HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Progress review and results update of all Work packages

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	4.5.2017
Dissemination Level:	Public

Contributors:	All Work package Leaders
Work Package Leader Responsible:	Nikolaos P. Kyrtatos (NTUA)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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TABLE OF CONTENTS

Summary

The objective of the current report is to present briefly the progress and intermediate results of all Work Packages of the HERCULES-2 Project at the end of the 2nd Year of the Project (30/04/2017). The Report is comprised of 11 individual reports, each one of them describing the progress of each of the 11 Work Packages of the Project. The Reports contain for each Workpackage:

- Objectives
- Progress in Year 2
- Results
- Next steps / future work

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP1**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	24.04.2017
Dissemination Level:	Public

Work Package Leader Responsible: Andreas Schmid (WinGD)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP1 Objectives

The objective of work package 1 is *to build engines, able to switch between fuels whilst operating in the most cost effective way and complying with the regulations in all sailing regions*. The work package is divided into two focus areas:

- two-stroke engines (handled by Winterthur Gas & Diesel AG) on the one hand
- and four-stroke engines on the other (handled by Wärtsilä Finland Oy).

1.1 Two-stroke

On the two-stroke side the objectives for the second project year were:

- Manufacturing of a fuel injection system, capable of handling alternative fuels
- Setup of injection test rigs for the validation of injector operation under worst conditions
- Modification of the Spray Combustion Chamber for the new injector design
- Evaluation of Spray and Combustion for different fuel compositions

1.2 Four-stroke

The first objective of the pre-study is to gather information about the suitability of gas condensate fuels to engines. Basic physical and chemical properties of four to five condensate fuels are collected. In particular, propane (C3H8) and hexane (C6H14) are studied, as well as two or three additional condensates from the carbon number groups of 7 to 14 and 15 to 20.

Based on the fuel property results, fuel admission, mixture formation, ignition and combustion phenomena are further investigated and the experimental setup is designed for the engine tests. The data will be also used for simulation and combustion analyses.

Additionally, the requirements for a flexible injection system must be specified in order to be able to operate the engine with various gas condensate fuels. Issues like fuel spray penetration into the combustion chamber and the effects of fuels on the injection nozzles and injection needle operation have to be clarified.

The continuous determination of the fuel is also important in order to be able to operate the engines on an optimal level even though the fuel quality fluctuates. The objective for this task is to compare different gas quality measurement systems and to evaluate their applicability.

During the second year of the project, engine tests have been conducted on a high speed diesel engine. For the engine operation 5 different fuels have been chosen.

The gas quality online measurement is being long term tested and validated in the engine laboratory. Main focus is put on the robustness of the measurements for the gas quality analyses.

2 Progress

2.1 Two-stroke

The injectors are currently manufactured at the partner's facilities (OMT, Turin). The solenoid valves to control fuel admission have been developed and are being manufactured from a supplier. The conversion of the test rig has been started. This happens in close collaboration with the supplier of the high-pressure fuel pump, as the container will host the pump, control and safety equipment and the test rig.

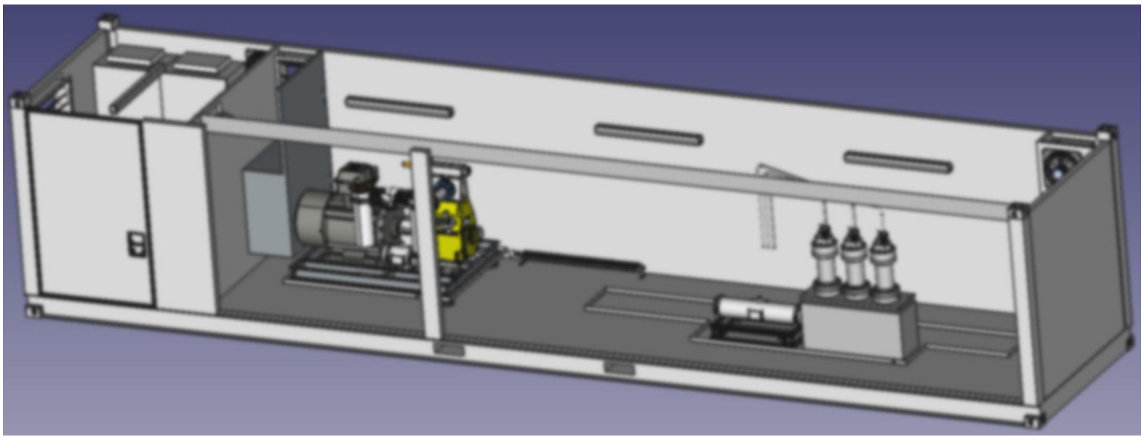

Fig 1: Container housing the high-pressure pump for alternative fuels, the injector test rig and control systems

In collaboration with the Suva (Swiss Accident Insurance Fund) a safety concept has been developed, containing an explosion protection document, in order to guarantee a safe operation of the test rigs and the engine with low flash point fuels, as for example ethanol. The local authorities have been informed. A fuel supplier has been contacted (this seems to be the most complicated part, as Swiss government has a monopoly on the sale of alcohol).

The design of the on-engine implementation of the fuel flexible injection system has been finished, manufacturing of the components started.

2.2 Four-stroke

Engine measurements with high-speed off-road diesel engine for the chosen fuels is being run with 5 different fuels

The installing and starting up of the medium speed marine engine is ongoing

The online gas quality measurement is setup and in operation in the engine laboratory.

3 Results

3.1 Two-stroke

To evaluate the performance of the new injection system and compare it with existing technologies, a reference data set was measured. Therefore, spray and combustion of WinGD's standard systems was experimentally assessed in the SCC. A first set of results is currently evaluated. The very first experiment showing the spray of a modern injection system under engine relevant conditions will be presented at the ILASS conference 2017 and so made accessible for the public:

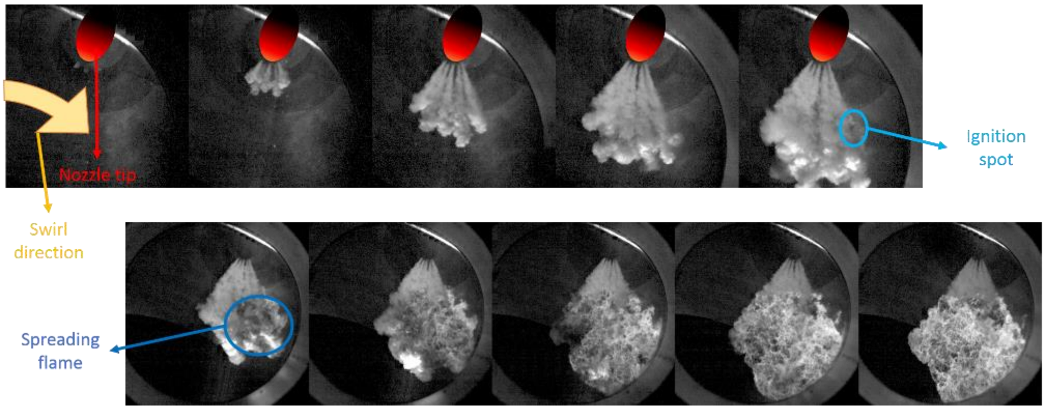

Fig 2:Spray, ignition and combustion of a real size two-stroke injector under engine relevant conditions

3.2 Four-stroke

Engine measurements have been performed on a high speed off-road diesel engine. Different fuels as LFO (light fuel oil, for reference), Naphtha, Kerosene, Glycerin+Mazut, and MGO have been evaluated regarding engine performance and emissions.

A new engine testing facility has been built at the University area in Vaasa. Installation and start-up of the medium speed marine engine (Wärtsilä 4L20) is ongoing. The results from the analyses and the high-speed engine tests will be the base for the upcoming tests on the medium speed engine.

The online gas quality measurement has been installed in the engine laboratory. The results show that the equipment is giving a robust analysis of the real gas quality. The results are calculated with a software that sends out the methane number and the heating value of the gas. Several functionalities for engine control has been identified.

Fig 3: Wärtsilä 4L20 is being installed in the test cell.

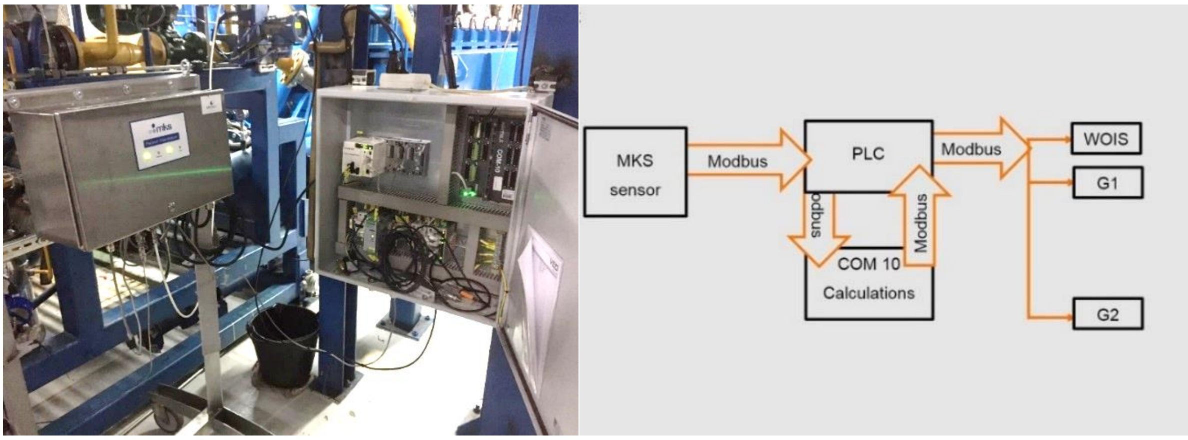

Fig 4:The MKS gas quality measurement installed at the engine laboratory (left). Setup for the gas quality measurement, analysing and calculation at the engine laboratory(right).

4 Next steps / future work

4.1 Two-stroke

The next steps are the setup of the injection test rigs, the tests of different fuels in the Spray Combustion Chamber and the preparation of the engine control system.

