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Volkswagen at the 37th Vienna Motor Symposium

- **New TSI engine generation is significantly more efficient**
- **Miller combustion cycle in combination with higher compression as the basis for further reduction in fuel consumption**
- **VTG turbochargers in volume-produced spark-ignition engines for the first time**

Wolfsburg/Vienna, 28 April 2016 – Volkswagen is presenting the latest generation of the so-called EA211 TSI evo at the 37th International Vienna Motor Symposium. The first model in this future generation of spark ignition engines is the 1.5-litre TSI. This simultaneously fuel-efficient and high-torque TSI engine is set to launch in late 2016, initially with outputs of 96 kW and 110 kW. One of the numerous highlights of the new power unit is the turbocharger with variable turbine geometry, which features for the first time in a volume-produced spark ignition engine.

Future fleet and emissions legislation demands further progress in terms of fuel consumption, CO_2 and emissions. In order to achieve these ambitious targets, a large number of technical innovations have been combined in the new EA211 TSI evo, which have been considered in a new kind of combustion process. The result is a maximum torque that is available extremely early (from 1,300 rpm) and over a broad range of engine alongside with significantly enhanced customer fuel economy, with consumption reduced by up to one litre over one hundred kilometres.

For more than ten years, Volkswagen has been supplying the direct-injection and turbocharged spark-ignition engines with TSI technology. During this time, numerous innovations have come onto the streets. Thanks to single-stage and two-stage turbocharging, integrated charge-air cooling, integrated exhaust manifold with thermodynamic benefits and also the cylinder deactivation implemented in the four-cylinder for the first time, the spark-ignition engine has evolved increasingly into a fuel-saving specialist.

With the latest generation of engines, Volkswagen is going one step further: the main technology elements of the new EA211 TSI evo result in efficiency benefits of up to 10 per cent compared with the previous 1.4l TSI (92 kW). An important aspect here is that the improvements in fuel economy take effect across a wide range of the engine map. Consequently, they do not merely apply under test bench conditions but also have a distinct impact on the customer's everyday driving. Details of the new/revised technologies featured are as follows:

- Miller combustion cycle with a high compression ratio of 12.5:1
- Turbocharger with variable turbine geometry (VTG).
- Common-rail injection system with up to 350 bar pressure
- Innovative thermal management
- Cylinder deactivation (ACT)
- APS-coated cylinder walls (atmospheric plasma spray)

In detail this means: the cylinder liners in the aluminium crankcase for the 110 kW power variant are coated using the APS process (atmospheric plasma spray). Fine-grain spray powders combined with a specifically optimised grinding process lead to the creation of tiny lubrication pockets, which ensure that the piston rings glide smoothly with low friction and little wear. Further benefits of this solution are the increased heat dissipation compared with cast iron, the resulting improvement in antiknock properties during combustion and improved corrosion resistance in respect of poor-quality fuels on global markets. APS technology has also demonstrated particularly good wear resistance in hybrid applications, whereby the cold engine is often started under higher loads.

The cylinder head has been extensively re-engineered. Initiatives include optimisation of the water jacket for improved heat dissipation and adaptation of the valve angle and combustion chamber for the best possible execution of the Miller combustion process. The proven concept of the exhaust manifold integrated into the cylinder head has been retained. In contrast to the EA211, the intake camshaft is adjusted using a high-speed hydraulic camshaft actuator with a central control valve. The adjustment speed of up to 300° of crank angle (CA) per second enhances the dynamics of the cylinder-fill control.

The cylinder deactivation, another subassembly from the EA211 engine assembly kit, has been improved and is entering volume production with the TSI evo. This, too, benefits engine efficiency and is an important feature when it comes to the customer experience. It closes off the intake and exhaust valves of cylinders two and three up to the mid-load range, while at the same time deactivating fuel injection.

The new map-controlled cooling module provides the engine with efficient thermal management. Among other things, the cooling module ensures the water in the crankcase and the engine as a whole remains stationary during the warm-up phase. The resulting rapid engine warming improves heating in the car's interior and reduces engine friction during the warm-up process. A further benefit of the map-controlled cooling module is that the engine can be cooled in close correlation with its requirements across the entire operating range.

Other features of the TSI evo include an extensive friction package. This encompasses a map-controlled, fully variable oil pump, polymer coating of the first main crankshaft bearing and a switch to low-viscosity 0W20 oil.

The Miller combustion cycle is a key innovation in the new EA211 TSI evo. The resulting improvement in thermodynamic efficiency has been systematically implemented through four main development targets:

- Increase in the geometric compression ratio to improve efficiency in customer-relevant operation
- Reduction of the final compression temperature through early intake valve closing and resulting expansion cooling in the intake stroke.
- Optimisation of the charge motion in the interests of rapid flame propagation to reduce knock tendencies at high specific loads
- Increase in charge density through efficient exhaust gas turbocharging

A world first for the TSI evo is the use of an exhaust gas turbocharger with electrically actuated variable turbine geometry (VTG). Due to early intake valve closing in the Miller combustion cycle, volumetric efficiency is lower than for an engine with standard valve timing. Under partial load, the resulting de-throttling leads to a fuel-consumption benefit for the TSI evo. High charge pressure balances out the effect of the inherently lower effective stroke volume to create high low-end torque. At low engine speeds in particular, this places very high demands on the turbocharging system. Through adaptation of turbine flow characteristics to match the operating points, an exhaust-gas turbocharger with variable turbine geometry presents the opportunity to provide very high turbine output and thus high charge pressure from low engine speeds. The increased accumulation effect on the VTG turbine, in combination with a reduced moment of inertia in the turbocharger, additionally results in very spontaneous response characteristics. Compared with a 1.4l TSI (92 kW), the step change in load to the maximum torque takes place some 35 per cent faster. Overall, VTG technology forms an integral part of the TSI evo combustion process.

The indirect charge-air cooling has also been modified. In contrast to the EA211, the cooler is located in the pressure pipe, downstream of the compressor outlet and before the throttle valve, meaning it, too, is cooled. The new installation position made it possible to increase the size and performance of the cooler, while maintaining a very compact overall package. It is now able to reduce the temperature of the charge air to 15 Kelvin above that of the ambient air.

The injection system is the first application of the fourth-generation Volkswagen direct- injection system. Optimisation of the overall system and its components facilitated an increase in injection pressure to 350 bar. The resulting smaller droplet size improves mixture formation, leading to benefits such as a substantial reduction in particulate emissions.
The innovation of reducing the diameter of the injector tip to 6 mm, which is beneficial for integration into the combustion chamber, improves stiffness and reduces temperatures at the injector plate.

Note: Text and photos are available from www.volkswagen-media-services.com

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