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

Part of the HDGAS project is the development and demonstration of a dual fuel HD engine that will combine diesel and liquefied natural gas. Part of this effort is the development and demonstration of the corresponding exhaust gas aftertreatment system. This aftertreatment system will have to reduce the tailpipe emission of particulate matter and nitrogen oxides towards EURO VI levels. But it will also have to limit the emission of methane to levels below 0.5 g/kWh according to the EURO VI test procedure. For this, such a system will combine several catalytic subsystems: diesel oxidation catalyst (DOC), particulate matter (PM) filter, selective catalytic NOx-reduction technology (SCR) but also a methane oxidation catalyst (MOC).

For meeting the above mentioned requirements, in work package 3 of the HDGAS project, new formulations for the SCR and MOC have been developed. Current state-of-the-art MOC are known to rapidly – and to a significant level irreversibly – deactivate with time. Furthermore, there is little or no knowledge on the long term effects of submitting SCR catalysts to LNG.

To support the exhaust aftertreatment system development process it was decided at the outset of the HDGAS project to submit full scale versions of the new catalysts to accelerated ageing experiments on an engine test bench. On this test rig the catalytic subsystems would be subject to the exhaust gas of a heavy-duty engine that would be operated in such a way that exhaust gas composition and temperatures would mimic the long term solicitation that would occur in the anticipated HDGAS dual-fuel demo engine.

At the outset of the project it was the ambition of the project to examine also the effect of LNG composition. In the course of the project it was decided that the focus of this composition related research would be on the poisoning effect of sulphur present in the fuel.

This research has been performed in the following sequence: first, based on literature and on in-house data an accelerated engine test procedure has been developed. Then the validity of this test procedure was examined in a first set of engine experiments. Based on the outcome of these experiments, the test procedure (and the corresponding engine operation) was adapted. Then a second, final ageing test phase was performed. In performing the research it was further decided to separate the investigation of S-poisoning from the investigation of other deactivation processes. For this reason, during thermal ageing, only sulphur free diesel would be used and high diesel to gas blend ratio's (that is low diesel energy replacement levels).

The results of these experiments have been analysed. They show that the accelerated ageing has little or no effect on the conversion efficiency of the SCR catalyst. This is not so for the MOC. There the experiments show a considerable reduction in conversion efficiency within 114 hours of ageing at temperatures above 500°C (40 hours at 525°C and 74 hours at 625°C). This would correspond to a significantly higher operating period in real life, but much shorter than the estimated required lifetime of 8000 hours. Also it was noticed that, in an almost S-deficient condition, a much stronger deactivation was observed in the engine tests than in the laboratory tests. The mechanism responsible for this difference has not been identified.

The results of the S-poison tests confirm the outcome of the laboratory tests: SO2 in the exhaust gas results in a rapid deactivation of the MOC. However, increasing the (lean burn) exhaust gas temperature towards 625°C results in an almost complete regeneration. Heavy S-loading seemed to have only a small effect on the SCR downstream of the MOC.

At the outset of the project it was the ambition of the project to also examine the effect of siloxanes on the durability of the exhaust aftertreatment system. Because of the strong wear induced on internal combustion engines by siloxanes (and because these siloxanes are almost absent in LNG) the study on siloxanes effect has been limited to a desk study.

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