On achieving zero wear rate in tough conditions – the peculiar case of the combustion engine valve

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Internal combustion engines constitute an important part of our modern society. Even though the phasing out of the technique in cars has begun, in favor for electrical engines, this will take time and there are many other application areas where its use will continue for many years to come. Small portable generators, long haul transportation, energy production in rural areas, and marine vessels, all use internal combustion engines in some form to produce power.

The flow of gases in to and out of the cylinder is controlled by valves. These play a crucial role in the generation of power, however simple the desired function may be. The gas channels need to be closed during the compression and subsequent combustion, and open to let a fresh charge of air in, or the exhausts out. A simple task at first glance, becomes far more complex when investigating the conditions of the components, the valve and the seat insert, closer. The pressure increase during combustion forces the valves to buckle, creating a micro sliding motion in the valve-insert interface. The rotational speed of the engine causes high speed impact between the two. The vicinity to the combustion results in high temperatures, and hot gases pass over the surfaces when the valve is open. All while no intentional lubrication can be employed. A tough situation, if the surfaces were allowed to wear, becomes even more intriguing when you take into account the long service life of the components. To keep the tough demands on function and fuel efficiency of the engine, the allowed wear of the mating sealing surfaces is in the range of single atomic layers per hundreds of operational cycles. This may seem impossible to fulfill, but made possible by the formation and replenishment of protective tribofilms. These are built up by combustion residues landing on the surfaces and becoming trapped when the valve closes. With time, more and more residues become trapped and worked by the closing valve, thus gradually covering the surfaces with a tribofilm. As long as new residues reach the surface, the tribofilm can be renewed to compensate for wear. With material loss and replenishment in balance, a net wear rate close to zero can be achieved. Even better, a well-formed tribofilm may have a greater wear resistance than the original component surface, thus allowing for some imbalance in the addition of renewing residues.

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