrication is generally costlier compared to hydrodynamic lubrication.

Q.2. How transition between various regimes of lubrication occurs on the basis of increasing load?

Ans: On increasing load on the tribo-surfaces fluid film between solids decreases. If fluid film is sufficiently thick and solid surfaces are rigid (no elastic deformation), fluid film lubrication hydrodynamic (hydrostatic), aerodynamic (aerostatic) occurs between surfaces. On increase normal load, fluid pressure increases, viscosity thickening occurs and to some extent solid surfaces deform. This form of lubrication is known as "Elastohydrodynamic lubrication". In this lubrication regime elastic deformation of the contacting surfaces increase the load bearing area whereby the viscous resistance of the lubricant becomes capable of bearing the load. On further increase in load direct contact between asperities occur and friction increases. Due to relative motion among asperities wear of surface occur. This regime is called boundary lubrication. To minimize wear under boundary lubrication boundary/extreme-pressure additives are used.

Q.3. What is the effect of adding additives to the lubricants?

Ans: In practice, liquid lubricants are subjected to a number of odd situations like formation of foam, oxidation, thermal thinning, squeezing out from tribo-surface, sludge formation, etc. To reduce the effect of those odd situations on lubrication, additives are used. Anti-foam additive reduce the surface tension of lubricant and allow better lubrication. Oxidation resistant additive reduce the chances of liquid lubrication. Boundary additives reduce the effect of liquid squeezing out. Similar polymer additives reduce the effect of temperature on the liquid viscosity.

Q.4. What is extreme pressure lubrication and what are the environmental hazards associated with it?

Ans: Extreme pressure term for additive is a misnomer. "Extreme pressure" additive act at high temperature and reacts chemically with metal to form a low shear interface film on metals. For example EP additives containing chlorine, sulfur, and phosphorus react with metal surfaces at relatively high temperature and form chloride, sulfide and phosphate lubricant layers respectively. Extreme pressure additives are usually

used in high contact pressure applications such as gearboxes. Major difficulty with extreme pressure lubricants is their carcinogenic nature and environmental pollutant, therefore extreme pressure additives should be avoided as far as possible.

Q.5. What is the effect on wear rate with respect to increase in temperature and speed?

Ans. Wear rate generally increases with increase in temperature. On increasing speed, wear rate may increase or decrease depending the lubrication regime. If tribo-pair is under mixed lubrication, then increasing speed shall reduce the wear rate. But if increasing speed in mixed/boundary lubrication causes high temperature rise due to insufficient thermal dissipation, then wear rate may increase. During “running in” period increasing speed causes increase in wear rate.

Q.6. What is the difference between absorption and adsorption?

Ans. Adsorption implies adhesion and absorption implies diffusion. Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, forming a molecular or atomic films (the adsorbate). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. Absorption is a bulk phenomenon in which the particles of gas or liquid get uniformly distributed throughout the body of the solid whereas adsorption is the phenomenon of higher particle concentration of gas or liquid on the surface so that surface film formation occurs. It can be said that absorption is a 'bulk phenomenon', but adsorption is a 'surface phenomenon'.

Q.7. With increase in temperature why does the viscosity of lubricant decreases?

Ans. Lubricant may be gaseous or liquid. In liquid, with increase in temperature molecular separation increases and their resistance to flow decreases, therefore decrease in viscosity with increase in temperature occurs. But in the case of gaseous lubricants, the molecular activities increase with increasing temperature. This means viscosity of gaseous lubricant increases with increase in temperature.

Q.8. Is there any liquid lubricant that shows negligible changes in viscosity with variation in temperature?

Ans. There is no liquid lubricant which shows negligible change in viscosity with variation in temperature. Some synthetic lubricants, such as Silicone which has very high VI = 300, have relatively weaker viscosity-temperature relation.

Q.9. Is there any standard parameter which denotes the viscosity variation of liquid lubricant with respect to temperature?

Ans: Viscosity of all liquid lubricant decreases as the temperature increases, but rate of decrease varies considerably. The sensitivity of viscosity thinning on increase in temperature is expressed by VI = Viscosity Index. In other words VI parameter may be used to denote the viscosity-temperature relation.

Q.10. How does a solid lubricant help in reducing friction and what are their specific advantages as compared to liquid lubricants?

Ans: A solid lubricant is basically any solid material which can be placed between tribo-pair and which will shear more easily under a given load than the tribo-materials themselves. In general solid lubricants help filling the surface irregularities in order to reduce the surface roughness and thus reducing friction. Solid lubricants are effective at high loads, high temperature and high pressure as compared to liquid lubricants.

Q.11. What are solid lubricants?