4.2 Four-stroke

Simulation on combustion for future fuel will continue. The fuels will be tested in VEBIC on the Wärtsilä 4L20 and the focus will be put on engine operation, emissions, and safety aspects on the tested fuels. Field testing in a power plant and on a LNG carrier vessel will be performed for online gas quality measurement. The system will analyse the gas quality and new controls will be implemented for optimisation of the engine operation.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP2**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	20/04/2017
Dissemination Level:	Public

Work Package Leader Responsible: Dr. Johan Hult (MDT)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP2 Objectives

- Further improve fuel flexibility of marine engines
- Increase understanding of injection, ignition, combustion and emissions formation for novel and mixed fuels to allow efficient operation
- Develop experimental and numerical tools required to exploit alternative fuels:
  - Experimental facilities with optical access
  - Development of numerical tools
  - Development of novel control strategies

For the two-stroke related activities the specific objectives for the 2nd year were:

- Design of fuel-flexible test facility
- Procurement and construction of fuel-flexible test facility
- Optical engine tests on alternative fuels
- Development of optical techniques for lube-oil visualisation and flame volume mapping
- Adaptation of reaction kinetics for large-bore engine CFD
- CFD simulation of fuel injection and ignition

For the four-stroke related activities the specific objectives for the 2nd year were:

- Build up lateral optical access on single-cylinder engine (SCE)
- First performance tests with optical assembly on SCE
- First preliminary tests concerning tracer fluorescence behaviour under realistic conditions
- First tests with measurement equipment
- Development and build-up of vertical access
- NOx model development and validation

2 Progress

The concept design for the fuel-flexible test facility was finalised, however, as presented already in the mid-term periodic report we do not expect to finalize the facility within the Hercules 2 time frame. On the test engine in Copenhagen we have performed optical tests on natual-gas operation, using a multiple camera set-up. Optimum camera positions and calibration procedures for this set-up have been identified. The CFD work within this period has focused on the use of detailed chemistry mechanisms for LNG developed at DTU. So far it has highlighted three problems that are now to be addressed in the last year with the help of a new partner (Politecnico di Milano) and extended activities at Lund (see details in section 4).

In Augsburg the set-up with lateral access is installed on the SCE-test-bench. First tests led to a damage of the optical lens. System needed therefore to be optimized. First results with optimized system expected mid April. Development of vertical access is ongoing. The concept is finalized. The system for tracer is designed. The basics of new NOx formation model finished.

3 Results

The aim of the fuel-flexible test facility was to allow optical analysis of fuel injection and ignition processes of both liquid and gaseous fuels. The overall system design specification was completed, assisted by detailed simulations and engineering estimates.

In order to provide data of flame extent and location for CFD validation we have performed two-stroke engine tests with a multi-camera imaging set-up, which allows time resolved, quasi-3D information of the flame topology during the early stages. Test were performed both on diesel, LNG and combinations of both (see fig 1). Laboratory tests for optical visualisation of lubrication oil and for high-speed Schlieren imaging have also been performed.

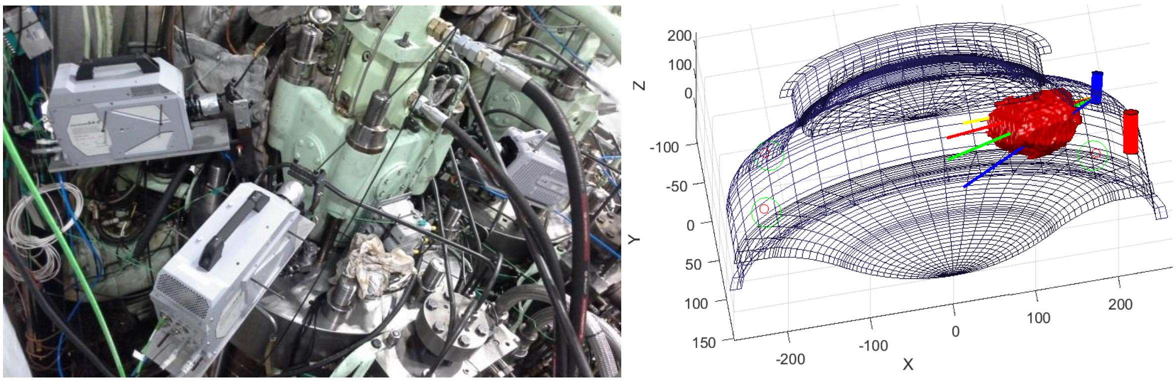

Fig 1: Triple-camera high-speed imaging on two-stroke engine (left), reconstructed flame kernel (right).

In order to perform not only qualitative but also quantitative comparison of the CFD simulation results with the multi-camera test data, new post-processing methods are being developed. Fig. 2 presents some early results of a diesel flame visualization as seen by the three cameras. The technique is to be further developed and applied (for diesel, LNG and their combination) for investigating different combustion modelling approaches.

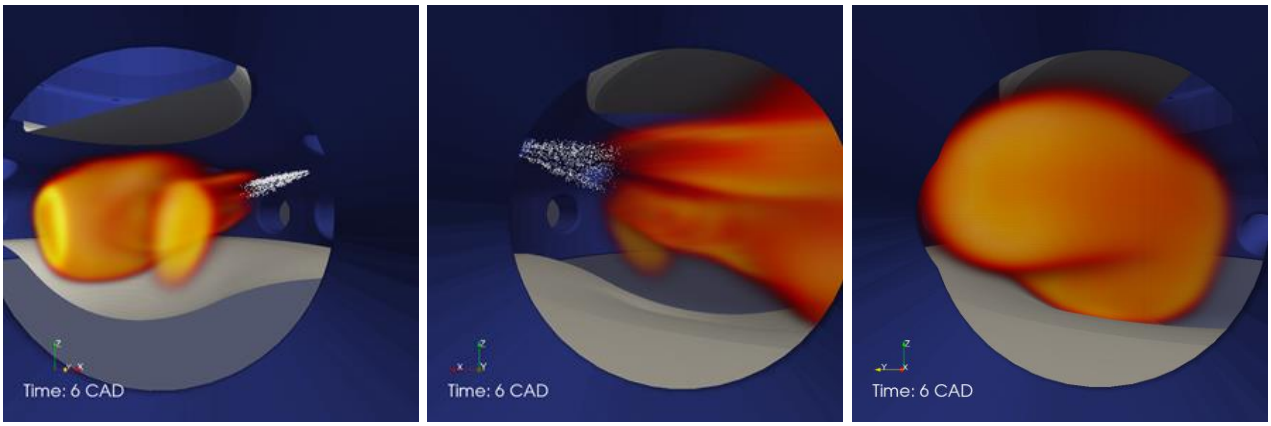

Fig 2: Flame rendering from CFD, as it would appear from the three cameras in Fig 1.

The specially cooled optic ring (see Fig 3) is installed on the four-stroke SCE and was tested up to maximum load without optical lens and problems. The first tests with optical lens lead to a damaged lens (see Fig. 3). The reason for the damage is probably due to higher oscillation than the calculation-model predicted (uncertainty of behaviour of silicon-paste). Due to the temperature-limit of the silicon-paste the gap between lens and the lens holder should be minimized as far as possible but now as one of the countermeasures had to be increased a bit.

The silicon paste is used to glue the lens into the holder and to seal it against the combustion chamber.

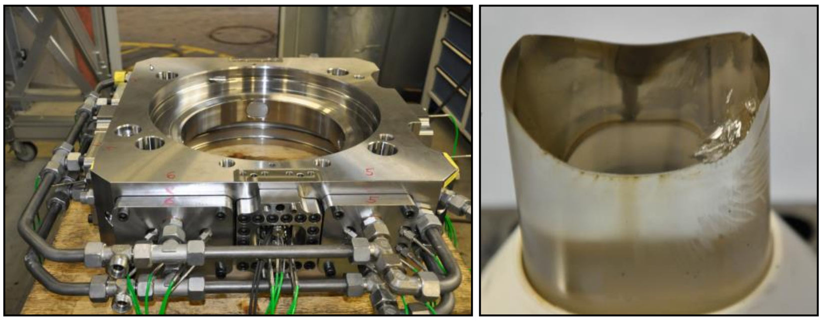

Fig 3: Optical ring for four-stroke single-cylinder engine (left) and optical window/lens (right).

The basics of the simulation model predicting *NO* and NO_2 under dual fuel operation have been finished and are ready for CFD implementation.

4 Next steps / future work

Planned activities for the 3rd year for two-stroke:

- Optical engine tests for visualising lubrication oil, and for high-speed Schlieren imaging of fuel jets.
- High-speed imaging of LPG combustion in test engine.
- The collaboration with the new partners in WP2 will involve the following topics:
  1. The charge preparation prior to injection i.e. the scavenging process (MDT, Milano)
  2. The turbulence chemistry interaction in a detailed chemistry approach (MDT, Lund)
  3. The computational time in a detailed chemistry approach which could be reduced by means of cell clustering method (MDT, Lund)
  4. Detailed chemistry mechanisms have also been prepared to generate tables for a precomputed chemistry approach (Politecnico Di Milano).
- Setup of new CFD validation cases for the different combustion modelling approaches based on the multi-camera test campaign.

Planned activities for the 3rd year for four-stroke:

- Lateral optical access: test of optimized system with lens.
- Vertical optical access: Finalization of the concept and procurement of the components, such as cylinder head, lens holder, lenses, adapted piston etc.
- Tracer: Finalization of the concept and procurement of needed components and tracers.
- Vertical-access: Build-up of concept on SCE for first tests.
- Tracer: Build-up of tracer-concept on SCE-test-bench.
- Validation and tuning of CFD with new NOx model.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP3**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	April, 21h 2017
Dissemination Level:	Public

Contributors: Max-Planck Institut für Eisenforschung
Deloro
Wärtsilä Finland
WinGD
ABB

Work Package Leader Responsible: Monika Damani (WinGD)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP3 Objectives

The objective of WP3 is to examine the feasibility of using novel materials, which are capable to withstand higher temperatures in order to enable higher engine loads. Hereby increasing efficiency and lower emissions by providing more freedom to optimize combustion and/or use new fuels. WP3 consists of two sub-projects (SP3.1 and SP3.2). SP3.1 aims to identify new materials (as well as to examine their manufacturing routes) for different engine components and SP3.2 is focused on materials (and topological) optimisation of turbocharger casings.

Within the 2nd year of Hercules 2, for both sub-projects extensive material characterisation was performed to facilitate a finale material selection. Interesting candidate materials were identified and prototype manufacturing was initiated.

