HDGAS

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

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).

An essential requirement of the tank system is the adequate supply of superheated LNG for the engine. Depending on the engine system the pressure of the Natural Gas at the engine varies between 10 bar and 300 bar. Pressure levels higher than 15 bar can only be provided by pumps. Below 15 bar the saturation pressure is used to transport the LNG out of the tank to the engine. For all systems the LNG has to be heated up from the cryogenic temperatures (typically -150 °C) in the tank to approx. ambient temperatures. Therefore the LNG is evaporated and superheated in a heat-exchanger and the attached piping. The energy for the evaporation is mainly provided by the engine coolant system. A challenge for this evaporation system can be highly transient cycles, where the engine loads change from almost 0% to 100% and vice versa. Other critical cases might appear when the coolant is still at low temperatures during cold-start.

In order to understand the physical behavior of the tank system a 1d-simulation tool has been developed based on the conservation equations of mass, energy and in a simplified way also the momentum equation. In addition the gas properties are implemented using the NIST data base REFPROP for pure methane together with thermo-physical data of the coolant. During the evaporation the gas has to pass from the one-phase status of saturated liquid through the two-phase transition of wet vapor until the status of saturated vapor is reached. As the system is used in a transient way the margins of the one-phase regions to the two-phase region move constantly. At these margins the derivatives of several properties are discontinuous.

All the mathematical equations and models are solved applying the commercially available software package IPSEpro by SimTech/Graz. This approach has been chosen in accordance with SAG and provides finally a much more sustainable solution, as many features like pre- and post-processing, mathematical solvers and procedures for data-storage and documentation are already available. Nevertheless the selection and numerical formulation of the equations has been done by the project team. All the special models are condensed in a DLL-file.

The application of the model has been done for an existing LNG-tank of SAG without pump. This tank system has been roughly measured on a testbed and the results have been compared to the simulation results. Other transient tests show a stable solution behavior for all investigated cases.

Finally it can be stated that the simulation tool fulfills the requirements and is already used by SAG.

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