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FRICTION REDUCTION IN SINGLE-CYLINDER ENGINES THROUGH DIAMOR® COATING

THE TASK

In combustion engine-powered vehicles, approximately 50 percent of the frictional loss is accumulated in the powertrain. Friction-reducing wear-resistant coatings provide an excellent potential to substantially increase the efficiency and service life of these systems and reduce pollutant emissions.

For the development and evaluation of modern wear-protection layers, scientists in the laboratory usually use tribological test apparatuses to determine quantitative information about the coefficient of friction and wear rates. At the other end of the technology chain, engineers develop engines whose characteristics such as performance and torque are determined as a function of engine speed with dynamometers. And finally, rates of acceleration, fuel consumption and other data are determined with the assembled vehicle under actual driving conditions.

To correlate the laboratory-measured coating properties with the actual field application advantages of the use of coatings is a major challenge. In order to bridge that gap, the task was to demonstrate the advantage of Diamor® coatings in actual internal combustion engines.

OUR SOLUTION

At the Fraunhofer Center for Coatings and Diamond Technologies (CCD) (see also p. 128), the advantage of using Diamor® coatings for commercially-available single-cylinder engines was tested in collaboration with an industry partner. The engine tests were carried out at the Center for Automotive Research (CAR) of the Ohio State University in Columbus, Ohio. In the first experiment, a previously used, approximately 10 HP go-cart engine was measured on the test stand with a classic engine test (power and torque measured against the RPM). The engine was then disassembled and some critical friction components were cleaned and coated with Diamor® (Fig. 1). In this coated state, the engine test was repeated. In an additional experiment a 7 HP single cylinder motor (Kohler Command Pro CH270) was tested.

Typical applications for this engine are garden machinery, emergency generators, and pumping systems. First, a factory-fresh engine was filled with conventional Pennzoil 10W-30 oil and run in 3 times for 30 minutes, each time with fresh oil. After the third run-in period the oil remained clear indicating that the engine was properly conditioned. This was necessary in order to demonstrate the frictional advantage of the Diamor® coating as directly as possible.

In the subsequent experiments, a 3 HP electric motor was used to drive the Kohler engine at different RPMs. The engine valves were left open during this so that only the mechanical friction needed to be overcome. The required torque to drive the engine was measured. Uncoated and coated configurations were tested with conventional and synthetic (Mobil 1) oils.

The experiments were conducted at room temperature, operating temperature (the engine run for 35 minutes until the oil had reached standard operating temperature), and repeated in the cold (in dry ice).

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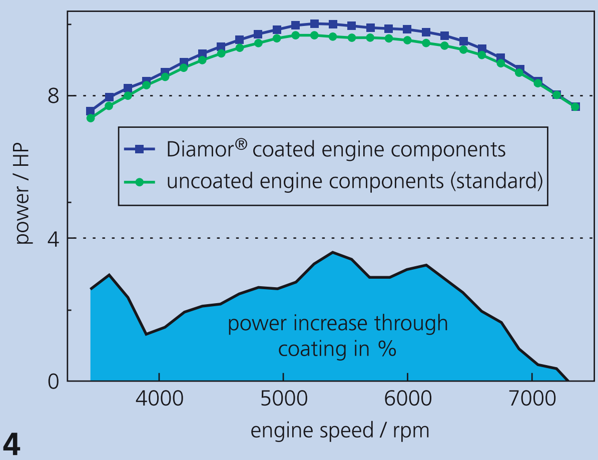
RESULTS

Figure 4 shows the power of the go-cart engine as a function of engine speed in the uncoated and coated conditions. The blue curve represents the power difference in percent. The data show that the Diamor® coating increased the engine power by more than 3 percent, particularly in the RPM range of peak performance. For racing motors, this power increase is significant.

However, the more important result is that the engine with coated components required a 350 RPM lower speed to achieve the same power level as the uncoated engine. In other words, the coated engine runs slower while providing the same traction force and this consequently lowers fuel consumption, and as a result of lower friction and lower engine speeds, also wears out less. Figure 6 shows the data for the Kohler engine driven in cold temperatures. The torque required to drive the Kohler engine is plotted against the engine speed. The reduction of the required torque and thus the friction exceeds 30 percent at 3000 RPM. The greatest benefit is demonstrated at cold temperatures. Figure 7 shows the over all engine speeds averaged reduction of friction at different temperatures. As a result, in this experiment, the Diamor® coatings provide a frictional advantage of 10-30 percent, depending on temperature.

Comparison of the engine power of a go-cart motor with and without Diamor® coatings



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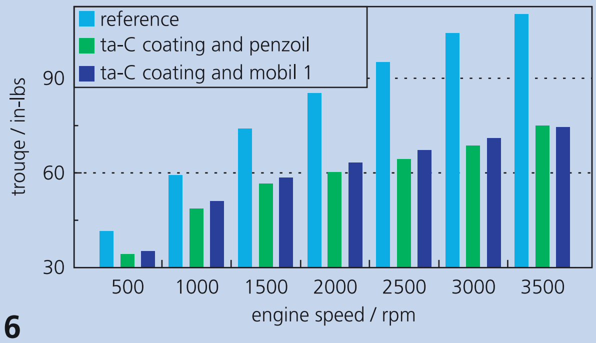
Torque in Kohler engine as a function of RPM, oil and coating at temperatures below 0°C



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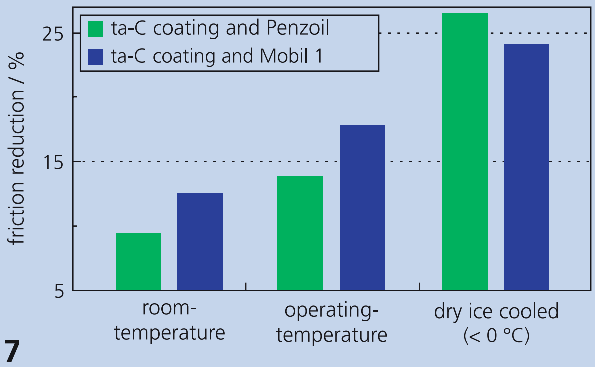
Average reduction of friction in the Kohler motor with coated components for different operating temperatures and with different oils



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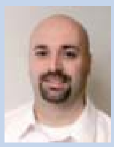
1-3/5 with Diamor® coated components in the single-cylinder test engine

CONTACT



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