2 Progress

Sub Project 3.1: *Novel materials for engine applications.* The following progress was made within the 2nd year:

- Evaluation of manufacturing routes such as casting (conventional, investment casting) and power based techniques (hot isostatic pressing, thermal spraying, welding)
- Comprehensive material characterisations investigating the mechanical (hardness, tensile and compressive testing between room temperature and 800°C), thermal (thermal shock tests) and corrosive (wet corrosion in acid aqueous solution at room temperature and 97°C, hot corrosion tests in different molten salts, oxidation behaviour) properties of suitable materials (three intermetallic alloys and two Co-based alloy), which were selected in the first period of Hercules 2, and a reference material (Ni-based alloy).
- Selection of an interesting candidate material and corresponding engine components
- Initiation of prototype manufacturing
- Simulation and rig testing of different bearing materials and bearing widths at differing sizes, speeds and temperatures
- Comparison of durability of bronze bearings and multi-metal bearings

Sub Project 3.2: *Novel materials for turbine casing.* The following progress was made within the 2nd year:

- Generation of preliminary (conservative) material design data for the relevant temperature range based on extrapolations of the available database
- Selection of the material to be used
- Design of the turbine casing and life-time calculations based on the preliminary data sets
- Initiation of an experimental material data generation program to validate the preliminary design data and
- Casting simulations

3 Results

Sub Project 3.1: *Novel materials for engine applications.*

Five different alloys (two iron aluminides, Alloy 1 and Alloy 2; one nickel aluminide, Alloy 3; and two Co-based alloys, MAT A and MAT B) were selected for detailed investigations. Casting and powder based methods such as hot isostatic pressing (HIP), welding, and thermal spraying were successfully examined as possible manufacturing routes (Fig. 1a). Due to its brittle nature, it was revealed that Alloy 3 is very hard to cast as well as to machine. Detailed material characterisation (Fig. 1b) was performed of the five different alloys and a Ni based reference material. Overall the alloy with the best combination of material properties and producibility was selected for further prototype manufacturing and testing.

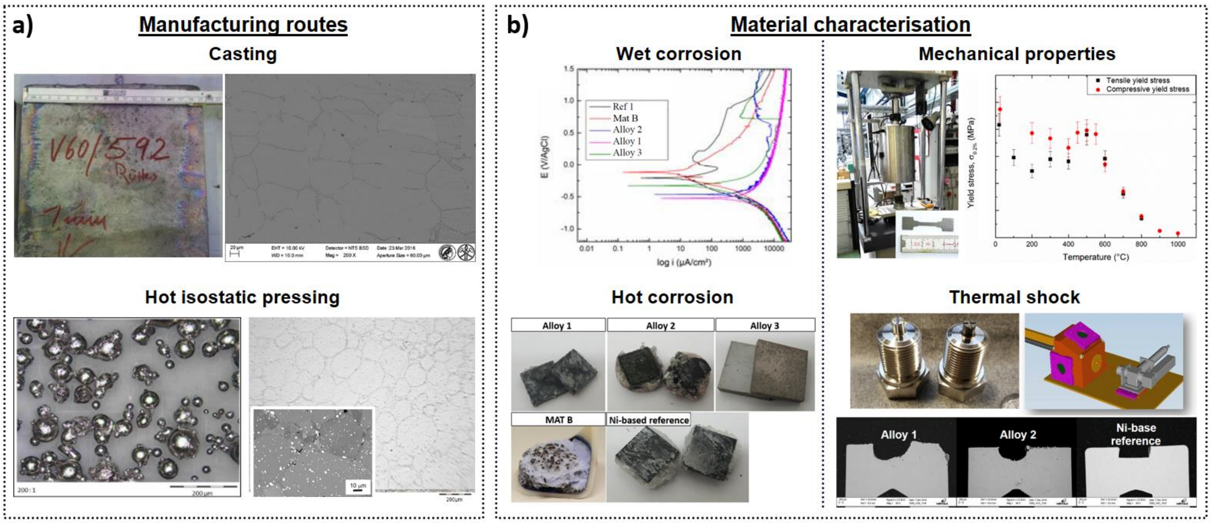

Fig 1: Collection exemplarily showing results from a) examination of different manufacturing routes and b) different material investigations;

Sub Project 3.2: *Novel materials for turbine casing*.

The generation of experimental material data program is almost finished, apart from the long-term creep tests. The preliminary material design data were confirmed or exceeded by the measurements. Casting simulation showed some potential hot spots which caused a re-design (Fig. 2).

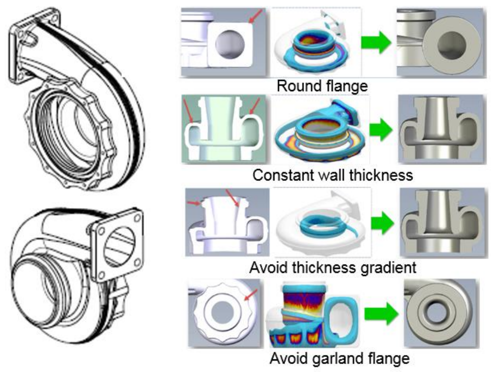

Fig 2: Design changes due to the casting simulation

4 Next steps / future work

Sub Project 3.1: *Novel materials for engine applications.*

The following steps are planed:

- Finishing of some delayed materials investigations
- Manufacturing of real size engine components from the selected intermetallic material (including optimisation of casting process and HIP process)
- Engine testing of the prototypes
- Material analysis of the engine tested prototypes
- Assemble a new bearing rig that allows loading of the bearings
- Simulation and continued rig testing of different bearing materials and widths under the impact of loading at differing sizes, speeds and temperatures

Sub Project 3.2: *Novel materials for turbine casing*.

The following steps are planed:

- Production (casting and machining) of some prototype turbine casings made of the selected austenitic heat resistant cast steel
- Non-destructive and destructive quality assurance testing
- Set up and carry out a component test program

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP 4**

Revision <Final>

Nature of the Deliverable: Report

Actual Submission Date: 2017-04-25

Dissemination Level: Public

Work Package Leader Responsible: Dr. Rayk Thumser, MDT-AUG

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP 4 Objectives

The overall objective of this work package is to increase the fatigue resistance for cylinder heads (WP 4.1) and turbocharger inlet casing (WP4.2).

The main objective within the second project year it to make the material test and the preparation of the “TMF loaded component like specimen”.

2 Progress

The selection of appropriate material for pilot study was done in cooperation with MDT-AUG and IWM. Five materials where selected. At the foundry at MDT-AUG different plates and sleeves (fig. 1) where produced. There was a multiple step process to optimize the different foundry process in dependency of the material composition, e.g. inoculation tests.

The selection of the material for turbocharger application was performed based on previous experience gained at MDT in relation to corrosion and material fatigue. The target is to find a material with similar strength and fatigue characteristics at elevated temperatures compared to the now used materials at current application temperatures. The planned tests are finished as calculated.

3 Results

The pre study for the cylinder head materials is finished. The base material samples are taken from sleeves, see figure 1. For the final materials quality the complex fatigue lcf and tmf tests are under investigation.

Fig 1: Cast Iron sleeves for specimens

For a component like specimen a hot burner rig setup was developed and proved, see figure 2.

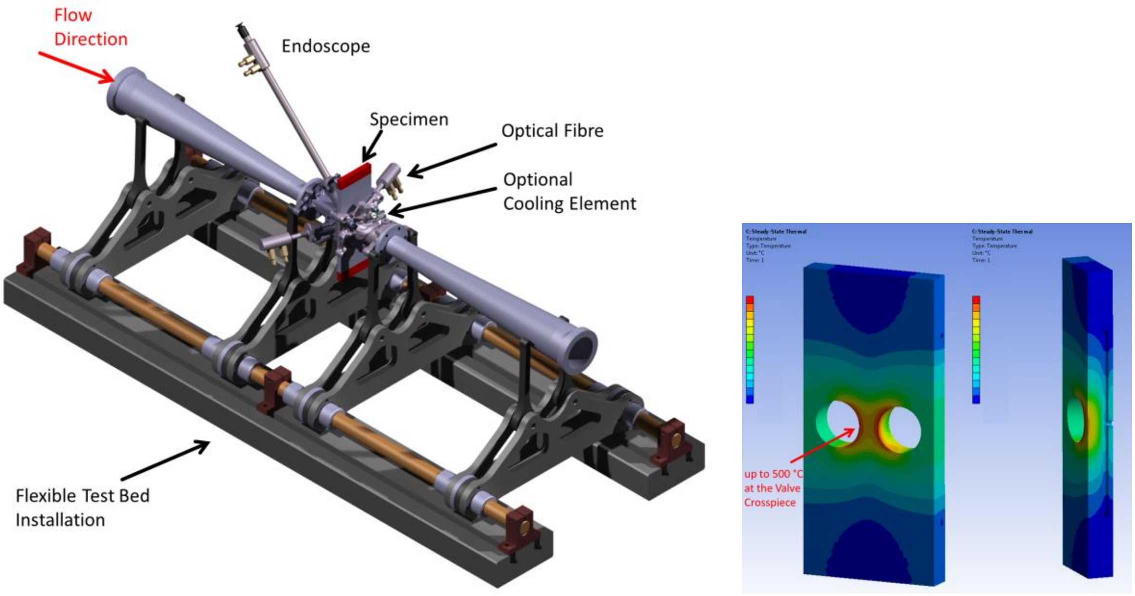

Fig 2: TMF test rig and specimen

The turbocharger material investigation was finished within second project jear. Here the focus is the ferry application, where the thermal stat-stop cycles (TMF) are the main dominant failure mechanism.

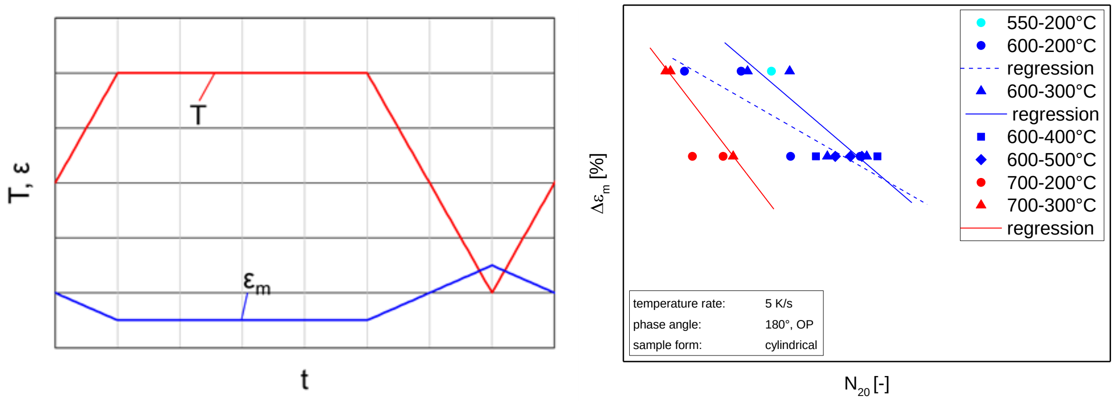

Fig 3: Typical test for turbocharge ferry application

A typical ispothermal test is shown at figure 4. These tests are needed to build up an mechanical model for finite element applications.

