Mild Hybrid Cost effective solutions for a fast Market penetration

European Commission

Thomson

Introduction

Road transportation sector faces multiple challenges today as affordable solutions are required to simultaneously reduce GHG (Green House Gases) emissions, together with noxious compounds (including nanoparticles emissions) under Real Driving conditions: in this context, the electrification of the powertrain will be a fundamental step, especially in high traffic density conditions in large urban agglomerations.

The THOMSON project addresses very precise and consistent objectives towards achieving high efficient, cleaner and affordable electrified powertrains. Approaches developed in the THOMSON project will demonstrate how the right combination of advanced engine **downsizing/turbocharging technologies, coupled with a 48V motor-generator system** for a rapid electrification through conventional vehicles. Considering the lower cost of these systems, 48V architectures are particularly of interest to cover B-C market segment, that are the market targets of the THOMSON project.

The improvement achieved with the mild hybrid systems is based on a certain number of engine technologies that are enabled by the 48 Volt architecture: **eBoosting, Electrically Heated Catalyst and electrically driven auxiliaries (such as cooling and oil pump)**. These can be integrated in the powertrain system to match on one side an extension of performance and functionalities with lower fuel consumption and, on the other side, they can assist the operability of the systems even under ambient conditions like cold starts and/or altitude.

Aim

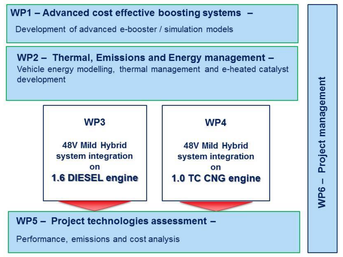
THOMSON project aims to demonstrate, through two demonstration vehicles:

i. integrate the downsizing, turbocharging technologies and the 48V motor generator system into two first-in-kind demonstrator vehicles.
ii. the capability of 48V system in achieving the environmental targets.
iii. to provide to the end user additional contents in terms of vehicle dynamic, driveability, enjoyability and NVH.
iv. in parallel to the technologies development, the simplification of the overall system, to optimize systems integration costs and competitive solutions for a quick time-to-market, potentially 2-3 years after the project end.

Within THOMSON the role of University of Bath is to

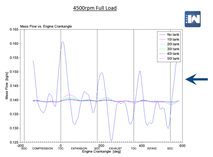
a. To build predictive 1D engine models to access engine performance for different air path and to optimise control strategies.
b. To developed an engine gas stand test facility to test different air paths and test components.
c. To characterise air system individually and in combination under steady & unsteady flows & typical running condition.

Method

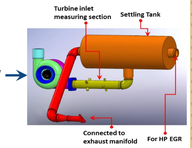


Overall methodology adopted in the THOMSON project

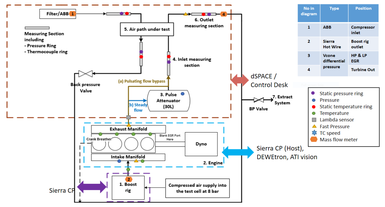
- Tasks split into 3 horizontal WPs – WP 1, WP 2 & WP 5 & 3 vertical WPs – WP 3, WP 4 and WP 6.
- WP 1 - develop models & technologies enabled by the 48V architecture - transversal to the 2 electrified power train
- WP 2 - drives the engine design phase considering e-boosting, e-heated catalyst and other e-auxiliaries and modules for thermal and energy management optimisation.
- WP 3 & WP 4 – Specific power train solutions developed, calibrated, tested & transferred to corresponding demonstration vehicles. Vehicle fully calibrated to measure performance & emissions under real driving conditions from chassis dynamometer and on-road using PEMS devices.
- WP 5 - Final demonstrator vehicles assessment & cost of proposed solutions based on potential market penetration.
- Bath University leads WP1 – characterise complete air system at both steady and transient conditions using a 30L settling tank. Also to predict the engine performance in 1D.



