

Interdisciplinary aspects of Tribology

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Abstract - Energy being an important aspect in today's world plays an important role in deciding the GDP of an industrialised nation. The wide spread involvement of friction and wear accounts for maximum energy losses. Due to this the focus of researchers has been shifted towards different aspects of tribology. The paper focuses on how the tribology has helped in conserving the energy and reducing the release of hazardous emission. Various studies related to the different sectors have been presented. Also, the emphasis has been laid on the role of tribology in different biological systems. Moreover, the discussion on the performance of biolubricants and the role of nanotechnology has also been made.

Key Words: Tribology, Bio Lubricants, Nano technology.

1. INTRODUCTION

Tribology is the study of science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear. Tribological knowledge helps to improve service life, safety and reliability of interacting machine components and yields substantial economic benefits. Wear is the major cause of material wastage and loss of mechanical performance and any reduction in wear can result in considerable savings. One third of the world's energy resources in present use are needed to overcome friction in one form or another. Recent advancements in tribological field have been led to energy conservation and sustainability. The different sectors where tribology plays an important role are discussed below:

2. AUTOMOTIVE TRIBOLOGY

To control the emissions of hazardous substances and utilize the resources efficiently have forced the government to increase the rigidity in the environmental laws and regulations. This has forced the automobile industries to find better and efficient vehicles that can be both energy saving and eco friendly. The research is being conducted for making better engine oils that can reduce both the friction and wear in the automobiles. Various researches have shown that about USD 20 billion can be saved every year by the reduction of wear and friction in US [1]. The various tribological parts in automobile vehicles include engines, CVT, transmissions, traction drive, drive train and

ancillaries [1]. The most important component where most of the fuel energy is lost in automobiles is engine. The energy is lost as heat to the surroundings the energy is also lost as friction. The engines are also the parts which are most responsible for the environmental pollution by releasing hydrocarbons, NO_x emissions and other pollutants. It has been observed that around 60% of the fuel energy is lost as heat in which 30% is lost as exhaust and 30% for cooling the cylinder. 15% is lost as mechanical losses and only 25% of the energy provides the brake power [2]. The tribological solution for the engine is the evolution of better lubricants and lubrication system. The 15% of energy that is lost as mechanical losses can be prevented by better lubrication. It has been seen that if mechanical losses are reduced by 10%, the fuel consumption will be reduced by 1.5% [3]. This adds up to a very large amount when all the motor vehicles of the world are taken into consideration. The tribological study of the parts of the automobile will help in developing suitable components for the automobile. The better lubricants can be developed. Bio lubricants are considered as the best lubricants for the replacement of mineral oils. These are 90-98% biodegradable and hence are eco friendly. Nano lubrication is also considered in the automotive application as it reduce the wear and friction of the parts effectively [4]

3. BIO TRIBOLOGY

Dowson and Wright introduced the term bio tribology to highlight the importance of tribology in the biological systems. It covers the various aspects how tribology is related to biological systems [5]. The bearing surfaces of humans undergoes wear and cause discomfort to them. The various applications of tribology in human systems include:

a) Oral tribology b) Ocular tribology c) Natural synovial joints and artificial replacements d) Cardiovascular tribology

3.1 Oral Tribology

It involves the study of wear of dentures. As a person grows older, he is possible need for partial and complete dentures. In order to develop durable dentures, we must have knowledge of the wear of teeth and effect of materials on the teeth. The study of oral tribology deals with the study of the mechanisms of how this wear occurs and how it can be controlled. If the wear is not controlled it will lead to abd mastic functions and will disrupt the normal living of human beings [6].

3.2 Ocular Tribology

It deals with the lubrication of contact lens. There is continuous movement of eyelids over the cornea which leads to the wear of the contact lens. In order to prevent the wear we need to have a proper lubrication in the eyes. The wear under study will help us to make better contact lens and provide relief to the human beings. The lubrication will help in preventing the tissues and also remove the impurities from the eyes. The friction between the eyelids and the lens is measured with the micro tribometer. This measurement of frictional forces helps in the making of better contact lens [7].

3.3 Synovial joints and artificial replacements

Synovial joints are the movable joints and a synovial fluid is present in between the joints which acts as a lubricant and reduces the wear and friction of synovial joints. Various theories have been put forward to understand the nature of synovial joint lubrication. The lubrication of synovial joints is a complex one and the exact mechanism of synovial joint is not completely understood. The natural synovial joints exhibit very low coefficient of friction and the study of these natural synovial joints can help in the treatment of Osteoarthritis [8]. The study of synovial joints can also help us in the making of artificial human joints. The natural human joints can get worn out or it may be harmful for the person due to some disease. The tribological study of the joints will help us in choosing the right material for artificial joints. Various joints such as metal on metal, metal on polymer, ceramic on ceramic, ceramic on polymer, ceramic on metal has been developed.

3.4 Cardiovascular Tribology

Artificial heart valves are implanted in the patients who have damaged their heart valves. Two types of valves are made: Mechanical heart valves (MHV) and Bio prosthetic heart valves (BHV). Less research has been done on the mechanisms of wear and friction in BHV's because of the fact that the wear and friction in BHV's is less than the MHV's. The applied forces on the MHV's are greater than the BHV's causing more friction and wear in them. MHV's is of three types: tilting disk, caged ball and bileaflets. The uncontrolled and immoderate wear can cause failure of the valves leading to the death of the person [9].