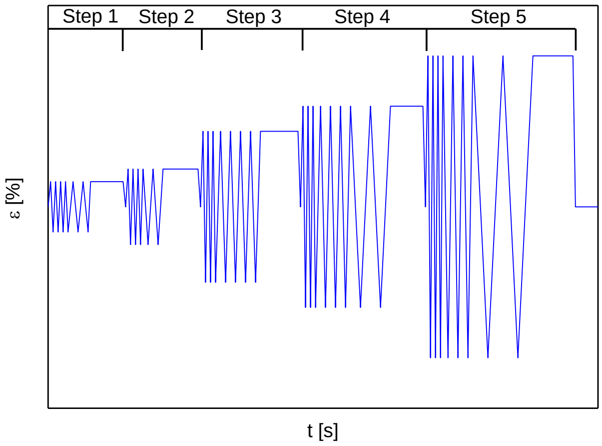

Fig 4: complex LCF test regime

4 Next steps / future work

Within the third project year the plan is to make material model development, validation on hot burner test ring and application to cylinder head.

For the turbocharger application there is a sophisticated material under development. The test results are used for the calibration of the deformation and the lifetime models.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP5**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	19.4.2017
Dissemination Level:	Public

Work Package Leader Responsible: Jonatan Rösgren (Wärtsilä Finland Oy)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP5 Objectives

The WP5 main objective is to secure optimized performance of the power plant throughout its lifetime. The aim is to retain engine's as-new performance using optimized engine control and parametrization methods as well as to develop control methods for hybrid engine propulsion systems.

Furthermore, to establish optimized performance concepts for two-stroke engines, the objective encompasses fundamental tribosystem modifications. Related sub-projects explore possibilities to apply advanced adaptive lubrication performance monitoring systems as well as fully flexible lube oil injection system. Securing lifetime performance of large two stroke diesel marine engines requires maximizing reliability and simultaneously optimizing fuel and lube oil consumption in order to achieve maximum sustainability and to comply with existing and future environmental regulations.

For the 2nd Year of the Project the objectives were:

- Development and tests of optimized control methods an parameterisation, engine control and hybrid control system development
- Development of simulation models and control methods for adaptive lubrication system, tribosystem monitoring development as well as establishment of testing environments for technology validation

2 Progress

Overall the progress is according to plan.

Sub-project 5.1 and 5.2

A rapid control system environment was developed for optimized control methods demonstration. In parallel, development and simulation of control algorithms progressed well and was brought to a stage where the initial optimized control methods full engine tests were performed. Robust control methods of hybrid engine propulsion system are being developed and tested and reference maps concept study is done. Concept reports deliverables for optimized engine knock control, engine control parametrization, as well as robust control of hybrid engine propulsion were successfully accomplished.

Sub projects 5.3 and 5.4

Investigating lubricant injection characteristics calls for the establishment of a sound testing environment. Therefore a system was implemented to provide testing conditions similar to real engine application boundary conditions in order to investigate thermo – physical properties and related effects on the lubricant spray. The test cell hence provides the possibility to address parameter variations such as pressure, temperature, injection pressure, nozzle geometry and lubricant property variations over the complete load range of a large two stroke marine diesel engine. Optimizing the injection performance of the new lubrication system also encompasses a numerical approach to predict lubricant spray characteristics. A 1D CFD approach is utilized, yielding a fast running application to compute spray characteristic variations and to visualize impingement effects on the cylinder wall. Tribosystem monitoring developments based on ultrasound reflectometry have led to prototype viscosity sensors as well as to wear monitoring possibilities, which will both be explored on a real engine test in near future.

3 Results

There are promising results from optimized control methods development. As an example, Fig 1 depicts the diesel hybrid-electric marine propulsion plant (HIPPO-1) predictive control.

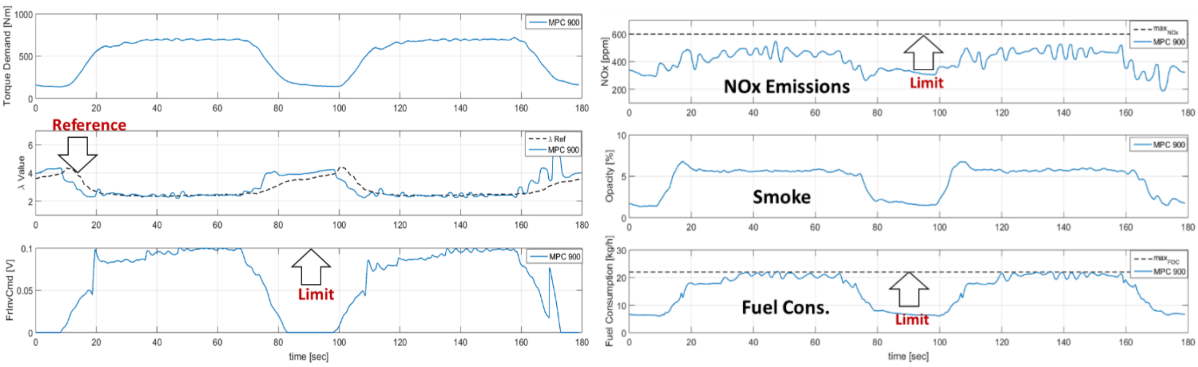

Fig 1: Propeller curve loading on the HIPPO-1 powertrain; (a) Torque applied by water brake dynamometer, lambda values actual and reference and actuator command; (b) NOx emissions, smoke emissions and Fuel consumption.

Experimental setup and simulation tool software for lubrication system is depicted in Fig 2.

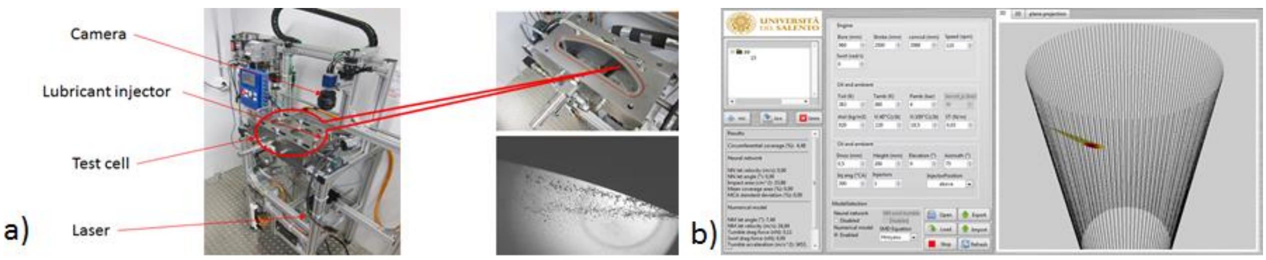

Fig 2.a): Schematic of the lube oil injection test cell and first impressions of the testing environment; b) Main screen of the Lube oil simulation tool

4 Next steps / future work

Remaining tasks to accomplish this Workpackage refer to optimizations of prototype lubricant injector performance on basis of computational simulation as well as the implementation of lubricant property monitoring techniques on a full-scale engine test. Furthermore full-engine scale demonstrators will be developed and tested for optimized control algorithms and reference parameters.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP6**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	21.04.2017
Dissemination Level:	Public

Work Package Leader Responsible: Dr. Mathias Moser (MAN Diesel & Turbo SE)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

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1 WP6 Objectives

The objective of WP 6 is to develop systems, methods and processes allowing for improved engine lifetime performance with reduced operating, maintenance and deployment costs. Non-normative changes in the demands and conditions for the operation of - and emissions from - the engine are to be taking into account. Included in the objective is the aim of expanding the present operating range of emission reduction technologies. In relevant new operating modes NOx emissions are expected to see up to more than 80% reduction.

2 Progress

During the 2nd year of the Hercules 2 project investigations based on the in the 1st year developed simulation models were carried out. Statistical analysis, based on operating data, has been performed in order to determine the relevant operating patterns of the vessels. The main EGR control system design has been decided and the implementation in the EGR software has started. For different applications (cylinder cut-out, EGR, SCR) and dedicated load profiles emission and fuel reduction could be shown.

Furthermore the quality of the tailored subspace search together with the current compression method was investigated.

3 Results

The simulation model predicts for the static cylinder cut-out an increased brake efficiency of more than 4%. This depended on the higher indicated mean effective pressure of the fired cylinders, which leads to an enhanced fraction of fuel burned and a reduced fraction of relative wall heat losses. Additionally, the NO emissions were reduced by up to 49% due to the reduced amount of diffusion combustion (see *Fig 5*).

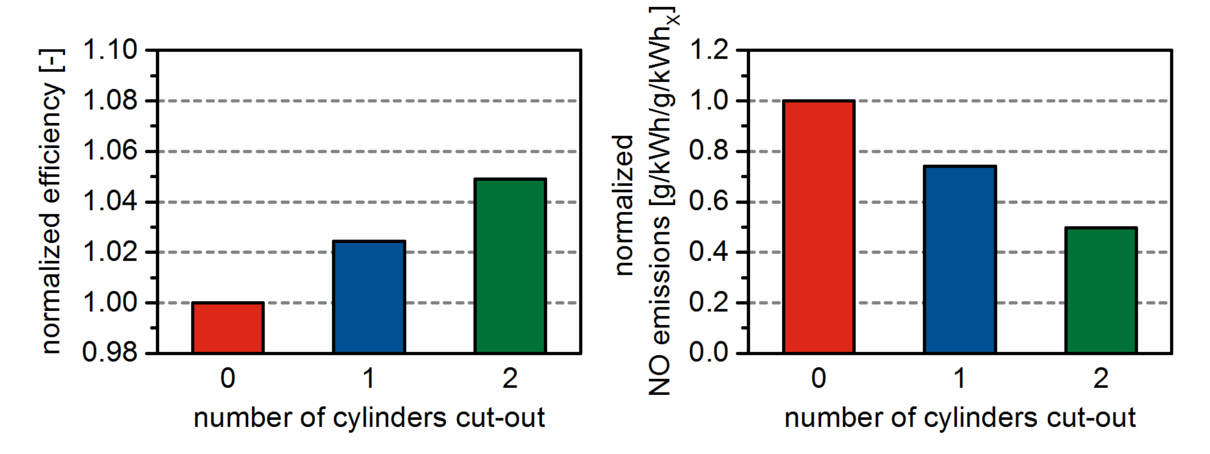


Fig 5: Normalized efficiency and NO emissions static cylinder cut out

A preliminary result from the statistical analysis of vessel manoeuvring is shown in Fig. The Figure shows a histogram of engine speed steps from a large datasets as function of step size and starting value of the step, both relative to MCR speed. Such a histogram helps to decide which vessels manoeuvres are most relevant when testing the performance of engine, control system and models.

