Advanced Automotive Gasoline Engines

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** Internal combustion engine technology is constantly evolving. A number of improvements in gasoline-powered vehicles have been made to optimize combustion, improve fuel economy and reduce emissions. Examples of advanced gasoline technologies include **reduced engine friction losses**, **direct gasoline injection**, **engine downsizing with turbocharger**, **variable valve actuation** (VVA) and **homogeneous charge compression ignition** (HCCI). The majority of these technologies are already commercially available or close to being on the market. Although HCCI technology is still under development for both gasoline and diesel engines, it promises improvement in fuel economy and exceptionally low NO_x and soot emissions.

■ **PERFORMANCE AND COSTS –** A study by the US Environmental Protection Agency (EPA, 2008) presents the potential CO_2 reduction and incremental compliance costs for a number of advanced gasoline technologies as compared to conventional port-fuelled injection vehicles. The costs account for both direct manufacturing costs and indirect costs. The technologies covered - and related CO_2 reduction and incremental compliance costs in 2006 US dollars – include a) engine friction reduction (1-3%, $0-126); b) homogeneous direct injection (1-2% $122-525); c) stratified direct injection (9-14%, $872-1275); d) downsizing with turbocharging (6-9%, $120-690); e) variable valve timing (1-4%, $59-209); f) variable valve control (3-6%, $169-1262); and g) cylinder deactivation (6%, $203).

■ **POTENTIAL AND BARRIERS –** Car ownership is expected to grow in many OECD countries as well as in emerging economies. Demanding environmental concerns and fuel economy standards, as well as increasing fuel prices, are the major drivers for advancement in engine technologies. The IEA study *Energy Technology Perspectives* (IEA, 2008) suggests that improving the fuel economy of light-duty vehicles (car, small van and sport utility vehicles) would be one of the most important and cost-effective measures to help reduce CO_2 emissions in the transport sector. Given the maturity of some advanced gasoline technologies, and the near-term and cost-effective solutions they can offer to energy and emissions concerns, there is neither technical-economic nor infrastructure barrier for deployment, although some technical bottlenecks have to be solved for technologies such as the HCCI.

TECHNOLOGY STATUS AND PERFORMANCE - Advanced gasoline technologies include a variety of new components and systems aimed at optimizing combustion and thereby improving the fuel economy and reducing the emissions of greenhouse gases and other pollutants. Major innovations are listed in Table 1.

■ ***Reduced engine friction*** technologies include systems, components and materials that minimize the friction between moving metal parts in the engine. These technologies are available in a significant number of engine designs [1]. Several friction reduction opportunities have been identified in piston surfaces and rings, crankshaft design, improved material coatings and roller cam followers. Various studies suggest that the CO_2 reduction potential for engine friction reduction technologies may range from 1-5% [1,2,3].

■ In the ***gasoline direct injection (DI) engines,*** fuel is injected at high pressure directly into the combustion chamber rather than into air intake manifolds. The key advantage is the improvement in fuel efficiency. The technology was developed more than 10 years ago and a number of different manufacturers are now using these types of engines in commercially available vehicles. The use of sulphur-free fuels is necessary to obtain the maximum benefit from this technology. Depending on the ignition and combustion mode and on the formation process of the mixture, DI engines can be categorized in *homogeneous charge*, and *stratified charge*, spark ignition. In the ***homogeneous charge (stoichiometric) DI engines***, a high-pressure fuel injector sprays fuel directly into the combustion chamber early enough in the cycle to promote homogeneous fuel-air mixing. These engines have the potential to reduce hydrocarbon emissions, increase power and improve fuel economy, while taking advantage of the highly-effective catalytic after-treatment systems, the same as the port fuel injection (PFI) engines. Various studies suggest a CO_2 emission reduction potential ranging from 1-5% [1,3,4] in comparison with PFI and multi-point injection. These engines are often supplemented with turbo-charging, supercharging[1], or both[2]. They are available from

Table 1 – Advanced Technologies for Gasoline Engines

Technology	Status
Reduced Engine Friction Losses	Production
Direct Gasoline Injection (incl. homogeneous/ stratified charge)	Production
Downsizing with Turbocharging	Production
Variable Valve Actuation	Production
Cylinder Deactivation	Production
Variable Compression Ratio	Prototype
Homogeneous charge compression ignition (HCCI)	Prototype

[1] Turbochargers and superchargers are air compressors that allow more air into an engine; turbochargers are powered by exhaust gases, while superchargers run directly on engine power.

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