Advanced Automotive Diesel Engines

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** Improvements in diesel engines can be achieved by combining a number of different technologies to improve efficiency and reduce emissions. These technologies include: **Piezo-injectors**; **Downsizing**; **Turbocharging**; **Cylinder deactivation**; **Optimised/advanced cooling circuit and electric water pump**; **Exhaust heat recovery**; and **Homogeneous charge compression ignition (HCCI)**.

■ **PERFORMANCE AND COSTS –** Implementing a full package of technologies would add (indicative only) incremental costs between €1135 for a small car and €1800 for a large car. It is estimated that these costs are likely to decline by around 10% in 2020 because of technology learning. The technologies covered - and related CO2 reduction and incremental compliance costs in 2008 Euros include: **a)** Reduced engine friction losses (3-5%, €40-60); **b)** Downsizing (3-10% €120-375); **c)** Exhaust heat recovery (1.5%, €45); **d)** HCCI (18-21%, €775-1,165); **e)** Optimised Cooling Circuit (1.5%, €35); **f)** Advanced Cooling Circuit and Electric Water Pump (3%, €120).

■ **POTENTIAL AND BARRIERS –** The increasing uptake of diesel vehicles is driven by further efficiency gains over gasoline and potential innovations that are not yet commercialised (e.g. HCCI). However, developments in advanced gasoline technologies are also likely to erode the performance gap with diesel and brake further expansion of the diesel market. In addition, the supply of diesel fuel is also constrained in some markets. Europe is already a net importer of diesel (and an exporter of gasoline to the US). While there are no general bottlenecks affecting the technologies described below, several of them still have a long way to go before they become commercial. Alternative technology options, increasing oil prices, incremental costs, as well as specific regional barriers, could slow down the deployment of diesel engines.

TECHNOLOGY STATUS AND PERFORMANCE – In general, advanced diesel engines gain efficiency through high compression ratios and reduced throttling or pumping losses. They may be turbocharged to recover exhaust heat and require a high-pressure fuel injection system to enable low-emission combustion. In addition, diesel engines have more advantages in torque over gasoline engines. With optimized transmission, this enables efficiency gains and the transmission to operate in higher gears for a longer period over the same drive cycle. The technologies listed in Table 1 can make contributions to better fuel economy and lower emissions. Rather than being radical innovations, many of these technologies have been in existence for several years and are advanced, refined and adjusted to optimise diesel technologies through e.g. re-engineering of associated systems, improved vehicle computer control and software sophistication, or changes in assembly procedures and systems. [1]

■ ***Piezo Injectors* –** Piezo-injectors are part of the improved fuel injection systems that allow much finer control and metering of the fuel spray while lowering consumption and emissions levels. Earlier injectors used electro-magnetic solenoids to move the injector needles and to allow the fuel to flow into the combustion chamber. Piezo-injectors use a stack of piezo-crystal plates that expand when an electric current is applied, which causes the needle to move. The expansion of the piezo-crystals is more precise and can be repeated more than the electro-magnetic solenoids, thus enabling precise fuel metering, lower consumption and

Table 1 - Advanced Diesel Technologies

Technology	Status
Piezo-injectors	Production
Downsizing	Production
Turbocharging	Production
Cylinder deactivation	Production
Optimised/adv. cooling and electric water pump	Production
Exhaust heat recovery	Prototype
Homogeneous charge compression ignition (HCCI)	Prototype

emissions. In recent years a new generation of piezo-electric fuel injectors has been developed by companies like Bosch, Continental and Delphi. These are now heading towards commercial production. [2,5,8]

■ ***Downsizing* –** Downsizing forces the engine into higher load operation with better mechanical efficiency and reduced pumping losses. This permits the engine's power and torque to increase (thus responding to new market demand or compensating for increased vehicle weight) without increasing cylinder capacity. As an alternative, engine capacity may be reduced while producing the same power. Reducing engine capacity with same power permits reducing fuel consumption thanks to four basic factors: a) Reduced pumping losses (i.e. less volume is swept on each engine revolution, higher average load on driving cycle, higher

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