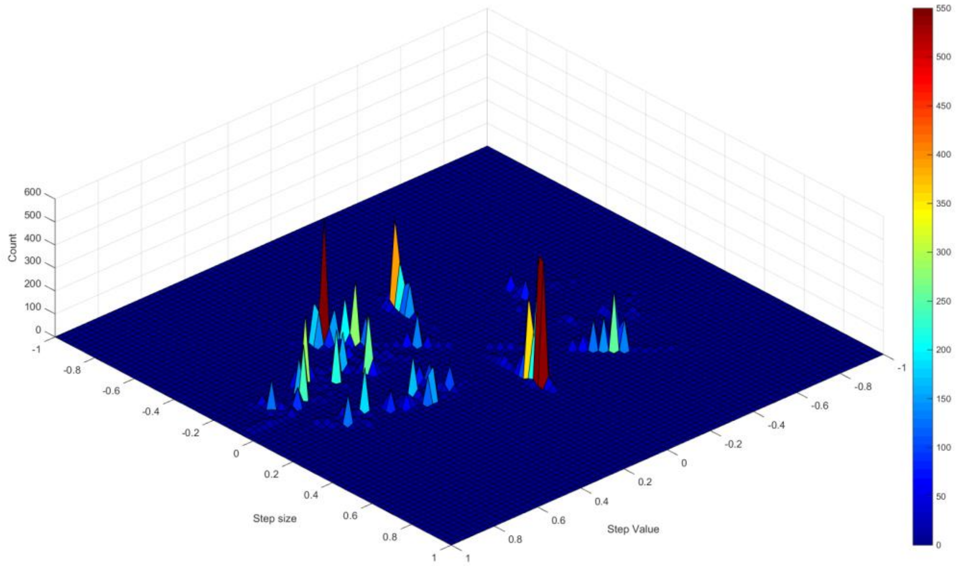


Fig 2: Histogram of engine speed steps as function of step size and starting value, relative to MCR speed.

4 Next steps / future work

In the 3rd year the cylinder cut out will be applied to an engine and tested on the testbed. Furthermore selected multiple-in, multiple-out controllers will be validated in terms of improvement of the dynamic engine behaviour.

The statistical analysis of vessel manoeuvring will be finished and the results will specify relevant manoeuvring patterns for future testing of the engine. Calculation of the scavenge oxygen setpoint must be studied to provide an appropriate solution. The final control system will be validated in low load conditions by simulation of the engine model and on a vessel operating at sea.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP7**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	25/4/2017
Dissemination Level:	Public

Work Package Leader Responsible: Jukka Leinonen (Wärtsilä Finland)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

HORIZON 2020

The EU Framework Programme for Research and Innovation

1 WP7 Objectives

- Integration of SCR (Selective Catalytic Reduction) with the existing strong Miller cycle 4-stroke diesel engine and combining it with particulate emission (PM) abatement technology would enable to achieve more than 80% NOx emission reduction and 25% reduction in PM. Also a combination of integrated SCR and EGR (Exhaust Gas Recirculation) is to be developed. Feasible solutions of combining the above mentioned technologies having as a target the near zero emission engine are also studied.
- Integrating methane and ethane abatement technology into lean burn 4-stroke gas engines will enable compact solutions to reduce emissions. The objective is a catalytic system working with the engine and optimization of the engine performance. Also the knowledge on deactivation & regeneration strategies for integrated catalyst solutions and methane formation and location in the engine exhaust system should increase. Target is a greenhouse gas emission decrease up to 15% and fuel savings up to 5%.
- Development of key technology for integration of the currently separated SCR aftertreatment into the existing 2-stroke engine structure, which enables widespread installation of SCR systems on all ship types and additionally increase overall NOx removal efficiency above 80%, reduce overall hydrocarbon emissions (HCs) by 50% or more, reduce PM emissions and lead to potential fuel savings of up to 5%.

Targets for 2nd year of the WP7 were:

- Experimental assessment of integration of methane and ethane abatement technology
- Feasibility and demonstration of selected optimum set-up for the combined on-engine after treatment solution
- NH3 sensor testing
- Feasibility and demonstration of NOx and particulate reduction with tests
- Prototype catalyst elements will be tested and compared on vibration test benches
- Install prototypes on future SCR positions of an engine in operation on a vessel

2 Progress

Experimental assessment of integration of methane and ethane abatement technology testing continued as planned at Wärtsilä Spain. Testing will continue during 3rd year of Hercules 2.

Feasibility and demonstration of NOx and particulate reduction with tests on test engine continued by PSI.

Feasibility and demonstration of selected optimum set-up for the combined on-engine after treatment solution testing completed, test equipment setup were uninstalled and test results analyzing was started. Test results analyzing will continue and test report will be created as planned.

VTT participated in a ship campaign in September 2017 and carried out testing of a NH3 sensor and the PN measurement system.

Methane catalyst study was transferred to VTT from Vaasa University within Workpackage 7 in autumn 2016. This transfer was considered necessary as VTT could offer a fast access to a research facility for catalyst testing. The corresponding funding of 55 k€ was also transferred to VTT to the budget of subtask 7.4.

SCR reduction agent injection solutions research was as made a thesis work of the CFD modelling of reductant injection and selective catalytic reduction of nitrogen oxides in a medium-speed diesel engine exhaust after treatment system

Feasibility and demonstration of NOx and particulate reduction with test on test engine were planned and tests were done by VTT at Wärtsilä Finland premises. Results are under analyzing and analyze continue as planned.

Prototypes of vibration resistant extruded catalyst samples were manufactured, pre-screened by push-out tests and tested on a hot-shake vibration test bench. Issues with the hot-shake test bench caused an accumulated delay of 8 months.

Concerning metallic catalyst supports, cold-shake vibration tests and catalyst adhesion tests were conducted. Due to an issue with production machining tools the prototype manufacturing of new metallic supports with coated catalyst was delayed, overall there is a delay of 9 months.

As the field testing of prototype catalysts cannot be started before their development, there is a delay of 8 months as well. However, preparations for the field test are on track and a slightly shortened field test should be able to still provide results for assessing the new catalysts.

The catalyst activity investigations together with PSI proceeded well and a publication is under preparation.

3 Results

Simultaneous abatement of NOx and PM emission investigated at the W6L20CR research engine (PSI LERF "Large Research Engine Facility") by combined application of EGR and water-fuel emulsion (WFE). The experience gained during the according performance tests shall further explore the potential for an engine application and will increase the knowledge base in regard to the combination of these emission reduction technologies.

For the reduction of the NOx a semi-short route EGR configuration is installed on the test engine. (see Figure 1).

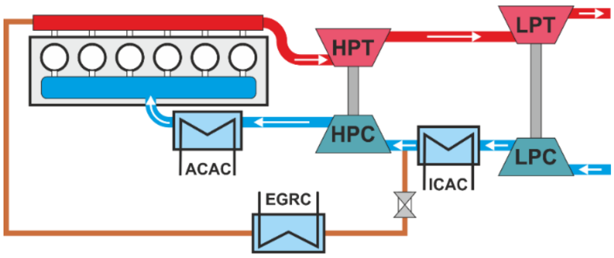


Fig 1: Illustration of semi-short route EGR system.

The WFE is introduced into the fuel system via a prototype system, which is able to mix the water on-line in the fuel supply line just before the high pressure pump. Figure 2 shows the schematic of the prototype WFE system installed on the engine.

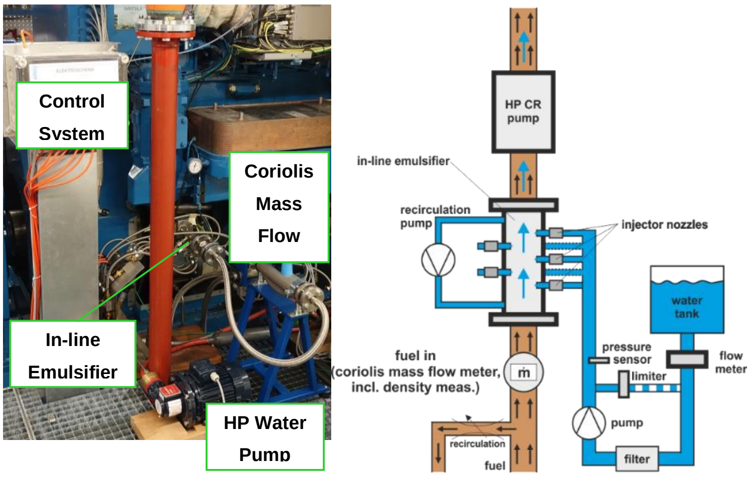


Fig 2: Schematic of in-line water fuel emulsifier (left) and installation on W6L20CR test engine at LERF, PSI (right).

Figure 3 shows the EGR rate variation influence on NOx and soot emissions at engine operation without and with 5 % water/fuel mass fraction.

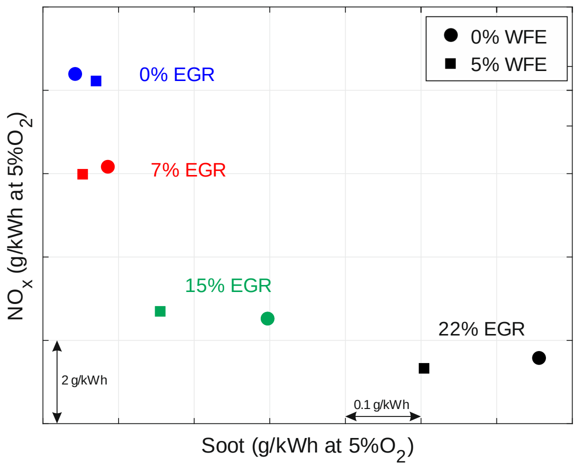


Fig 3: NOx and soot emission of EGR rate variation at engine operation without and with 5 % WFE at 50 % load, constant SOI (10°CA bTDC) and 1000 bar rail pressure

Besides the influence of the EGR-Rate, also the effect of rail pressure variation and injection timing (start of injection) has been investigated. The results show a high potential for the simultaneous application of EGR and WFE with regard to a low-NOx and soot operation. In combination with optimal engine tuning (injection pressure and timing) engine efficiency could be maintained or is only slightly reduced while criteria gaseous emissions are considerably lowered and particulate emissions remain at a low level.

VTT carried out testing of a NH3 sensor and the PN measurement system. These tests are supported by other measurements which characterize the exhaust gas matrix. The PN system operated successfully during the ship campaign. The PN data analysis has not yet been accomplished.

In the NH3 study, the aim is to test the applicability of electrochemical method for NH3 slip measurement and to find reliable sensor for controlling the urea dosing and decomposing units. NH3 sensor responds to changes of NH3, and SO2 was observed to interfere to some extent with NH3 results. The data analysis has been started. Based on these preliminary results we are planning a long-term test of several months for NH3 sensor during summer 2017.

Figure 6 shows part of the arrangement of ship measurements in the support structure of exhaust channels.

Fig 6: Particle mass concentration and particle number measurements during the ship campaign.

Methane catalyst study was performed at VTT during second year of the project. In this work the regeneration of a methane oxidation catalyst (MOC) by H2 was studied.

The catalyst sample used in this study was designed for oxidizing CH4. The catalyst utilized platinum-palladium as active metals on a tailored coating developed for lean natural gas applications and supported on a metallic substrate.

