D6.5 – Comparative Engine Dyno Test Results

HVO vs Diesel

Innovation Action

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Publishable summary

Heavy-duty vehicles are widely used in the transport sector in Europe. Heavy-duty vehicles transport 75% of freight over land in Europe (1). Because of their load capacity and annual mileage, heavy-duty vehicles are also a significant source of greenhouse gas (GHG) emissions in Europe. Therefore, any reduction in the emissions of these vehicles will aid in overall reduction of GHG.

Ford Otosan proposed the hybridization of the long haul tractors as a solution to support the efforts to reduce GHG emissions of heavy-duty vehicles.

The hybrid truck proposed by Ford Otosan will include an e-axle as the key component of electrified powertrain. The e-axle is a powerpack that consists of electric motor(s), a multi-speed gearbox and a differential. Project partners Ford Otosan and FEV will design and implement an e-axle to the baseline truck within this work package, in order to reach the project targets of at least 10% energy saving and zero emission drive.

In the first phase “Requirements - Target Definition and Concept Study”, several concept design options were reduced to two distinct topologies. For both topologies, the optimum gear numbers and gear ratios were identified in order to meet the vehicle performance and efficiency targets. Their performance and efficiency were evaluated in different drive cycles. Furthermore, the most promising topology was implemented in a hybrid F-max tractor analytical model. The energy saving through hybridization with an e-axle was calculated in the reference cycles (2).

In the second phase “Layout Design”, the most promising topology was further detailed. Successfully completed activities in this layout design phase include: e-Motor selection, evaluation of vehicle level requirements with traction curve analyses, development of a duty cycle from Ford Otosan target drive cycles, 3D layout modelling; gear design, modelling of system deformations; safety analyses of transmission components such as gears, bearings, shafts and splines; housing concept design, lubrication system development, shifting system development, and initial supplier selection for sensors. According to the results of the layout design phase, the selected concept can be implemented in an e-axle system that will satisfy the project targets hence could evolve into the final product.

In the third phase “Detailed Design”, all work conducted so far has been elaborated and deepened with additional activities such as the finite element analysis of the housing, multibody simulations of the shifting system and additional detail design work such as generation of the drawings and tolerance stack up analyses being performed.

In the fourth phase “e-Axle Prototype”, detailed process regarding e-axle prototype production has been explained. The fourth deliverable (D6.4) focused on the general description of the e-Axle system including the assembly review. Then the e-axle assembly separated into 3 sub-assemblies as mechanical component assembly, high voltage component assembly and electrical control system component assembly. These sub-system prototypes have been reviewed separately in the delivery. Although the Covid-19 pandemic affected the delivery times from the suppliers and some quality issues observed on some parts which had required update, the first physical prototype has been assembled.

In this study, effects of hydrotreated vegetable oil (HVO) fuel on performance and emission characteristics of heavy duty engine (Ecotorq) is investigated.

In the engine dynamometer, engine itself, engine calibration, testing room and environmental conditions (such as inlet air temperature, exhaust back pressure) are kept same. Characterization tests like engine mapping and emission transient WHTC are run for both HVO and Diesel fuels.

Test results are compared by taking the conventional Diesel results as reference. In conclusion, under the light of the compared results, application opportunity and possible calibration requirements are also discussed for HVO fuel.

Engine's torque and emission behavior seems to be very comparable with conventional Diesel outcomes. In specific fuel consumption HVO fuel has an advantage of 2-4% [gr/kWh] depending on the engine operation mode. This is most probably due to the higher lower heating value of the HVO fuel compared to the Diesel used. Similar values are seen on CO2 emissions. NOx values are slightly augmented by 5% in Normal engine mode (see section 3.3.2), but slightly decreased by 5% for exhaust gas treatment mode (EGTM) engine operation mode (see section 3.3.3) with the same calibration. This is most related to the cetane number of HVO fuel and its combustion response to different start of injection calibration. As the start of injection is retarded in EGTM mode same calibration resulted in lower NOx. PM emission is hugely lowered compared to the conventional Diesel by 30-60%. Exhaust temperatures are slightly lowered by 10°C. THC and CO emission of HCO is also in very comparable levels with the Diesel results. HC and CO have also decreased tendency with retarded combustion in EGTM.

HVO seems to be a transparent fuel to be used as a Diesel alternate. A couple of changes in engine calibration would be needed to smoothly operate a heavy duty truck with HVO fuel like soot load estimation calibration and extra heating in cold start and EGTM mode.

By the next phase of the project, documentation of control system test results will be a report containing the test results of the algorithms for hybrid control strategy, vehicle control, electrical system and e-axle transmission control. The report will inform about the latest status of the algorithms in the reporting day. The tests will be executed at least in one of the MIL, HIL, rig, vehicle environments depending on the algorithm and prototype maturity.

According to the current status of the development process, the hybrid F-Max tractor with the proposed e-axle concept can satisfy the project targets with the proposed project timing.

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Project partners:

#	Partner	Partner Full Name
1	FEV	FEV EUROPE GMBH
2	DAF	DAF TRUCKS NV
3	FPT	FPT INDUSTRIAL SPA
4	FORD	FORD OTOMOTIV SANAYI ANONIM SIRKETI
5	IRIZAR	IRIZAR S COOP
6	IVECO	IVECO S.p.A.
7	VOLVO	VOLVO TECHNOLOGY AB
8	VDL	VDL ENABLING TRANSPORT SOLUTIONS BV
9	ABEE	AVESTA BATTERY & ENERGY ENGINEERING
10	AVL	AVL LIST GMBH
11	EATON	EATON ELEKTROTECHNIKA SRO
12	GARR	GARRETT MOTION CZECH REPUBLIC SRO
13	IDIADA	IDIADA AUTOMOTIVE TECHNOLOGY SA
14	IFP	IFP Enegeies Nouvelles
15	AVL	AVL MTC MOTORTESTCENTER AB
16	NESTE	NESTE OYJ
17	PRIMA	PRIMAFRIO SL
18	SHELL	SHELL GLOBAL SOLUTIONS (DEUTSCHLAND) GMBH
19	SIE	SIEMENS INDUSTRY SOFTWARE SAS
20	TECHNA	FUNDACION TECHNALIA RESEARCH & INNOVATION
21	TOTAL	TOTAL MARKETING SERVICES
22	UMIC	UMICORE AG & CO KG
23	UNR	UNIRESEARCH BH
24	JRC	JRC -JOINT RESEARCH CENTRE – EUROPEAN COMMISSION
25	CHALM	CHALMERS TEKNISKA HOEGSKOLA AB
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