TopWeld® steel pistons make passenger car diesel engines even more economical

Stuttgart, September 2011 – MAHLE has been using steel pistons in commercial vehicle engines since the mid-1980s. But MAHLE also develops steel pistons for passenger car engines that reduce fuel consumption by up to five percent. The company will present the novel TopWeld® steel piston, which utilizes every potential improvement that has been identified to date, at the Frankfurt Motor Show 2011.

The high requirements for the load capacity of every individual engine component and its contribution to reducing fuel consumption secured the breakthrough of MAHLE steel pistons in commercial vehicles in the past already. They have proven themselves a million times over for more than 20 years.

Modern passenger car diesel engines follow the same high standards. MAHLE has therefore applied this knowledge to several variants of steel pistons for passenger car applications. The TopWeld® steel piston significantly reduces fuel consumption by applying a variety of technological principles. Based on a diesel engine reference vehicle, MAHLE has measured potential savings of about 5 g/km of CO₂ for TopWeld® steel pistons, using the NEDC (New European Driving Cycle). This corresponds to a reduction in fuel consumption of about 0.2 l/100 km.

The TopWeld® steel piston is also forged of steel. Two components are welded together to form a large, closed cooling channel. The steel used for the TopWeld® piston is of the grade 42CrMo4, which provides significantly greater strength and rigidity than aluminum. The piston height can thus be reduced by 30 percent. As a result, the contact surface between the piston and cylinder wall is smaller, as is the friction loss, which leads to measurable fuel consumption savings.
The lower piston height can also be utilized to increase the length of the connecting rods. The longer the rod, the closer the engine designer can come to the ideal of a vertical connecting rod motion, and the less the gas forces press the piston sideways against the cylinder wall, which likewise reduces friction. Instead of increasing the length of the connecting rods, the height of the engine block could alternatively be decreased due to the lower piston height. This reduces the mass and the space requirements of the engine.

Lower piston heights also mean less oscillating masses. The counterbalance weights and bearing widths can be reduced, which in turn reduces the bearing friction.

In addition to the piston height, the wall thickness and thus the mass of the steel piston can also be reduced because of the increased strength of the material. Shorter and lighter piston pins (connecting elements between the piston and the connecting rod) are likewise conceivable. The piston pin used in the MAHLE TopWeld® steel piston has a mass of just 181 g at a diameter of 28 mm.

Despite the greater density of steel, the mass of the piston group (piston and piston pin) of the TopWeld® piston is less than that of conventional aluminum pistons for passenger car diesel engines.

One distinct advantage of the MAHLE TopWeld® steel piston arises due to the different thermal expansion of steel and aluminum. When the engine warms up, aluminum pistons expand so much that their outer diameter would be nominally greater than the inner diameter of the surrounding cylinder, which causes significant friction loss.

In contrast, steel has a similar thermal expansion to gray cast iron. That is: in a warm engine, the cylinder expands by about as much as the piston gets larger around the circumference. The clearance between the piston and the cylinder wall stays at about the same
low level for all operating points. Friction losses due to interference seldom occur. Altogether, the sum total of the reduced friction sources, depending on the engine type, leads to fuel savings of two to five percent.

The MAHLE Group is one of the 30 largest companies in the automotive supply industry worldwide. With its two business units Engine Systems and Components and Filtration and Engine Peripherals, MAHLE ranks among the top three systems suppliers worldwide for piston systems, cylinder components, as well as valve train, air management, and liquid management systems. The Industry business unit bundles the MAHLE Group's industrial activities. These include the areas of large engines, industrial filtration, as well as cooling and air-conditioning systems. The Aftermarket business unit serves the independent spare parts market with MAHLE products in OE quality. In 2010, the MAHLE Group achieved sales of approximately EUR 5.3 billion (USD 7 billion); more than 47,000 employees work at over 100 production plants and eight research and development centers.

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