Bio tribology has also played an important role in ventricular assisting devices (VAD). Ventricular assisting devices are required when there is a failure of heart chambers. Types of VAD's include: pulsatile pumps and rotary pumps. The pulsatile pumps consist of many mechanical parts in which a considerable amount of friction and wear occurs. Tribological study of the parts of pumps can help us in reducing the wear and friction in them. It helps us in choosing the right material and increase the lifeline and durability of the mechanical parts conserving the energy [9].

4. OCEAN TRIBOLOGY

It involves the investigation of friction and wear in the sea water environment. The sea water is very corrosive in nature resulting in the increase of surface roughness of the mechanical parts of machines. A decrease in the lubrication effect is also observed that leads to increase in the coefficient of friction and energy consumption to drive the parts. There also occurs an increase in the wear of the drive parts and parts fail more quickly than their expected time. The corrosive nature of the sea water also release hazardous emissions and disturb the ecological balance of the marine aquatic life. Tribological studies on different materials have been carried out [10]. These include polymers, metals, alloys and polymers. Yano et al. carried an investigation on bronze propeller and corrosive nature was studied [11]. Nik et al. conducted an experiment on aluminum 6061 alloy and studied its corrosive nature [12]. Similar researches have been done on Ti-6Al-4V and Monel K500 alloys and methods were developed to reduce wear and corrosive effects [13]. This will result in saving of material and energy consumption.

5. GREEN TRIBOLOGY

Green tribology is a that subdivision of tribology whose main aim is to preserve the environment [14]. It involves the study of friction and wear of materials in such a way that it reduces the contamination of the environment and conserves the energy. The various applications of green tribology include automobiles, bio tribology, renewable energy tribology and a section of geo tribology [15].

In automobile industries, development of biodegradable lubricants is in progress. Vegetable oils are considered as the potential source of replacing the mineral oils [16,17]. The mineral oils release a lot of hazardous emissions and are doing a lot of harm to the environment [18]. The vegetable oils are 90-98% biodegradable, hence eco-friendly in nature [19]. Various researches on the vegetable oils as lubricants is being done [20-22] and some vegetable oil are being used as lubricants.

In biomimetic tribology, the biomimetic materials, surfaces are chosen in way so that they are more eco-friendly. The characteristics of the biomimetic tribology include:

- a) Tribological study of the bionic system and materials.
- b) Understanding the topography, geometric configuration and the surface texture of the material and locating the materials with exceptional tribological properties.
- c) Development of bionic system and structure.

Various researches being conducted on the biomimetic tribology involves the adhesion at the fluid solid interface, adhesion between the feet of animals and solid surfaces [23, 24].

The green tribology also includes the renewable energy system. The renewable sources of energy include the generation of electricity from natural renewable sources of wind and tidal streams. It is estimated that 80% of electricity will be developed by the eco-friendly sources [25]. The mechanical parts of wind turbines and tidal power turbines will experience friction and wear. The tribological study of the mechanical parts can help in reducing the friction and wear. This will ensure generation of more electricity with less mechanical losses increasing the power output.

6. MANUFACTURING TRIBOLOGY

It includes the study of the metal working fluids (MWF) employed in the machining operations [26]. The MWF's are used for cooling and lubrication purposes. The MWF's are used in various machining operations: turning, milling, grinding and drilling. Most of the current MWF's used are mineral oils because of their better cooling and lubricating properties. These also increase the productivity of manufacturing system. The main disadvantage of the mineral oils is their non biodegradability and their non renewability. A research study showed almost 320,000 tonnes of MWF's are used per year. The mineral are less biodegradable and about two third has to be disposed [26]. As a result, governments have posed a restriction on the amount of hazardous emissions released by the mineral oil. The judicious use of the non renewable resources is also a main area of concern. Research is being conducting for finding a replacement of the mineral oils. The study shows vegetable oils are the potential candidates for the replacement of mineral oils as cutting fluids. Vegetable oil possesses all the properties necessary for functioning as a cutting fluid lubricant. The Area of concern for vegetable oils is their oxidation stability. The vegetable oils tend to oxidise when operated under high temperatures [27-29]. This concern is limiting the use of vegetable oils as lubricant. The oxidation stability can be increased by the surface modification of the oils and make the vegetable oils more efficient.

The energy conservation of natural resources can be done by having a better understanding of friction and wear mechanisms. This will help in developing right lubricants for cooling and lubrication purposes e.g the development of minimum quantity lubricants (MQL) [30]. In MQL, very small amount of lubricant is applied between the surfaces, hence also called as near dry machining or semi dry machining. MQL in grinding process has resulted in decrease of consumption of power. A notable decrease in the wear of the grinding wheel was also found.

7. CONCLUSIONS

This paper represents an overall review of influence of tribology in the energy conservation. The different areas where the control of friction and wear can help in energy conservation have been discussed. The development of bio lubricants has provided a good alternate solution in the automobile and manufacturing sectors. The understanding of friction and wear has also helped a lot in the medical sciences

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