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Friction is not a devil

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Tribology: It's economic and environmental significance

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ABSTRACT
This paper analyzes the importance of tribology in the global economic aspect. Energy saving are achieved by the implementation of various tribological related improvements in transportation, manufacturing, power generation and residential sectors. From this, friction reduction, wear reduction, energy loss reduction, CO_2 emission reduction and energy saving are discussed. It can be concluded that advance tribological technologies benefits the economy and environment through energy saving and harmful gases emission reduction.

1. Introduction

Tribology has been discovered over thousands of years. During Paleolithic period, bearing made from antler's bone was used as a tool to create fire solely by friction. Other examples include the Babylonian wheel and tripartite disc wheel in Mesopotamian chariot (Figure 1), which was created during 3500BC and 2800BC respectively. Such discoveries are crucial in keeping the survival of mankind during that time until today. Over the course of time, tribology has become an important aspect in achieving sustainability and energy efficiency for various daily life applications.

Figure 1: Persian bas-relief on chariot wheel.

Tribology is the science and technology of interacting surfaces in relative motion and the practices are associated to friction, lubrication and wear. Tribology exists in almost all our daily activities including walking, running, moving, etc. Besides, tribology is also present in various applications including automotive, industry, sports, cosmetics and biomedical sectors. Some applications of tribology are shown in Figure 2 and Figure 3. One big misconception about friction is that it is always considered a bad thing as it causes an object to slow down.

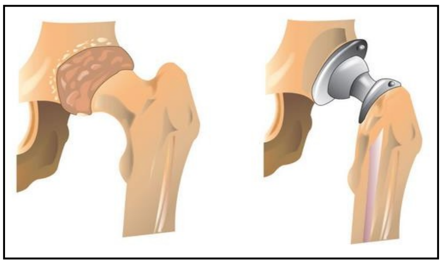

Figure 2: Hip artificial joints.

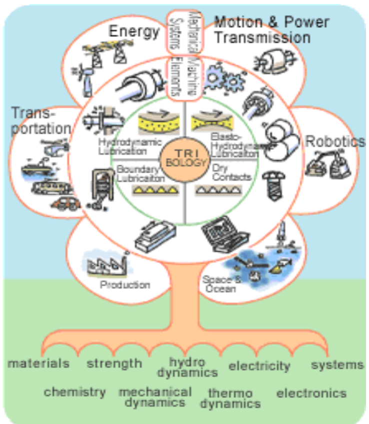

Figure 3: Tribology branches.

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A simple example of tribology in daily life can be illustrated as in Figure 2. Bone joints (ball and socket) are lubricated by the synovial fluids, which prevents the ball and socket from direct contact with each other, otherwise wear will happen on the bones and the person will experience extreme pain. In biomedical field, the development of artificial knee requires deep integration of tribological theory for minimal surface wear, thus prolong the life of these joints. Such development usually includes the selection of corrosion and wear resistant materials, evaluation of wear mechanism of wear and utilization of countermeasures.

Friction also is crucial in most modern day industrial process. Most machining processes are impossible to achieve without friction such as cutting and drilling. Friction of disc brakes enable a car to stop and it is due to friction that human is able to stand and walk. All those examples proved that tribology is very important in nearly everything around us. With proper tribological approach, reduced frictional losses in machineries can result in lower energy or fuel consumption, which in turns resulted in lower operational/maintenance cost and fewer harmful gases emissions to the environment.

2. Frictional and energy losses in heavy- duty vehicles

The average global energy consumptions for four categories of heavy duty vehicle are listed in Table 1. They are mainly attributed by frictional losses in engine, transmission and other components as shown in Figure 4. It can be seen that from the total energy supplied by the fuel, only 34% of that energy is used for moving the vehicle and the rest (66%) is considered lost to the surrounding.

Table 1: Energy consumption annually.

Single-unit trucks	180,000 MJ
Trucks and trailers	1,440,000 MJ
City buses	1,080,000 MJ
Coaches	920,000 MJ

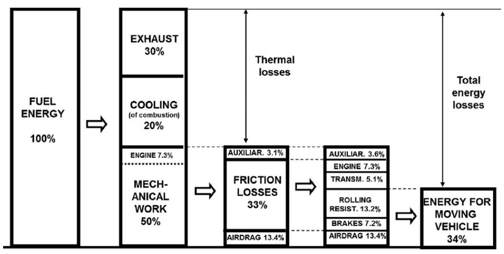

Figure 4: Percentages of energy consumptions in heavy duty vehicles [1].

By implementing tribological knowledge and approach on vehicle developments, the energy losses from frictions can be reduced and therefore, more energy can be used for moving the vehicles. A reduction of 10% in frictional losses can result in a reduced fuel consumption of 7.4%. Thus, fuel efficiency and performance of the vehicles can be improved and more money can be saved.

Holmberg et al. (2014) reported that the goal of achieving friction coefficient of ≈0.01 in truck and bus components within the decade will result in 13.8% reduction of fuel consumption (≈2.7 million TJ/a), equal to 104,500 million Euro per year can be saved globally and reduction of 196 million tons of CO2 emission [1].

3. Frictional and energy losses in transportation, manufacturing, power generation and residential sector

In total, around 23% (119 EJ) of the global total energy consumption are contributed by tribological contacts. From that amount, nearly 20% is used to overcome friction and 3% is used to repair worn parts due to wears, which are 103 EJ and 16 EJ respectively

Technological advancement in tribology nowadays include the findings of new surface modification, materials and lubricants technology to reduce friction and wear in transportation, manufacturing, power generation and residential sector. The energy losses due to friction and wear are predicted to be reduced by 18% (21.5 EJ) in 8 years and 40% (46 EJ) in 15 years. These reductions are said to generate saving up to 1.4% of the GDP annually, and 8.7% of the global energy consumption for 15 years.

Among the four sectors, for 8 years, it was predicted that the largest energy saving is contributed by transportation (25%), followed by power generation (20%) and manufacturing and residential sector by nearly 10%. While for 15 years, the saving can reach up to 55%, 40%, 25% and 20% respectively.

Furthermore, with the implementation of advance tribological technologies can reduce harmful gases emissions by 1,460 $MtCO_2$ (≈455,000 million Euro) and 3,140 $MtCO_2$ (≈973,000 million Euro) in 8 years and 15 years respectively [2].

4. Conclusion

Tribology is very important to be practiced in all sectors since it can benefit greatly in economic aspect and environmental conformity through energy saving and greenhouse gases (GHG) emission reductions.

Acknowledgement

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Reference

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[2] Holmberg, K., & Erdemir, A. (2017). Influence of tribology on global energy consumption, costs and emissions. Friction, 5(3), 263-284.