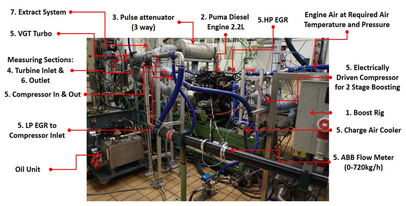
Engine gas stand settling tank hardware design & manufactured based on initial 1D modelling study



Schematic of the engine gas stand test facility



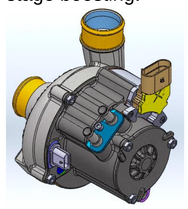
Test facility commissioned and tested successfully



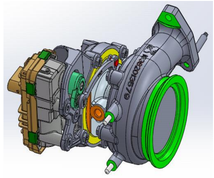
Engine gas stand

The facility has been commissioned and proven to work. Initial results include mapping turbine, compressor and e-booster. System level studies including 2 stage boosting, positioning intercooler pre/post 2nd stage boosting.

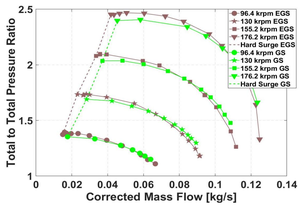
Insulated turbine volute for enhanced energy recovery and improved catalytic light off time



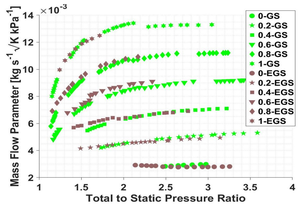
Electrically driven compressor for improved low speed torque and transient performance



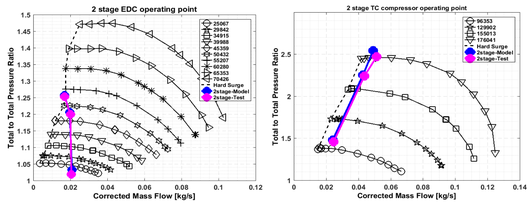
Variable geometry turbocharger tested in engine gas stand



Turbocharger compressor characteristic map comparison from engine gas stand and conventional gas stand



Variable geometry turbine characteristic map comparison from engine gas stand and conventional gas stand



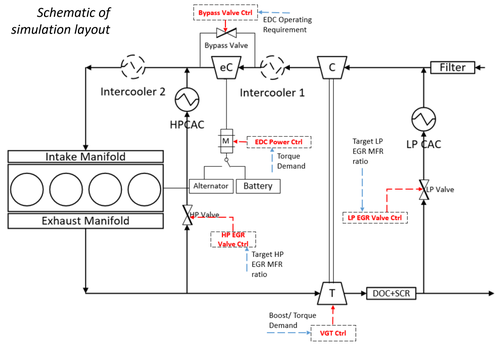
System level test - 2 Stage boosting

Future testing include studying LP-EGR & HP-EGR on compressor and eBooster performance, transient system performance.

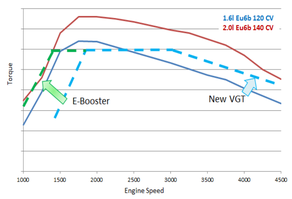
1D Simulation

The simulation is based on a multi-stage electric boosting system for the Fiat 1.6L Diesel engine which has been downsized from a 2.0L baseline engine. The 1.6L engine air-path is composed of two EGR loops (low and high pressure) and a two-stage boost system, comprising an electrically assisted compressor and a VGT turbocharger.

Schematic of simulation layout

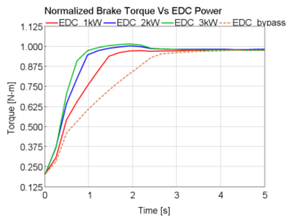


Engine full Load Torque Curve



By applying both VGT and eBooster, the engine low speed output is increased, also the transient time for target torque can also be further reduced.

Transient Torque Vs eBooster Power



In this system, controlling methodology is a key point for optimizing system performance, there is a compromise between eBooster power consuming and engine pumping loss.

Acknowledgements

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