During the experiments additional SO2 was fed into the catalyst in 20 h periods. After each 20 h, H2 was fed into the catalyst in order to study how the catalyst regenerates. The exhaust gas emissions of HC components as well as NOx, CO and formaldehyde were measured both up- and downstream of the catalyst sample. These experiments were carried out on March 2017. At the moment the measurement data is being analysed. The preliminary results show that the regeneration with H2 resulted to release of SO2 from the catalyst. The catalyst efficiency also increased due to the regeneration phase but decreased again with time. However, no final conclusions can be made before the result calculation and analysation is finalized.

SCR reduction agent injection solutions research, the CFD software STAR CCM+ is used to simulate a selective catalytic reduction system for a medium speed diesel engine. The model includes reductant injection, decomposition, and mixing as well as detailed surface chemistry for the catalyst.The objective of this work was to provide a functional SCR model with all key phenomena appearing during the injection of UWS (Urea Water Solution) into the exhaust system upstream of the SCR catalyst.Gaseous ammonia injection is investigated as an alternative to urea-based liquid solutions. Different mixer geometries are presented and the effect of pressure drop and mixing phenomena of ammonia with the exhaust gas upstream of the catalyst is included. The results have been analyzed by looking at the velocity profile and the distribution of NH3 along the mixing pipe. Also, the pressure drop over the mixer and the uniformity of NH3 at the catalyst surface is used to analyze the performance of the static mixers. The difference between NH3 gas injection and UWS injection depended on the mixer geometry and the injection location.

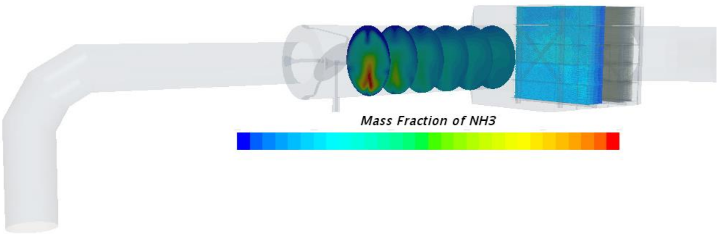


Fig 7: Ammonia distribution and selective catalytic reduction for the SCR system with plate mixer

Feasibility and demonstration of NOx and particulate reduction with test on test engine were finally performed by VTT at Wärtsilä Finland premises. During the DF-engine test LFO and natural gas were used as fuels at five load levels. Parallel to PN and PM measurements we carried out a test with a particle sensor based on diffuse charging method. The particle sensor is originally designed to be utilized in vehicles but in this experiment, we tested its applicability to particle mass and number measurements in DF-engines. The data analysis is unaccomplished.

Six modifications of vibration resistant extruded ceramic catalyst modules were built as prototypes, after pre-tests five proceeded for testing on a hot-shake vibration test bench. Promising samples were identified from the WinGD defined test cycle. A slightly improved design of one of the samples will be re-tested on the vibration test bench in May.
Concerning metallic catalyst supports, data from cold-shake vibration tests is available. There were indications for insufficient catalyst adhesion, which was investigated by separate catalyst adhesion tests. Due to prototype manufacturing issues the hot-shake tests are delayed.

For field testing of the catalyst prototypes WinGD designed and arranged a test setup for a vessel in service, however, due to the delays in the prototype manufacturing the tests could not yet initialize. The field test protocol was adapted to allow judgement of the catalyst suitability within a shorter trial duration.

The reaction kinetics of the SCR reaction under elevated pressures were investigated together with PSI. By comparing catalysts of equal (1.0 wt%) V_2O_5 content but different cell density (26 cpsi and 46 psi) and equal cell density (46 cpsi) but different V_2O_5 content (0.5 and 1.0 wt%), the effects of diffusion limitation under elevated pressure was demonstrated (see Figure 8).

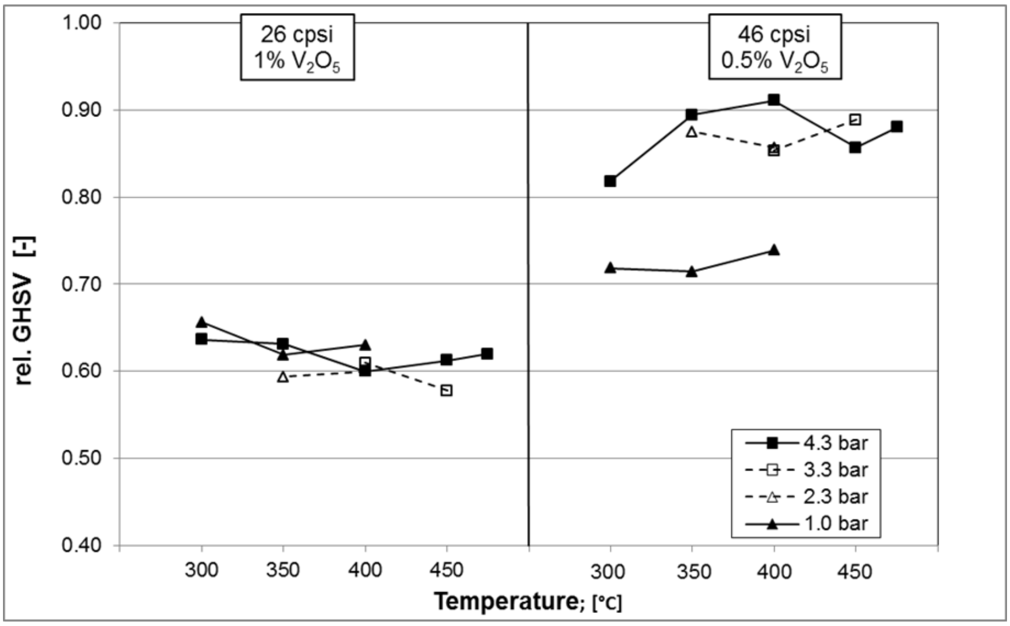


Fig 8: Comparison of maximum GHSV for 80% DeNOx at 2 ppm NH3 slip for selected catalysts relative to a 46 cpsi 1% V2O5 catalyst.

4 Next steps / future work

During the last year, the focus will be to continue and complete ongoing activities especially:

- Experimental assessment of integration of methane and ethane abatement technology
- Feasibility and demonstration of selected optimum set-up for the combined on-engine after treatment solution
- Feasibility and demonstration of NOx and particulate reduction with tests
- Prototype catalyst elements will be tested and compared on vibration test benches
- Install prototypes on future SCR positions of an engine in operation on a vessel

VTT will focus to analyse test results from made tests. PSI will continue demonstration of NOx and particulate reduction test with W20 test engine. Wärtsilä will concentrate to compete testing with installed test equipment at Spain and analysing results from the tests. WinGD will focus on the design, development and validation of robust catalysts. After finishing the evaluation of the prototype catalyst modules on the vibration test benches, the field testing of the prototypes in a test vessel shall provide feedback on their suitability for later applications. A publication related to the pressurized SCR reaction kinetics is planned together with PSI.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP8**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	23/4/2017
Dissemination Level:	Public

Work Package Leader Responsible: Lone Schmidt, MAN Diesel &Turbo

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

HORIZON 2020

The EU Framework Programme for Research and Innovation

1 WP8 Objectives

Integrated SCR and combined SCR and filter

- Investigation of High Pressure SCR process; injection, mixing, decomposition and flow distribution with the aim of making the SCR components compact while still maintaining the same high performance as best available technology today
- Designing of engine integrated High Pressure SCR with system with unaffected engine footprint and only slightly affected gallery arrangement around the engine
- Testing of compact High Pressure SCR component performance on 4T50ME-X test engine
- 80% PM reduction with after-treatment system (based on IMO Tier II engine out emissions)
- 80 % NOx reduction with after-treatment system to reach IMO Tier III limits
- Reduce the necessary installation space for after-treatment system SCR on DPF within IMO Tier III (SCR only) system
- Adaption and integration of the after-treatment system (SCR on DPF) on a marine Diesel engine

For integrated SCR, the focus in the 2nd year of the project has been on the first two points. In order to minimize risk and gain knowledge several pilot testbeds have been developed and tested and a lot experimental data generated. Test results have been used for choosing integrated SCR components, configurations and evaluate CFD models in order to develop a compact integrated design to be tested on the test engine.

For combined SCR and filter, the objectives for the 2nd year have been:

- Build-up of synthetic gas test bed including particulate matter generation and characterisation
- Investigation and characterisation of SCR coated Diesel particulate filters, laboratory scale
- Pre-tests of Diesel oxidation catalysts (DOC) on engine test bed with different marine fuels
- Validation measurement of urea decomposition in hot gas flow test rig under pressure and numerical simulations
- Measurements and simulations on the influence of mixing elements on urea decomposition

2 Progress

High pressure SCR processes has been study on a slip stream (2 % exhaust gas) from a two stroke diesel engine. Ammonia and urea as reducing agent has been compared and different reactor and catalyst configuration have been tested. A testbed for study turbulent mixing has been used with three different mixing configurations, and the experimental data have been used for validation of different CFD models. The integrated high pressure SCR for the test engine has been designed and the design has been evaluated with CFD and FEM analysis.

Furthermore the traverse mechanism for local gas measurements was successfully tested on the 4T50ME-X test engine.

