How to Deal with Friction and Its Adverse Impact on Energy and Environment: A 21st Century Dilemma

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To meet the needs of our highly mobile lifestyle, worldwide energy consumption has intensified in recent years and now stands at around 13,000 million tons of oil equivalent per year. With increasing population, mobility, and industrial activity, this number will undoubtedly surge further, especially in the transportation sector, which has already reached more than one billion motorized vehicles worldwide. It is hard to believe, but about one-third of the fuel's energy in these vehicles is still consumed by friction, and on average, only about 20% of the fuel in our gas tanks is actually used to move our cars. Globally, transportation sector accounts for about 20% of the world's energy consumption and some 23% of total greenhouse-gas emissions every year. With respect to the state of the art in current engine technologies, increasingly harsher operating conditions of many moving parts are rendering most traditional materials and coatings ineffective and hence there is an urgent need for the development of more robust materials and coatings that can prevent wear and scuffing and reduce friction in next generation transportation vehicles. At present, DLC coatings are used extensively to meet the specific application needs of current engines and other moving mechanical systems [1]. In our laboratory, we have been focusing on the design of next generation novel tribological coatings that can extract DLC boundary films in-situ and hence provide ultra-low wear and –friction even with the use of base lubricating oils. Specifically, new breed of designer coatings which are primarily made of catalytically active hard and soft phases (i.e., VN, NbN, WN, MoN, HfN, and Co, Ag, Ni, Cu, Sb, etc.) affording ultra-high hardness, toughness in addition to excellent catalytic responsiveness to the hydrocarbon molecules of lubricating oils. Specifically, when tested in neat or marginally additized base oils, these catalytic coatings crack or fragment long-chain hydrocarbon molecules of lubricating oils to produce a carbon-rich boundary film whose structural chemistry is similar to those of DLC which is well known for its favorable friction and wear properties [2]. Overall, comprehensive friction, wear, and scuffing studies in our laboratory have confirmed that these nanocomposite coatings could serve as the next generation materials for a wide range of demanding automotive applications. They can reduce parasitic friction losses (thus increasing fuel economy) as well as minimize wear and scuffing failures (hence increasing component durability/reliability).

[1] S-C. Cha and A. Erdemir, eds., "Coating Technology for Vehicle Applications" Springer, New York, 2015.

[2] A. Erdemir et al., Nature, 536(2016)67-71