DI-CNG engine results

Direct injection of CNG supports downsizing and turbocharging of engines. Prior to launch of Life DI-CNG program it was demonstrated during engine tests by Ford as well as during vehicle tests by Daimler, that it was possible to achieve performance levels similar to modern direct injection gasoline engines. In particular the low end torque can be significantly increased compared to state-of-the-art port fuel CNG injection technology. Thus no sacrifice in driving comfort can be expected with DI-CNG technology. This competitiveness appears as an important criterion to increase market share of CNG powered vehicles.

REFERENCES

EU regulations and policies:
1) European alternative fuel strategy, COM (2013) 17

CNG Injection Technology:
2) www.gason.eu
3) http://delphiau.to/EngineManagement
4) H. Husted, G. Karl, S. Schilling, C. Weber; 23rd Aachen Colloquium, 2014

Presentation:
http://delphiau.to/AutoDayGreen

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Global Powertrain Systems Business Unit Headquarters

Delphi Automotive PLC is a high-technology company that integrates safer, greener and more connected solutions for the automotive sector. Headquartered in Gillingham, U.K., Delphi operates technical centers, manufacturing sites and customer support services in 44 countries.

Life13 ENV/LU/000460 Life DI-CNG

Industrialization of Direct Injection Compressed Natural Gas injectors

KEY FIGURES
Duration: June 2014 - May 2018
Total budget: €7.97 M
Life funding: €3.43 M

KEY OBJECTIVES
• Install pilot line for manufacturing of Delphi DI-CNG injectors for passenger vehicles.
• Equal or better torque and power output compared to direct injection gasoline and diesel engines.
• Emissions reductions:
  23-25% CO2; >90% particulates;
  35-60% NOx (compared to diesel);
  80% CO (compared to gasoline).

Presentation:
http://delphiau.to/AutoDayGreen
Compressed Natural Gas as alternative fuel

The Life program supports novel technologies that have promise to protect the environment while counteracting climate change and global warming. As part of its decarbonisation strategy, Europe is looking at alternative fuel sources. Within the alternative fuel strategy paper it has been concluded that Compressed Natural Gas (CNG) is important as an alternative fuel to reduce oil dependency and greenhouse gas emissions. CNG offers interesting physical and chemical properties that render it attractive as an alternative fuel for automotive applications.

CNG is mainly composed of methane, CH₄. It has the highest hydrogen to carbon ratio of any fossil fuel and therefore offers optimum composition to reduce CO₂ emissions. The gravimetric specific heating value of methane is higher than for gasoline or Diesel fuel. When compressed to 200 bar CNG also gains volumetric specific heating values enabling tank storage for useful vehicle range. CNG is widely accepted by the public thanks to industrial applications for stationary heat and power generation and the private sector. A CNG grid is available in all industrial countries and fulfills high quality standards for safe transport, storage and handling.

CNG becomes attractive as an alternative fuel, because it is fully compatible with bio-methane. Bio-methane is obtained through an upgrade of biogas which can be generated from wide variety of natural sources or organic waste. CNG has gained further interest, because it can also absorb and store hydrogen. Hydrogen could be produced by electrolysis while using excess electrical energy originating from renewable sources like wind or photovoltaic. Alternatively hydrogen can be further reacted with excess CO₂ to form methane. This conversion is known as “Power-to-Gas”. Thus numerous scenarios appear viable to alter the natural gas composition such that it will become a sustainable fuel for green and low emission vehicles.

Delphi’s DI-CNG injector has captured attention, because it is considered as a key enabling technology for the development of future clean and efficient vehicles and could facilitate wider acceptance of CNG powered vehicles. The most significant benefit of DI-CNG technology is the fact that it can provide similar driving comfort, especially similar low-end torque to modern internal combustion engines. At the same time it enables lower greenhouse gas and particulate emissions than conventional engines that use gasoline or diesel fuel.

During Horizon2020 GasOn² project, it is targeted to build DI-CNG powered demonstrator cars that run only on methane based fuel with high power, greatly reduced emissions and high range.

Delphi CNG injector systems

Delphi has significant experience producing fuel injection systems for gasoline, Diesel and CNG engines. Delphi’s Multec® CNG injectors for port fuel injection engines can operate on compressed natural gas, propane and liquefied petroleum gas.

In addition Delphi has recently developed an injector for direct injection CNG operation. Direct injection and turbocharging are key technologies for downsizing of modern internal combustion engines. Research performed at Delphi CTC Luxembourg in close collaboration with customers Daimler and Ford has demonstrated that this technology now offers the potential for significant improvements in efficiency, power output and emissions.

DI-CNG injector design

Delphi DI-CNG injector operates with solenoid actuation similar to Multec® gasoline injectors. Conversely to standard gasoline injectors, we developed an outwardly opening valve design that offers improved sealing. This design change was key to reduce gas leakage given that the pressure for CNG operation (typically 6 to 16 bar) is one order of magnitude lower than for gasoline operation (typically 150 to 350 bar). Moreover the novel nozzle design allows to reach the higher flow rates required to compensate for the lower specific heating value of CNG compared to gasoline.

Special materials and interfaces were developed to achieve robust durability and overcome increased wear behavior of CNG gas.

DI-CNG injector technical specification:
Pressure range: 6 to 16 bar absolute
Flow rate: up to 7 g/s @ 16 bar
Injector dimensions for connection to rail, electrical connection as well as body and tip diameter according to customer requirements.

Delphi DI-CNG injector results

Direct injection of CNG demands fast injection cycles and accurate control of gas volume over a broad range. The quantity of injected gas can be fairly easily regulated by variation of pressure and/or injection time. Thus it becomes possible to inject quantities of 50 mg or above at a typical pulse width of 7 ms.

From durability testing, we have successfully demonstrated that the leakage rate can be maintained below required limits and well beyond expected lifetime.

Such validation at component level is mandatory prior to subsequent testing on engine and in vehicle.