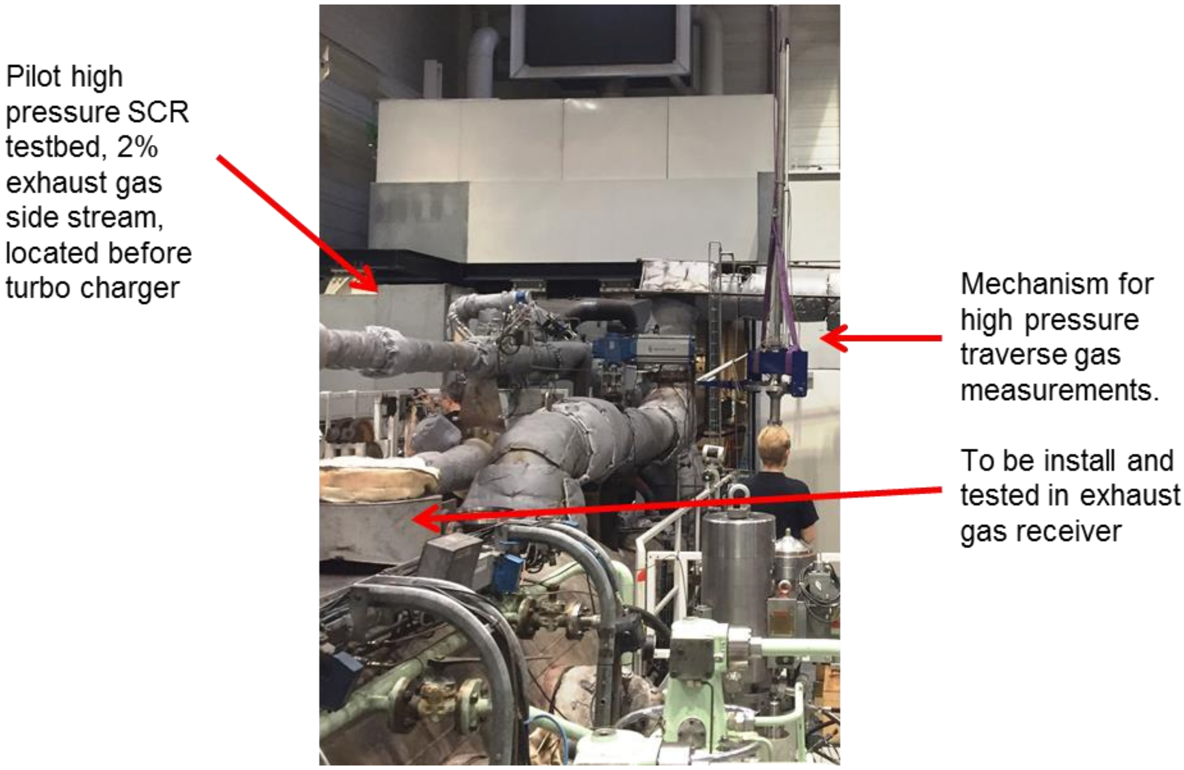
A synthetic gas test bed for filter testing has been built up during the 2nd year of the project. This test rig is required for the investigation of the SCR coated DPF substrates in laboratory scale. Besides that, a benchmark of the back pressure at room temperature has been carried out as well as optical investigations with a scanning electron microscope. In addition, a pre-test of two DOC systems with different coatings has been accomplished on an engine test bench.

Having installed and tested the hot gas test rig in the 1st year of the project, studying urea decomposition was the core of the 2nd year.

3 Results

3.1 Engine integrated SCR

The high pressure SCR pilot test bed is shown in *Pic 1*. This testbed has been used for a range of different high pressures SCR experiments. Shown is also the traverse mechanism for local gas measurement that was successfully tested at different loads: 25% to 100%.



Pic 1: Pilot SCR testbed and traverse mechanism installed on T50ME-X engine.

The test performed on the test bed covers a range of different operating conditions at different loads. Different catalyst and reactor configurations has been tested as well as experiments with ammonia respectively urea as reducing agent. The experimental results for two different catalyst models are shown in *Fig* . Model 1 showed the best DeNOx performance with a delayed ammonia slip, and will be used in the integrated SCR solution for the test engine.

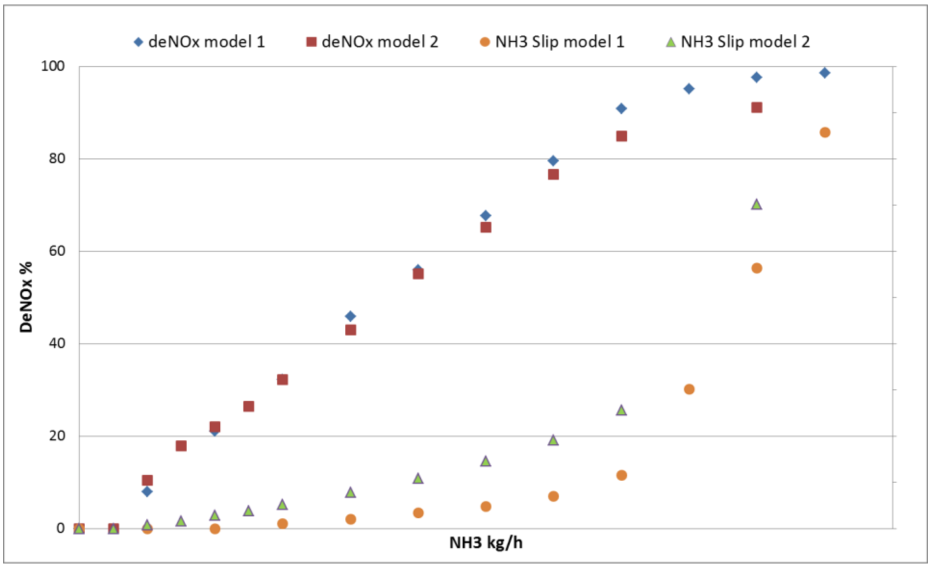


Fig 1: SCR Performance for catalyst configuration model 1 and model 2.

The comparison with urea and ammonia as reducing agent showed that only little difference in performance and ammonia slip, and urea will therefore be used.
The engine integrated SCR design is shown in *Fig* . Also shown is CFD calculation performed in order to evaluate the design.

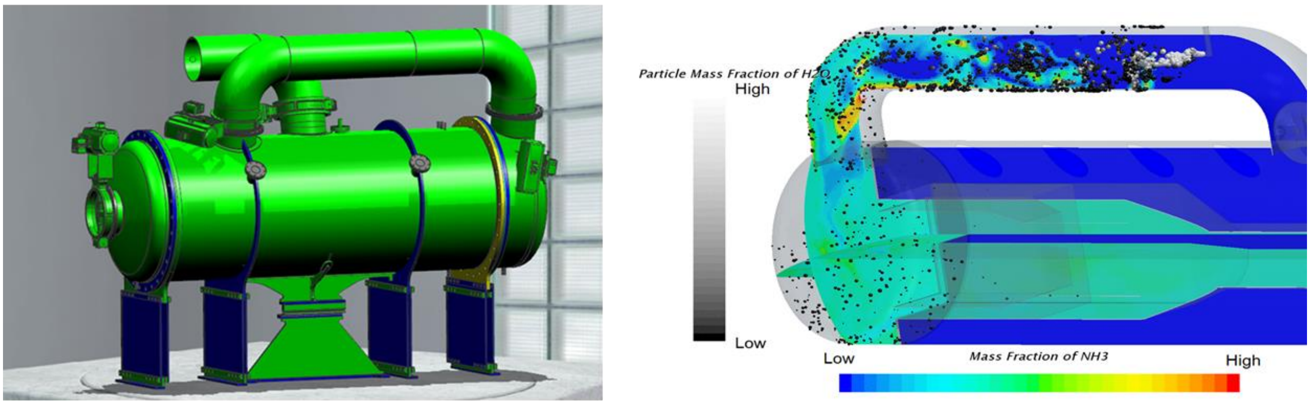


Fig 2: Engine integrated High pressure SCR design. CFD calculation has been used to evaluate urea evaporation, mixing and flow distribution.

The catalyst element is located inside the exhaust gas receiver and fully integrated with the engine.

3.2 Combined SCR and filter

Fig 6 shows the flow test bench used for the back pressure investigation on the left. The pressure drop of the coated DPF substrates has been measured depending on the volume flow through the substrate. In addition, Fig 6 shows an SEM image of an uncoated DPF. The high porosity of the wall, which is required for the coating, as well as the asymmetric cell structure, for the higher ash capacity, is illustrated.

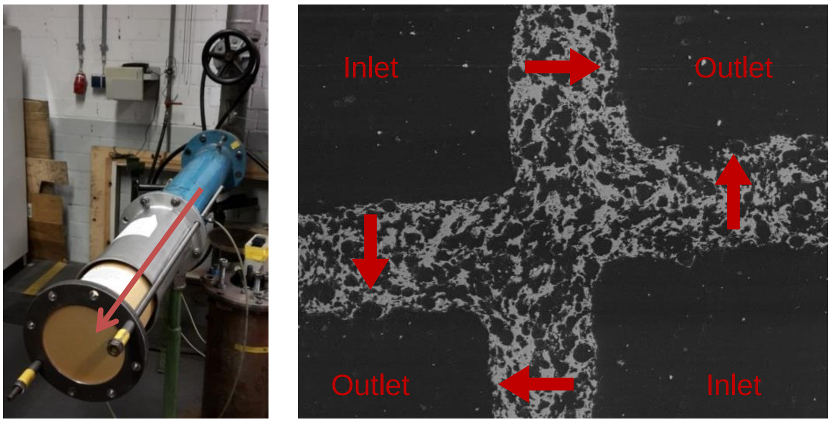


Fig 6: Back pressure test bench (left) and SEM image of uncoated DPF (right)

The results of the DOC tests show that both DOC systems can generate the required share of NO_2 of the total NO_x by oxidizing the NO. Fig 7 shows the exhaust after treatment systems which was installed during the DOC investigation as well as the canning of the DOC system.

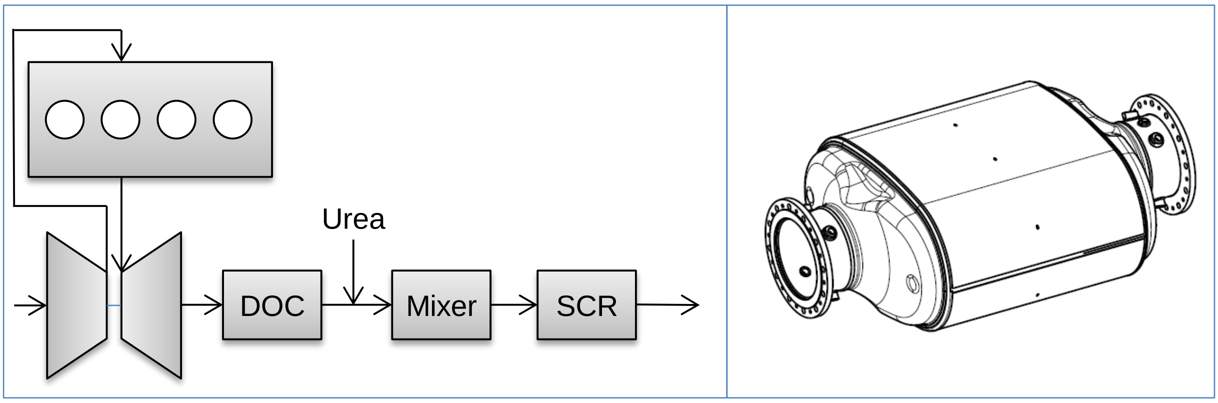


Fig 7: EAT system with DOC, mixer, SCR (left) & DOC-canning (right)

Regarding the urea decomposition, the first task was to study the influence of temperature and pressure on the urea decomposition. This includes investigations of the spray as well as the chemical components of the reactions. Fig 8 shows results for exemplary operating points.

