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PRESSRELEASE

Piston technology for modern combustion engines

Frankfurt, September 2013 – The thermal and mechanical loads on pistons in modern gasoline and diesel engines have seen a massive increase, primarily due to higher levels of specific output. Furthermore, the pistons are intended to increase engine efficiency, for example through reduced weight and friction. MAHLE has thus developed pistons for both types of combustion that increase load capacity and contribute to reduced fuel consumption.

The mechanical and thermal loads that act on a piston are largely determined by the combustion process. Apart from inertia forces in high-speed concepts, the mechanical load is dominated by peak cylinder pressures. The specific engine output can be thought of as a representative physical dimension for the thermal load in similar combustion processes. Gasoline engine development in recent years has seen more and more peak cylinder pressures of over 12 MPa and levels of power density up to more than 100 kW/L. The higher heat input in line with the increase in power density causes the piston temperature to rise.

As turbocharging becomes more widespread, it can be expected that specific output will continue to increase and that the field of application for new developments in coming years will include power densities of up to 130 kW/L.

The EVOTEC SC gasoline engine piston
The EVOTEC 2 piston, with its weight-optimized design, is currently a very good basis for prevailing power densities of around 100 kW/L. In comparison with the EVOTEC 2 piston, the EVOTEC SC has an additional cooling channel, which is created by inserting a salt core during casting. The integrated cooling channel causes temperatures at the piston crown and in the region of the first ring land to drop by up to 25 K. The load capacity at these locations is significantly increased, which makes power densities of over 100 kW/L possible. Such pistons reach operating temperatures more quickly, which has a favorable effect on exhaust gas emissions.

The new EVOLITE gasoline engine piston
In addition to expecting the pistons to withstand extremely high stresses, manufacturers require that the oscillating masses of the piston be lowered. These are very significant for the transient responsiveness of the engine as speeds increase. They are also critical if an acceptable engine vibration behavior must be achieved through mass balancing. This presents the challenge of handling high external loads with minimal piston weight. It must also be ensured that design changes to the piston do not compromise its behavior in terms of frictional loss or noise, but instead improve them if possible.

With the development of EVOLITE, the latest generation of gasoline engine pistons, MAHLE demonstrates that the limits of lightweight design can still be extended. The new piston design for modern, highly loaded gasoline engines that are optimized for frictional loss represents the next step in the ongoing development of the EVOTEC 2 design, which has been tried and tested in series production. The goal of development was to update the EVOTEC principle and to use ultramodern simulation tools to uncover additional potential for mass savings and incorporate them in a manufacturable product. A numerical 3D topology optimization of the EVOTEC 2 piston concept was performed in order to develop the EVOLITE. Due to the advanced state of technology in piston construction, additional

improvements to the design are often possible only by means of such numerical structural optimizations.

An improvement in the connection between the skirt and the box wall has increased the service life in this area by nearly eight times in comparison with the EVOTEC 2, while the weight has been reduced by 5 percent. The EVOLITE piston design offers potential in every respect to provide a low-weight solution, particularly for four-cylinder engines where the oscillating masses are very significant to noise emissions due to vibration.

Both test bench and live engine results have proven that friction, crucial to low CO_2 emissions, is further reduced in comparison with the EVOTEC 2. A CO_2 advantage of 0.46 g/km was determined for the EVOLITE piston in the NEDC.

Currently the process development of the EVOLITE piston is completed.

MAHLE steel pistons for diesel engines

In diesel engines, steel pistons provide significant potential for reducing CO_2 emissions in comparison with the aluminum pistons that have been typical up to now. MAHLE has therefore developed steel pistons for passenger car diesel engines to readiness for series production. The fundamental design advantages in comparison with aluminum pistons have already been discussed extensively. On the one hand, the benefits are found mainly in the area of frictional loss. In collaboration with a manufacturer, MAHLE has again demonstrated this frictional loss advantage in test bench analyses under both partial load and full load. Thermodynamic conditions additionally result in advantages in combustion that lead to a reduction in fuel consumption and emission levels. The lower compression height of a steel piston can also be utilized to increase the swept volume or to decrease the height of the engine.
The MONOTHERM piston from MAHLE, which has been tried and tested many times over in commercial vehicle engine applications, combines these advantages. It will be used in a

series production passenger car diesel engine for the first time in 2014.

As a further development of the single-piece MONOTHERM piston, the new two-piece MonoGuide piston closes the gap to the TopWeld steel piston introduced in 2012. In comparison with the MONOTHERM piston, the MonoGuide has a longer skirt, which remains decoupled from the piston crown in contrast to the TopWeld. This flexible design significantly improves the NVH behavior of such a piston and therefore seems to be well-suited for the use in aluminum engine blocks as well.

About MAHLE

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 as well as 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 2012, the MAHLE Group achieved sales of nearly EUR 6.2 billion (USD 7.9 billion); approximately 48,000 employees work at over 100 production plants and 7 research and development centers.

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