Ans: Solid lubricants are self-lubricating composites, having relatively low shear strength. These lubricants are able to transfer a layer on the tribo-surfaces and as a result reduce the friction coefficient. The most common solid lubricants are polymers [Poly Tetra Fluoro Ethylene (PTFE),Nylon], metal-solid [Molybdenum Disulfide], carbon and graphite, ceramics, etc.

Q.12. What are additives and how can additives like friction modifiers enhance the quality of lubricant?

Ans: Basic lubricating oils, having appropriate viscosity, may be useful for idle tribological conditions. In practice, very high load, very low relative speed, environment humidity, surrounding temperature, etc. effect the performance of basic oils. Therefore to make basic oil more useful for practical situations additives are mixed with basic oils. In other words additives are soluble compounds that enhance the characteristics of lubricant. Typically lubricants contain 90-95% base oil (most often petroleum fractions, called mineral oils) and lesser than 10% additives. Friction modifiers are additives that reduce friction by increasing the adhesive film strength to avoid surface to surface contact. In other words these additives provide a cushioning effect and keep metal surfaces apart from each other.

Q.13. What are characteristics of good lubricants and what is lubricity?

Ans: A good lubricant shall possess the following characteristics:

- High boiling point.
- Low freezing point.
- High viscosity index.
- Thermal stability.
- Corrosion prevention.
- High resistance to oxidation.

The property of lubricant of reducing friction is known as lubricity.

Q.14. What are the major factors which affect the selection of lubricants?

Ans: Load and speed are two major factors which affect selection of lubricants. Requirement of fluid sealing, material conductivity, friction coefficient, and surrounding environment are additional factors which affect lubricant selection.

Q.15. Is it necessary for solid lubricants to possess lesser hardness as compared to the surfaces being lubricated?

Ans: Yes it is necessary for the solid lubricants to possess lesser hardness as compared to the surfaces being lubricated in order to reduce the wear of the surfaces. Use of harder lubricants will damage the surfaces and would increase the surface roughness.

Q.16. Can the oil used for lubricating a diesel engine be used in a gasoline engine?

Ans: It is not advisable to use the lubricating oil suitable for diesel engine for lubricating gasoline engine because diesel-engine lubricants are more viscous as compared to lubricants used in gasoline engine. Putting too thick oil in a gasoline engine will make it run hotter. Higher viscosity oils impose startup problems and are difficult to pump the lubricant. This may lead to lubricant starvation of tribo-surfaces.

Q.17. Why are foam inhibitors used in lubricants and what purpose do they serve?

Ans: Lubricant foams formation due to agitation and aeration occurs during operation. Foaming interferes with flow rate and heat transfer, and increases oxidation. The foam inhibitors reduce the surface tension between the air and liquid to the point where bubbles collapse thereby reducing the foaming effect. These additives, usually long chain silicon polymers, are used in small quantities of about 0.05% to 0.5% by weight and they tend to lower the surface tension.

Q.18. Different additives are added in the lubricants to enhance the specific properties of the lubricants. Does addition of multiple additives create interference with the desired characteristics for which they are added?

Ans: Yes, addition of multiple additives does create interference. For example dispersants accelerate the oxidation of oil & anti-oxidants must be included when these additives are used. Hence it is very important to have complete detail of the additives i.e. about their effects and interferences to enhance existing properties, or to impart new properties to the lubricant.

Q.19. If a lubrication mechanism has to be designed for a complete mechanical system, then should a single lubricant be used for the complete system or different lubricants shall be preferred for different sub systems.

Ans: It is better to use a single lubricant for the complete mechanical system because single oil reservoir & circulation system can be used for the complete system which would prove economical, reliable and easily storable. Use of single reservoir system also reduces the chances of wrong usage of lubricant in different sub-systems. Although keeping in mind the functional and design requirements, if a particular sub-system requires the use of different lubricant, then more emphasis must be paid to choose solid lubricants or inert coating for critical tribo-surface in addition to single lubricant for whole machine.

Q.20. Are there any general guidelines or thumb rules for lubrication selection?

Ans: There are some guidelines which can definitely help in identifying the general characteristics of lubricants for a tribological system such as:

- Too much speed – lesser viscous oil, oil circulation system with greater oil flow rate, gas lubrication.
- High operating temperature – High viscosity index oil with anti oxidant additives, greater oil flow rate, solid lubricants.
- Too much debris – Circulation system with filtration
- Requirements of long life – Oil/grease with additives, provision for re-lubrication.
- Too much load – More viscous oil, grease, EP additives, and solid lubricants.

Q.21. What is journal bearing and what are the common components of journal bearing?

Ans: Journal or plain bearings consist of a shaft or journal which rotates freely in a supporting metal sleeve or shell. There are no rolling elements in these bearings. Journal is the part of the shaft in contact with the bearing which slides over the bearing surface. The common components of journal bearing are:

- Housing
- Journal or shaft
- Bearing liner
- Oil inlet
- Drain