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
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9 - MAN - MAN Truck & Bus AG - DE
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Executive summary

Heavy Duty Gas Engines integrated into Vehicles (HDGAS) is a three-year Horizon 2020 (H2020) programme to develop knowledge and know-how in several areas surrounding Natural Gas (NG) powertrains, including; engine design, fuel storage, supply systems, aftertreatment system specification, development and calibration. Within HDGAS Work Package 4 (WP4), the aim is to assess low-pressure positive ignition direct injection gas engines and relative advantages of lean burn and stoichiometric combustion within the constraints of the baseline engine. This report for Task 4.1 details the simulation results used to aid the specification of the lean burn engine variant of WP4.

To enable the specification of the lean burn variant for WP4, simulation tasks have been completed, aiming to identify appropriate components and calibration settings. Required combustion characteristics were defined, and an engine specification has been developed, supported by 1D analysis, appropriate literature and relevant benchmarks. 3D simulation was then used to conduct detailed assessments around the developed geometry of the combustion chamber. The results seen within the simulation tasks highlight the CO_2 benefit of the lean burn variant compared to the baseline engine. A full assessment of the relative CO_2 benefits will be completed during the engine testing tasks of WP4.

The main benefit seen for lean burn operation compared to stoichiometric operation is the ability to vary the target lambda according to the speed and load. At low load throttled conditions, allowing higher excess air reduces the pumping losses incurred from throttling, although there is a trade-off with longer combustion burn duration. At higher loads, where boosting is required, the increased excess air reduces the peak combustion temperature thereby reducing heat transfer losses – again this is offset against the increase in combustion burn duration. Further investigations highlighted the benefits of optimising the intake valve profiles and both intake and exhaust valve timing to lower pumping losses at low load throttled conditions. Simulations have also indicated that EGR, at both part load and full load, would be beneficial for both CO_2 and NO_X emissions.

The evaluation of the aftertreatment system with regards to emissions control, has shown the challenge of achieving the hydrocarbon limits for a lean burn engine owing to lower exhaust system temperature compared to stoichiometric operation. Simulations indicate that the emissions targets can be met with exhaust thermal management employed. This however, carries a CO_2 penalty, which has be clarified.

Heavy duty compressed natural gas engines that operate under lean conditions are not currently in production at Euro VI, however, if the right combustion characteristics can be achieved, a lean burn application could be viable within Euro VI emissions legislation when used in conjunction with a state-of-the-art aftertreatment system.

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