

**Less friction means fuel savings**

Stuttgart/Germany, September 2009—By simply reducing friction in the engine, installing an optimized oil pump, and implementing an intelligent cooling strategy, MAHLE is able to reduce the fuel consumption of an engine by up to four percent in the New European Driving Cycle (NEDC).

At approximately 40 percent, pistons, piston pins, piston rings, and connecting rods (collectively known as the power cell unit, PCU) and the crankshaft fitted with gaskets account for the largest proportion of frictional loss in the engine. Another 20 percent of engine friction can be attributed to the valve train, comprising the camshafts, valves, and lever system. For both areas, MAHLE has developed new solutions to reduce friction.

Rolling bearing for the camshaft

By using compact needle bearings instead of the plain bearings commonly in use today to support the camshaft(s), MAHLE has devised a high-efficiency solution: the low friction camshaft (LFC). In an engine with double overhead camshafts (DOHC), frictional loss is reduced by some 300 watts with this solution. Depending on the engine, the LFC can drive fuel consumption down by around one percent. Because rolling bearings also use less lubricating oil than plain bearings, an oil pump with a smaller pumping power can contribute an additional percentage point to fuel efficiency.

Lightweight valve

As an alternative to the rolling bearing, the MAHLE lightweight valve can be used as a means to achieve fuel savings. Because they comprise up to 40 percent fewer oscillating masses and feature lower valve spring forces, lightweight valves enable power savings in the valve train of up to 60 watts per cylinder in a four-valve DOHC engine, for example. This opens up a fuel savings potential of approximately one percent.

### Optimized piston and piston ring combinations

MAHLE has tested different piston and ring types to determine which combinations are the most favorable in terms of reducing friction. In a DOHC test engine, for example, MONOTHERM<sup>®</sup> steel pistons with a GRAFAL<sup>®</sup>-coated piston skirt, a diamond-like carbon-coated piston pin, and an optimized ring set proved to be the best combination. When combined with a modified position of the connecting rods and crankshaft, the friction in the PCU dropped by up to 30 percent in some cases.

### Split cooling as part of an optimized holistic solution

An optimized oil pump, which supplies a cooling system with separate circuits for the engine block and the cylinder head (split cooling), enables additional friction-optimization measures by separate cooling of the engine block. In combination with the low friction camshaft or lightweight valves and an optimized PCU fitted in an engine, MAHLE achieved fuel savings on the chassis dynamometer of up to four percent in the NEDC compared to a series mid-size vehicle.

The MAHLE Group is one of the top 30 automotive suppliers and the globally leading manufacturer of components and systems for the internal combustion engine and its peripherals. Around 45,000 employees work at over 100 production plants and eight research and development centers. In 2008, MAHLE generated sales in excess of EUR 5 billion (USD 7.3 billion).

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