Tribology
Module3: Wear

Q.1. What is wear constant and how it is related to coefficient of friction?

Ans: As per Archard's wear equation, wear volume rate (m^3/s) is proportional to normal load (N), relative speed (m/s) and inversely proportional to hardness (N/m^2). Wear constant (non-dimensional) is constant of proportionality relating wear volume rate with load, relative speed and hardness. There is no established relation between friction-coefficient and wear rate, but reduction in friction-coefficient means lesser resistant to relatively moving surface and as a result lesser wear rate.

Q.2. What are the main criteria for classification of wear and what are various types of wear?

Ans: Failure mechanisms causing wear are used to classify wear. For example wear caused by formation and rupture of adhesive junctions is known as "adhesive wear". Wear caused by abrasion of hard surface on soft surface is termed as "abrasive wear". Formation of brittle layer due to chemical action and removal of that layer by mechanical action is called "corrosive wear". Similarly formation of subsurface cracks and rapid propagation of those cracks to surface due to friction is named as "fatigue wear". There are more than 2000 wear equations to describe the wear behavior. There are more than 35 mechanisms detailed as wear sources. This means there are more than 35 types of wear.

Q.3. In a tribological system where two tribo-surfaces are moving at relatively high speed, should the design of such system involve the use of similar metals or dissimilar metals to prevent adhesive wear and seizure?

Ans: Whether low or high speed, molecular attraction, between similar materials will be higher so resultant friction shall be higher. Therefore, from tribological point of view similar materials shall never be recommended. However if overall cost (i.e. inventory cost and manufacturing processing cost) of dissimilar metals is much higher compared to savings in friction loss, then designers may select appropriate lubricant for similar materials tribo-pair.

Q.4. What is the difference between zero wear and measurable wear and how does zero wear increases performance?

Ans: Removal of material which causes polishing of material surfaces may be known as zero wear. Zero wear is basically a polishing process in which the asperities of the contacting surfaces are gradually worn off until a very fine, smooth surface develops. On other hand removal of material from surface that increases vibration; noise or surface roughness may be treated as measureable wear. Zero wear is desirable for better life of tribo-pair. Due to zero wear significant reduction in friction, noise and vibration can be achieved which increases the overall performance of the system.

Q.5. In a tribo-pair interaction, why does contact occur only at asperities?

Ans. Every engineered surface is rough on nanometer to micro meter level. In absence of full film lubrication (thick lubrication), when surfaces come in contact, asperities (peaks on the surfaces) interact. During the interaction tip of the asperities may break-off (reduce roughness) or scratch opposite surface (increase roughness). However asperity contact can be avoided by developing appropriate lubricant layer between tribo-surfaces.

Q.6. What is seizure and what causes it in a tribological system?

Ans. Seizure means “to bind” or “fasten together”. Seizure is an extreme form of adhesive wear, which occurs as a result of mutual plastic deformation of materials. In ordinary cases after seizure components do not get separated on their own. Manual force is required to separate the parts. In other words, after seizure tribo-pair lose its utility and cannot be used without proper reconditioning. Causes for seizure are:

- Poor heat dissipation.
- Poor lubrication or improper lubrication.
- Smaller clearances.
- Installation errors.
- The tendency of the metals to form strong bond in solid state.

Q.7. What are MR fluids and what is their usage in tribological system.

Ans. MR Fluids stand for magneto rheological fluid. MR fluid is a type of smart fluid. When subjected to a magnetic field, the fluid greatly increases its apparent viscosity, to the point of becoming a viscoelastic solid. Importantly, the yield stress of the fluid when in its active state can be controlled very accurately by varying the magnetic field intensity, which allows usage of MR fluid in many control-based applications.

Q.8. What is the optimum value of impingement angle to minimize erosive wear?

Ans. To minimize the erosive wear, it is important to estimate material (surface on which particles are going to strike) hardness. Low value of impact angle results cutting wear, which means material hardness help to reduce wear rate. On other hand large impact angle causes fatigue wear, therefore soft (ductile) material may be suitable.

Q.9. Are there any general changes/improvements that can be incorporated in the design of mechanical system to eliminate different types of wear?

Ans: Different types of wear can be eliminated by following these guidelines:

- Selecting right lubricant and ensuring optimum quantity of lubricant.
- Confirming surface finish of tribo surfaces to reduce friction, vibration, noise.
- Right material selection with appropriate surface hardness.
- Increasing heat dissipation from the system to avoid excessive operating temperatures.
- Replacing the lubricant to remove the debris after periodic intervals.

Q.10. Does suspension system in an automobile help in reducing or eliminating fretting wear?

Ans: Suspension system in an automobile does help in reducing fretting wear by damping the vibration and shocks generated by the interaction of tires and road surface.

Q.11. Is lubrication useful in reducing fretting wear?

Ans: Fluid lubricant reduces friction and takes away wear debris from source. The removal of debris helps to control wear within mild regime. Therefore lubricants are useful in reducing fretting wear.

Q.12. How can compliant mechanism be useful in reducing wear due to friction?

Ans: Compliant mechanisms are jointless and flexible mechanisms that transfer an input force or displacement to another point through elastic body deformation. Due to the absence of any joints there is lesser friction and hence there is no wear other than fatigue wear.

Q.13. Can the use of tribology knowledge be made in metal removing operations in machine tools?

Ans: Any material interaction where one material slides or rubs over another is affected by complex tribological interactions. This means tribology plays an important role in manufacturing. In metal-forming operations, friction increases tool wear and the power required to work a piece. This results in increased costs due to more frequent tool replacement, loss of tolerance as tool dimensions shift, and greater forces required to shape a piece.

Q.14. What specific design changes are implemented on piston rings and oil rings in order to reduce wear?

Ans: Ring wear can be reduced by designing appropriate profile so that full film lubrication is made. But excessive lubricant may enter in combustion chamber and cause incomplete combustion and as result pollution. Therefore minimizing wear is achieved by appropriate selection of (chemically inert) material and appropriate design with suitable hardness of piston rings.

Q.15. Is there any method in tribology to separate the wear debris from the lubricants?

Ans: Separation mechanism of wear debris from the lubricants varies from application to application. For example in ferrography wear particles are separated by magnetic (or similar) arrangement. To recirculate the same lubricant in machine filtering system is used to separate wear particles. For example in IC engine filtration is widely used to remove particles from oil in the oil sump. The debris particle size that would be filtered depends upon the mesh size of the filter membrane.

Q.16. If a tribological pair is brought up to the hardness and surface finish of the order of slip gauge, would it help in reducing friction and wear?

Ans: Excessive smooth surface minimizes the abrasion but provides many locations for adhesive wear. Sufficiently high hardness minimizes the plastic deformation and as result minimizes adhesive wear. This means abrasive and adhesive wear and friction can be minimized by very good surface hardness and roughness, but other wear mechanisms (pitting, fretting, corrosive, etc.) may persist.

Q.17. Is it possible to predict the fatigue life of a mechanical component like a passenger car chassis or an I-beam in a commercial vehicle chassis due to fatigue wear?

Ans: The fatigue life of the any mechanical component can be predicted by simulating the real life conditions inside a test chamber with the help of artificially generated operating conditions. After extensive testing, curve fit equations may be generated, which may be used later to estimate the fatigue life.