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The challenges of natural gas direct injection and its application to a natural gas-diesel dual fuel concept

Die Herausforderungen von Erdgasdirekteinblasung und die Anwendung in einem Erdgas-Diesel Dual-Fuel-Konzept

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Abstract

In this publication the application of Delphi's injector for low-pressure direct injection of CNG is reviewed. Furthermore, aspects of the injector development are highlighted and durability test results are presented. The injectors are designe……..

Kurzfassung

Der vorliegende Beitrag befasst sich mit der Entwicklung und Anwendung des aktuellen Erdgasinjektors für Niederdruckdirekteinblasung von Delphi. Neben verschiedensten Aspekten ……..

1. INTRODUCTION

Automotive manufacturers find it increasingly challenging to meet the stringent CO_2 emission limits imposed by the EU. The corporate average CO_2 emission of new passenger cars ……

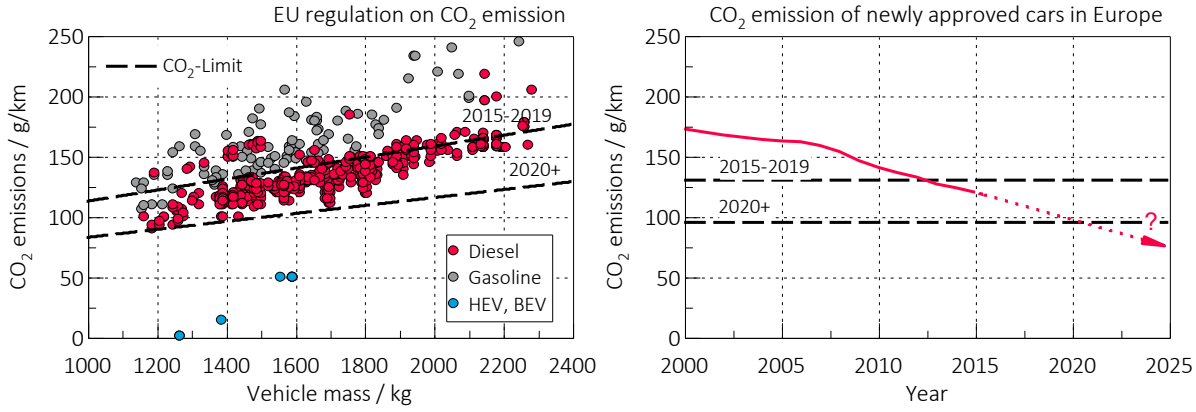

Figure 1: The CO_2 emissions of the portfolio of a German OEM in 2015 (left) and the trend of the average CO_2 emissions of new passenger cars in the EU (right) [3, 4].

1.1. Technology

This demonstrates on the top the current technologies of NG passenger cars and projections into the near and distant future. Today's available NG powered passenger cars are designed as bivalent engines. They can be operated with CNG or gasoline. Thereby, the requirement of a dense network of NG filling stations is relaxed. However, in bivalent engines the higher knocking resistance of CNG compared to gasoline cannot be considered, because for the definition of the compression ratio the fuel with the lower is existing in **Table 1.**

Table 1: Injector specifications

Parameter	**DI-CNG specifications**
Pressure range	6 – 16 bar absolute
Flow rate at 16 bar absolute	7 g/s
Injector body diameter	21 mm
Injector tip diameter	7.5 mm

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The flow and pressure specification of the Delphi DI-CNG injector enables specific power of up to 40 kW/cylinder with GDi-typical dynamic response at low engine speeds.

The maximum operating pressure was the result of a compromise between contradicting factors: power level is increasing with pressure while vehicle driving range and tip sealing are improving when lowering it.

The achieved level of performance is similar to today's GDi applications [13, 15, 27] and demonstrates the potential of the DI-CNG technology compared to PFI (see **Figure 2**).

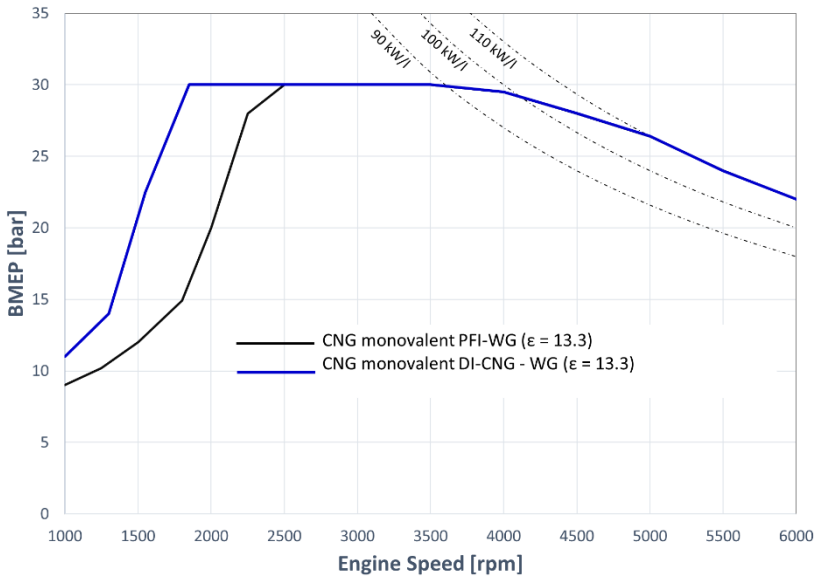

Figure 2: DI-CNG vs. PFI-CNG torque curves [27]

The fifth generation of the injector is shown in the figure below. The injector meets the packaging requirements and is compatible with today's GDi engine applications. A reduction to 6 mm tip diameter version is under investigation but will results in a minor reduced flow rate at a given pressure.

2. SUMMARY AND OUTLOOK

In this paper concepts and results with Delphi's injectors for low-pressure direct injection of CNG are presented. Furthermore, aspects of the DI-CNG injector development are highlighted. The DI-CNG injectors are designed for passenger car engines and operate at CNG pressures of up to 16 bar. The main motivation to introduce DI-CNG is the improvement of the low-end torque and to enable scavenging. Thereby, the low-end torque and performance of today's GDi engines are matched. Furthermore, measurements with monovalent DI-CNG engines demonstrate that the emission of particles in the NEDC is reduced by a factor of 10 compared to GDi engines. The consequent design of passenger car engines for monovalent DI-CNG operation in combination with downsizing enables the reduction of CO_2 emissions by 31 % in the NEDC and by 29 % in the WLTC……

3. STATUS OF DI-CNG

The provision of a fuel injector for natural gas was required for the dual fuel concept. In this chapter, it will be first explained why direct injection of NG is preferred to port injection and how it solved its drawbacks. Since no injector for direct injection of NG is readily available on the market, a new device had to be developed. The product development will be described from the definition of the injector requirements, through concept decisions, up to the testing and validation of the built injector prototypes. The benefit of direct injection of NG in terms of reduction of CO_2 and particulate emissions will finally be illustrated with experimental results measured on vehicles equipped with the Delphi injectors……

3.1. Direct Injection of Natural Gas

The current state of the art for light duty CNG engines in series production is port fuel injection. In downsized, boosted engines this results in a loss of low-end torque when compared to a gasoline direct injected (GDi) engine due to lower volumetric efficiency and the inability to perform scavenging. The……

3.1.1. Injector design and development

The Delphi DI-CNG was developed to allow easy conversion of existing downsized and boosted GDi engines. The ultimate technology goal is to exceed the torque and power of the gasoline version of the engine while maximizing the vehicle driving range for end-user……

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4. REFERENCES

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