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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11 - RCD - Ricardo UK Limited - UK
12 - SAG - SAG Motion GmbH - AT
13 - TNO - Nederlands organisatie voor toegepast natuurwetenschappelijk onderzoek - NL
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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

The overall objective of the HDGAS project is to develop, demonstrate and optimize advanced powertrain concepts for dual-fuel and for pure natural gas operation engines, perform integration thereof into heavy duty vehicles and confirm achievement of Euro VI emissions standards, in-use compliance under real-world driving conditions and CO2 or greenhouse gas targets currently under definition. An essential step is to develop an advanced LNG fuel tank system which is in line with relevant present and yet to be defined technical specifications and standards for fueling interfaces and filling processes. This tank system and the standards are developed in HDGAS Work Package 2 (WP2).

One objective for the development of the tank system is to enable "one line" filling. This means that no vent-back line to the filling station should be necessary. This is possible because of the so-called "vapor collapse" – a process which is introduced by generating a LNG spray in the tank and which significantly reduced the tank pressure during the filling process. This vapor collapse was investigated in detail to find an optimal solution for spray generation on the one hand, and to gain deeper insight into the process itself to support the follow-up standardization.

The LNG spray within the tank was investigated by means of 3D Computational Fluid Dynamics (CFD) simulations. By tracking the particle trajectories within the tank two issues could be addressed:

- A direct optimization regarding the spray bar layout was performed. Namely, the required spray direction and opening angle to fill the available space with LNG spray were determined. This supports a fast pressure drop in the tank, which lasts as long as possible during the filling process. Both facts support a short tank filling time.
- By detailed time-of-flight investigations, a suitable model and simulation workflow to estimate the heat transfer between LNG spray and vapor was derived.

In a subsequent step, reduced thermodynamic 1D models were generated to perform simulations for a wide range of admissible operating points based on the heat transfer maps obtained from the 3D CFD simulations. These models were applied to calculate upper and lower limits for the filling time. By means of these filling times, the required filling station parameters (with respect to pressure and temperature) for different initial states of the tank were determined.

The application of optimized spray bars will enable the development and implementation of single line filling stations. This will reduce cost and complexity and increase acceptance in the market. The standardization will help to establish LNG as an alternative fuel (cf. also targets of the LNG Blue Corridors program).

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