Argonne researchers Ali Erdemir (front) and Osman Eryilmaz prepare for a pin-on-disk friction test on a new lubricant. Erdemir holds the test load that will be placed on top of the pin holder of the friction test machine.

FACT OR FRICTION

FRICTION LOSSES SIGNIFICANTLY IMPACT FUEL CONSUMPTION

Every time we fill up our gas tanks, as much as one-third of the fuel is used to overcome friction. Some friction is productive. After all, you need friction to brake and you wouldn't move if there wasn't friction to create traction.

Argonne National Laboratory teamed with the VTT Technical Research Centre in Finland to look at global energy consumption in cars due to friction. Argonne materials scientist Ali Erdemir co-authored the study with Kenneth Holmberg and Peter Andersson of VTT.

"Worldwide on average, one passenger car uses 90 gallons (340 liters) of fuel to overcome all forms of friction," said Erdemir, an Argonne Distinguished Fellow. "We also found that friction energy losses in electric cars are only about half that of cars with internal combustion engines."

Friction loss in vehicles includes the energy used to overcome the rolling resistance of tires, brake contact, pumping losses, and the rubbing and turning of various mechanical parts in the engine and transmission systems.

According to the study, the energy output of fuel in a car engine breaks down like this: 33 percent is spent in exhaust, 29 percent is used for cooling and 38 percent for mechanical energy (33 percent for friction losses and 5 percent for air resistance). When compared to a conventional car with an internal combustion engine, an electric car with no such engine has only half of the friction loss.

With current technology, only 21.5 percent of the fuel's overall energy output is actually used to move the car.

With current technology, the authors concluded that only 21.5 percent of the fuel's overall energy output is actually used to move the car (see chart on next page).

On the bright side, there are technologies that can reduce the impact of friction. These include new surface coatings, surface textures, lubricant additives, low-viscosity lubricants, ionic liquids and low-friction tires.

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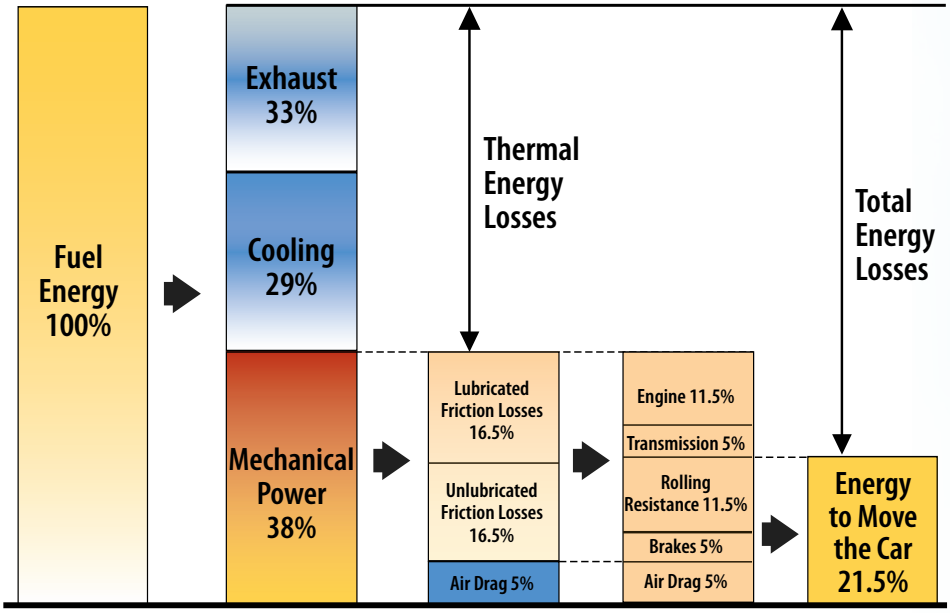

A breakdown of passenger car energy consumption.

"We want to bring attention to the fact that many of these technologies exist today," Erdemir said. "By 2020, implementing these technologies will bring frictional losses down significantly, thus improving fuel economy."

As part of Argonne's tribology (the study of friction, wear and lubrication) research group, Erdemir is involved with many projects that aim to reduce friction, including:

- **Boron-based advanced nanolubricants** that can be added to existing oils to improve lubricity by up to 50 percent. Argonne's boron-based additives are environmentally safe, inexpensive, and have an unusual capacity to enhance the anti-friction and anti-wear properties of sliding surfaces in diesel- and gasoline-powered engines. The unusual lubricating mechanism of boric acid in these oils and fuels is controlled by its very special chemical structure and its ability to form a strongly bonded protective boundary film on rubbing surfaces.

- **Superhard and slick nanocomposite coatings** that improve the reliability and performance of all kinds of moving mechanical systems, including engines. Argonne's material reduces friction by 80 percent, increasing energy efficiency, eliminating wear and scuffing-related failures and extending the life of mechanical components. This technology won an R&D 100 Award in 2009 and has been licensed to automotive manufacturers.

- **Ultrafast boriding** is an innovative heat treatment process that uses boron compounds to convert surfaces into extremely hard and thick layers providing superior wear resistance. Compared to existing thermal treatment processes, Argonne's ultrafast boriding method provides much higher energy efficiency, productivity and near-zero emissions. After successfully boriding multiple quantities of industrial parts with a pilot-scale reactor, the Argonne technology is now being transitioned to Bodycote, one of the world's largest thermal processing companies, for full-scale commercialization.

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Reference

Holmberg K, et al. Global Energy Consumption Due to Friction in Passenger Cars. *Tribology International* (2011), doi:10.1016/j.triboint.2011.11.022 http://www.sciencedirect.com/science/article/pii/S0301679X11003501

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