Global Energy Consumption Due to Friction in Passenger Cars, Transportation and Industry

Presented by Dr. Kenneth Holmberg

Total energy production worldwide was about 500 Exajoule (12,000 Mtoe) in the year 2010, and of that 20%-25% was used to overcome friction. Transportation and industry are the two largest users of energy worldwide, consuming almost a third each of the total energy production. About one third of the energy consumption in transportation goes to overcome friction while it's closer to one forth in industry.

At this session a new method is presented to analyze energy consumption, CO2 emissions and the economic impact of friction on a global level based on a breakdown of the frictional energy all the way down to tribological micro-contacts and demonstrated for passenger cars. Calculations on the global fuel energy consumption used to overcome friction in passenger cars, in terms of friction in the engine, transmission, tires and brakes will be presented. Friction in tribocontacts was estimated according to the prevailing contact mechanisms such as elastohydrodynamic, hydrodynamic, mixed and boundary lubrication. Coefficients of friction in the tribocontacts were estimated based on available information in the literature on the average passenger car in use today, a car with today’s advanced commercial technology, a car with today’s most advanced technology based upon recent research and development and a forecasted car with the best technology forecasted in the next 10 years.

In passenger cars, a third of the fuel energy is used to overcome friction in the engine, transmission, tires and brakes. The direct frictional losses, with braking friction excluded, are 28% of the fuel energy. In total, 21.5% of the fuel energy is used to move the car. Worldwide, 208,000 million liters of fuel was used in 2009 to overcome friction in passenger cars. Reductions in frictional losses will lead to a threefold improvement in fuel economy as it will reduce both the exhaust and cooling losses also at the same ratio.

Globally, a passenger car consumes on an average 340 liters of fuel per year to overcome friction, which would cost 510 Euros, according to the average European gas price in 2011, and corresponds to an annual average driving distance of 12,130 km. By taking advantage of new technology for friction reduction in passenger cars, friction losses could be reduced by 18% in the short term (5-10 years). This would equal worldwide economic savings of 174,000 million Euros, fuel savings of 117,000 million liters and CO2 emission reduction of 210 million tons.

The friction-related energy losses in an electric car are estimated to be only about half those of an internal combustion passenger car. Potential actions to reduce friction in passenger cars include the use of advanced coatings and surface texturing technology on engine and transmission components, new low-viscosity and low-shear lubricants and additives and tire designs that reduce rolling friction.

Advanced industrial machinery, in this case represented by paper machines, was analyzed with the same method described above. Paper machines use 0.381 EJ electrical energy annually to overcome friction. This is 9.2% of the total energy consumption of the paper machine. In paper mills, 15%-25% of the energy is consumed by friction. An estimation of the total energy consumption due to friction worldwide based on these two studies, carried out as case studies in the transportation and industrial sectors, will be reported.

This keynote address is based on a technical paper authored by Kenneth Holmberg, Peter Andersson and Roope Siilasto of the VTT Technical Research Centre of Finland, Espoo, Finland, and Ali Erdemir with Argonne National Laboratory, Argonne, Ill., USA.
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