HIGH PRODUCTIVITY EQUIPMENT

The need to reduce CO_2 emissions in the automotive industry is a major driver for innovation. In different countries there are various regulations with corresponding goals and deadlines, but the bottom line is that CO_2 emissions should be significantly reduced by 2020-2025.

Tribological coatings can contribute to this goal by reducing friction in the engine (figure 1). Many components, such as injection systems, piston rings, valve train components, piston pins, bearings and gears are being coated to reduce wear and friction and thus save fuel and reduce CO_2 emissions. In this article the focus is on piston rings and the machine engineering to coat them in a cost-effective way.

Hydrogen-free Carbon Coating

Geert-Jan Fransen, product manager tribological coatings, explains: "Conventional PVD coatings for piston rings are mostly CrN coatings. However, we developed a hydrogen-free carbon coating, ta-C and a-C, that offers many functional benefits, such as an average 20% reduced friction loss, very low wear and superior scuff resistance. This coating has to be deposited at low temperatures, between 130 and 200°C. And although this is a normal process temperature for tribological sputter coatings, for ta-C and a-C coatings which are deposited by arc technology, this is a low temperature. The higher plasma densities from arc technology are typically resulting in higher temperatures. In order to enable high rates for hydrogen-free carbon coating coatings, substrate cooling during deposition is required.

Long Target Lifetime

"In order to build a cost-effective coating machine, specifically for these a-C coatings on piston rings, we have integrated CARC⁺ technology on our existing Hauzer Flexicoat® 1000 machine," Geert-Jan continues. "The CARC⁺ technology has been chosen, because we can achieve a much higher arc current, reduce coating roughness and achieve longer target lifetimes.

This is especially relevant, because the market demands thick carbon coatings, more than 20 µm is quite common. Furthermore the coating zone has been increased by approx. 24% by re-arranging the cathode configuration of the system. On top of the functional diameter of the substrate table has increased, enabling more spindles in the same machine. The overall load increase that could be achieved is approximately 57%, depending on the preferred spindle diameter."

Cooling Features

"As a second step, additional cooling features have been integrated in order to be able to increase the deposition rate without overheating the parts. Upon request modular cooling packages can be selected varying from cooling devices at the outside circumference of the substrate table, as well as within. Also the position on the heating system can be selected modularly. In the most efficient configuration the heating system is transferred to the centre of the coating chamber. Both the heaters and the cooling device can be transferred into the deposition chamber depending on the process steps and the need to either have cooling or heater power available. As an additional benefit the heaters are not present during deposition and therefore do not get coated upon, minimizing coating flaking during deposition and consequentially preventing defects in the coating. The patent on the innovation is pending."

Optimized Configuration

"We believe in multi-functionality, so we made it possible to use the machine either in an optimized CrN set-up as well as an optimized configuration for hydrogen-free carbon coatings, a-C. Special power supplies have been selected to match the increase in deposition rate. A benefit of this new configuration is that a full table, 20 spindles of ø 100 mm, can achieve approximately 25 µm of hydrogen-free carbon coating. This, combined with a load increase of 57% and a cycle time reduction for CrN coating of 21% and for a-C coating of 36%."

Benefits of a-C coating:

- 20% reduced friction loss
- Very low wear
- Superior scuff resistance

Productivity increase because of new features:

- Load increase ± 57%
- Cycle time reduction 21% (CrN coating)
- Cycle time reduction 36% (a-C coating)

Innovation Process

"The new optimized configuration of the Hauzer Flexicoat® 1000 machine has been developed together with customers," says Geert-Jan. "The coating and productivity requirements have been defined in order to build the optimum machine with the lowest cost of ownership. At this moment we are adapting this concept for other coating technologies, which also require low deposition temperatures. So, if you want us to calculate some options for your specific application, please do not hesitate to contact us."

FRICTION LOSS DIESEL ENGINE

4 cilinder diesel engine

Operating point: 2.000 rpm / Temperature oil = 90°C

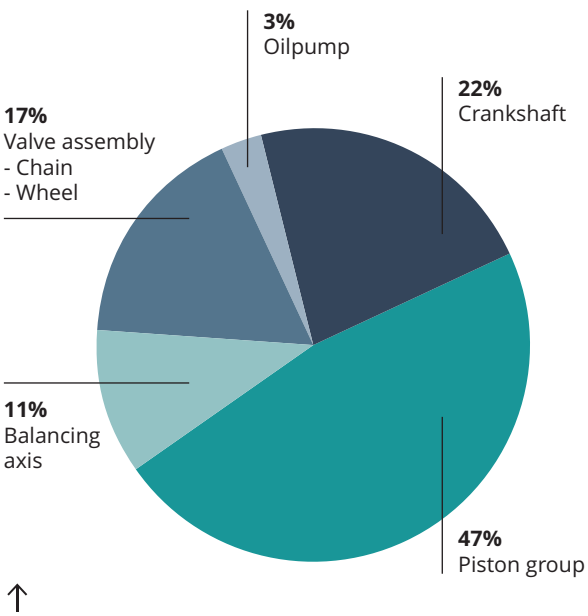

Figure 1: The amount of friction in engines as a percentage of the total friction