Heavy Duty Gas Engines integrated into Vehicles

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Project partners:

1 - AVL - AVL List GmbH - AT
2 - BWR - Borgwarner Ludwigsburg GmbH - DE
3 - BOSCH - Robert Bosch GmbH - DE
4 - DAI - Daimler AG - DE
5 - DINEX - Dinex Ecocat OY - DK
6 - FPT - FPT Industrial S.p.A. - IT
7 - IDIADA - Idiada Automotive Technology S.A.- ES
8 - IVECO - Iveco Espana SL - ES
9 - MAN - MAN Truck & Bus AG - DE
10 - POLIMI - Politecnico di Milano - IT
11 - RCD - Ricardo UK Limited - UK
12 - SAG - SAG Motion GmbH - AT
13 - TNO - Nederlands organisatie voor toegepast natuurwetenschappelijk onderzoek - NL
14 - TUG - Technische Universiteat Graz - AT
15 - UEF - ITA-Suomen Ylipisto (University of Eastern Finland) - FI
16 - UASE - Hochschule Esslingen - DE
17 - UNR - Uniresearch BV - NL
18 - VOLVO - Volvo Technology AB - SE
19 - VIF - Virtual Vehicle Research Center - AT

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Executive summary

MAN and IDIADA are developing within HDGAS project an advanced dual-fuel LNG prototype truck. This advanced truck will feature a low pressure injection (indirect injection in the intake system) engine with a diesel like performance and drivability. The MAN engine will have as economical advantage a less complex injection system hardware compared to HPDI and spark ignited engines (useful for a still small LNG trucks market with around 30 to 50% extra-costs to the equivalent truck), will have the capability to revert to full diesel operation when required as well, thus allowing LNG dual-fuel MAN trucks run solely on diesel whenever it is a lack of LNG stations (around 60 LNG stations are available in Europe at the moment in 2015) or in case of LNG is not available for any reason.

Deliverable 5.1 condenses the results of the task 5.1, Development of initial dual-fuel engine assessment, where a complete instrumentation of the engine was performed to gather information in pure diesel engine operation and an initial dual-fuel operation. A mild dual-fuel conversion of the engine by means of a Master-Slave approach was performed to allow engineers gather initial information about the engine operation when natural gas is injected in the intake system. To achieve the same power and torque for a given engine operating point, much higher air consumption was observed by the engine through the 2-state waste-gated turbochargers. This point confirms the expectations of IDIADA about the need of a boost management control for the future engineered engine with a different engine management system to the Master-Slave approach.

Certification like tests demonstrated the full compliance of the baseline diesel engine with Euro VI. Furthermore, the MAN D2676 engine tested according to the power regulation R85 achieved the declared performances (power and torque).

The performed tests demonstrated the engine operation in dual-fuel mode, with an initial (laboratory level) Master-Slave approach (similar to the state of the art dual-fuels of 2013), where the diesel baseline engine Control Unit (ECU) is interfaced by a Gas Control Unit (GCU) by CAN. The engine operated with up to 70% diesel replacement by natural gas in low and mid load operating points without exceeding the in-cylinder pressure, while from 1200 Nm the in-cylinder pressure limited the dual-fuel operation by approximately half. With these initial tests CH_4 emissions were observed to exceed the Euro VI emissions without using a CH_4 catalyst to oxidize unburned methane, as it was expected.

The baseline engine without including any of the new innovations which will be fitted in the task 5.3, Development of dual-fuel engine, operating in dual-fuel “master-slave” mode delivered power and torque as for the baseline engine. However due to the limitations of the initial GCU, the engine operation was not optimized and the exhaust temperature measured was too low to obtain a good CH_4 oxidation in the catalysts as required.

CO, NO_x and PM were measured in WHSC and WHTC certification like tests below Euro VI limits. Given the results achieved, the efforts during the dual-fuel Development task 5.3 will focus in the optimization of the diesel pilot injection, Gas injection, aftertreatment optimization by means of a CH_4 catalysts as well as an optimized boost control and exhaust thermal management as expected.

The baseline tests for performance, emissions and mapping, where useful to gather information about the engine baseline operating temperatures and pressures, thus defining the limits which will be used as reference for the future full dual-fuel engine with integrated management control unit to be developed under task 5.3 Development of dual-fuel engine. In addition the data gathered during the activity is useful for the tasks 5.2 CFD – Gas exchange and Injection systems since data coming from the engine test bed is useful for the generation and correlation of a virtual engine modelled by means of 1D tool (Gt-Power) and 3D tool (AVL Fire).

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