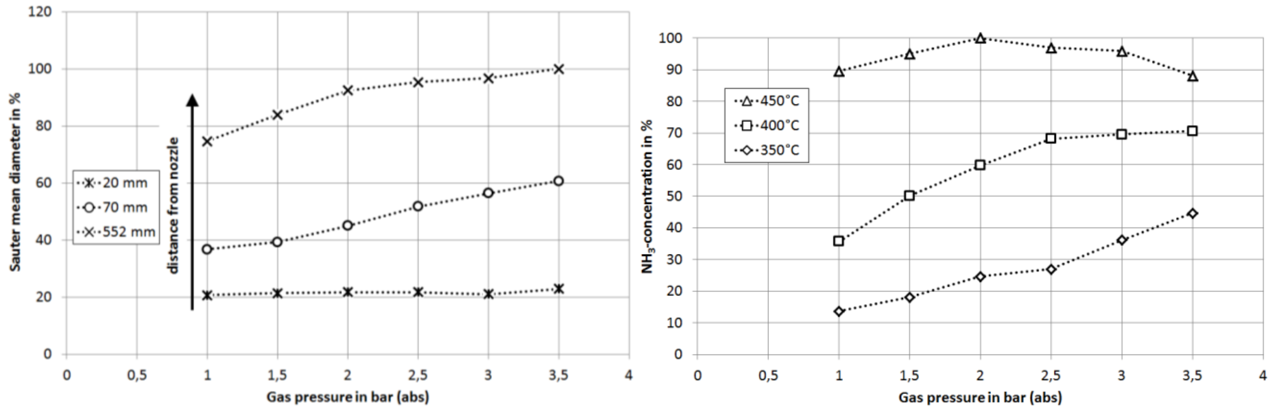


Fig 8: Influence of pressure on mean droplet diameter(left) and NH3 concentration (right)

Mixing elements are helpful to reduce time and space needed for the urea decomposition. Therefore, they are crucial to design compact SCR-systems. The strong influence on the process can be seen in Figure 9, which depicts the spray configurations with and without mixing element.

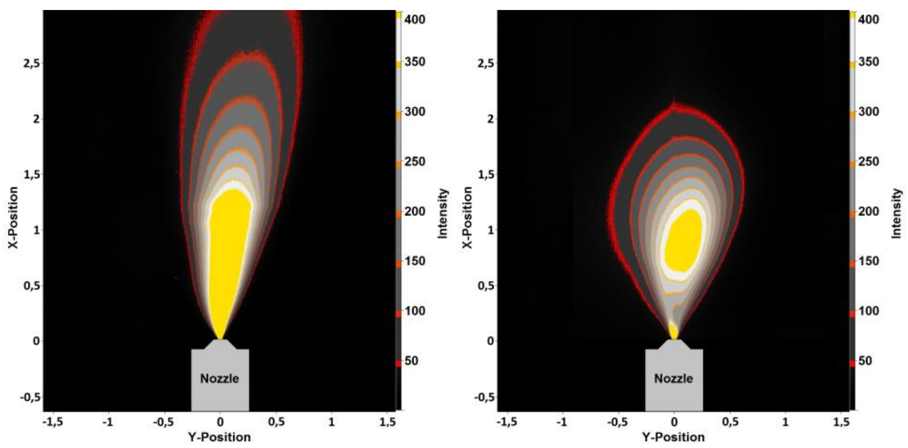


Figure 9: Appearance of spray near field without mixing element (left) and with mixing element (right)

Parallel to the experimental investigations, numerical studies were carried out for the same operating matrix. Fig 10 shows the spray behavior depending on temperature and pressure. The simulations show good accordance to the experimental results.

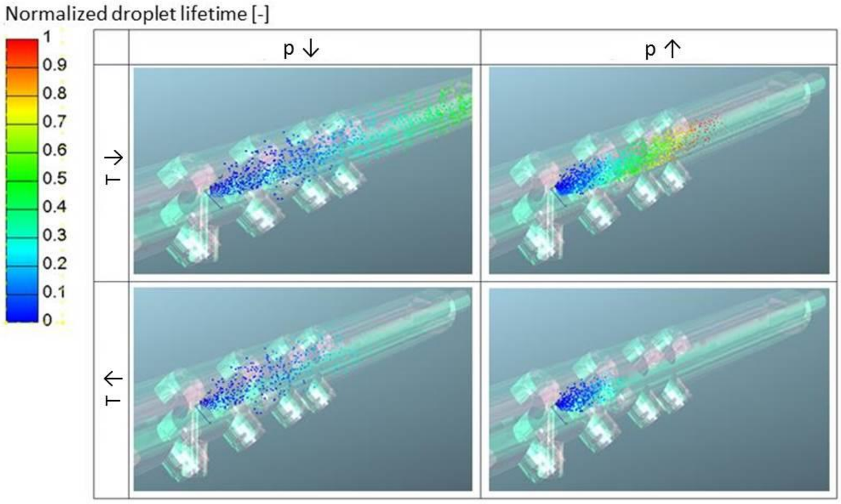


Fig 10: Simulated spray behavior at different operating conditions.

4 Next steps / future work

Engine integrated SCR. Procurement of a new exhaust gas receiver for the test engine, catalyst elements and other auxiliary SCR components are on-going. The next step will be rebuilding of the test engine and test of the integrated SCR system.

In the 3rd year of the project it is planned to carry out investigations of an exhaust after treatment system on a marine distillate engine comprising DOC, mixing unit, SCR coated DPF. Therefore, the SCR has to be replaced by an SCR coated DPF (see Fig 7). These tests will verify the design of a scaled up systems based on the results of the laboratory tests on the synthetic gas test bed.

Regarding the investigation of urea decomposition, the 3rd year will be dedicated to enhanced setups and improved configurations of decomposition units. The results and knowledge from the second year form the basis for these investigations.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP9**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	29/4/2017
Dissemination Level:	Public

Work Package Leader Responsible:	Nikolaos P. Kyrtatos (NTUA)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

HORIZON 2020
The EU Framework Programme for Research and Innovation

1 WP9 Objectives

The overall objective of the Work Package 9 is to carry out the administrative management of the project.

Among all administrative management activities, the main objectives of WP9 for the 2nd Year of the Project were:

- Preparation, execution and post-processing of major project meetings
- Follow up actions regarding Grant Agreement Amendment #1.
- Preparation and submission of Periodic Report #1 to the EC.
- Participation and representation of the Consortium in the EC Mid-Term Review Meeting.
- Distribution of the EC interim payment for period I to the Project Consortium

2 Progress

During the 2nd Year of the Project, the main activities within WP9 were:

- Preparation, execution and post-processing of major project meetings
  - 3rd Project Technical Board Meeting, in Athens, 12/05/2016
  - 3rd Project Steering Committee Meeting, in Helsinki, 6/10/2016
  - 4th Project Technical Board Meeting, in Helsinki, 6/10/2016
  - 2nd Partners' Forum, in Helsinki, 6/10/2016

  Besides the organization of the Meetings, the Minutes of Meetings, Action Lists and Compendium of Presentations were compiled and a Poster Session at Partners' Forum was also organized.
- Follow up actions regarding Grant Agreement Amendment #1.

  During the 1st project year, WP5 Leader requested the inclusion of a new partner in the Project and in WP5, namely the POLITECNICO DI MILANO. NTUA prepared all required documentation and submitted officially the Amendment Request to the EC on 30/09/2015. The Grant Agreement Amendment #1 run into force on 23/10/2015.The distribution of pre-financing to new partner #33 POLITECNICO DI MILANO was transferred on May 2016.
- Preparation and maintenance of specific templates to collect participants' inputs to the required EC reporting documents (e.g. templates for Periodic Report #1), according to the specifications of the EC.
- Preparation of guidelines for submission of Financial Statements for Period 1 Reporting (October 2016).
- Preparation and submission of Periodic Report #1 to the EC.

  The work of the project must be reported to the EC per partner and also per Work Package (WP). The WP Reports submitted by the partners are consolidated into the WP Consolidated Periodic Reports which in turn are consolidated into the overall Project Report, which together with the Consolidated Financial Reports are delivered to EC after the end of each reporting period. All Reports and all Financial Statements information are submitted to the EC via the EC Participant Portal.

The full package of Reports for the 1st Period of the HERCULES-2 Project was submitted electronically to the EC together with the Financial Statements, submitted via EC Participant Portal on 23/12/2016.

The Package included:

a. Publishable summary
b. Project objectives for the period
c. Work Performed, progress towards objectives and results, major achievements, deviations and corrective actions per WP
d. Detailed description of the Consortium Management Activities
e. Tables with Deliverables and Milestones
f. Detailed Gantt Charts per Task
g. Financial Statements per Activity (Forms C) per partner including detailed list of Major Cost Items
h. Detailed Workpackage progress via the WP Consolidated Periodic Reports
i. Detailed description of the work performed by each partner via the Partner Periodic Reports

- Participation and representation of the Consortium in the EC Mid-Term Review Meeting. The EC Mid-Term Review Meeting was held in Brussels on 7th December 2016. The Consortium was represented by 5 persons (1 from the Coordinator NTUA and 4 of the major project partners MAN Diesel & Turbo, Wärtsilä and Winterthur Gas & Diesel Ltd.). The EC was represented by the EC Officer and the 1 EC Reviewer.
- Handling of EC interim payment for Period I, prepare distribution chart for interim payment to partners, obtain approval from the Project Steering Committee (PSC) and distribution to all partners.
- Keeping records and financial accounts of the distribution of the Community financial contribution.
- Maintaining of the project internal database for reporting and controlling, including the adaptation of the structure after changes in the Work plan and the Consortium.
- Communications with EC: issues related to the Project including the Grant Agreement Amendment #1 and other contractual or administrative transactions (e.g. EC Information Letters regarding the GA).
- Resolution of various issues, related to Beneficiaries' financing, accounting, eligible costs.
- Handling project correspondence and day-to-day requests from partners and external bodies.
- Implementing and maintaining the project infrastructure, e.g., the internal platform for information exchange and email lists.
- Monitoring of compliance by beneficiaries with their obligations under the grant agreement

- Keeping up-to-date with EC rules, guidelines, documentation.
- Handling of legal and IPR issues.
- To represent the HERCULES-2 consortium and act as an intermediary, between the Consortium and the EC for all information flow.

3 Preliminary results

N/A

4 Next steps / future work

In addition to the activities mentioned above that will continue during the 3rd Year of the Project, NTUA as Coordinator will also perform the following actions:

- Preparation and maintenance of specific templates to collect participants' inputs to the required EC documents.
- Review of periodic reports to verify consistency with progress and costs.
- Compilation of 2nd Periodic Report.
- Follow partners’ costs, review and submit Financial Statements / Certificates on Financial Statements.
- Preparation of specific templates to collect participants' inputs for the Final Reports.
- Compilation of Final Reports.
- Maintenance of the Consortium Agreement.
- Updating project website with current partner details.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP10**

Revision Final

Nature of the Deliverable: Report

Actual Submission Date: 29/4/2017

Dissemination Level: Public

Work Package Leader Responsible: Nikolaos P. Kyrtatos (NTUA)

Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

HORIZON 2020

The EU Framework Programme for Research and Innovation

1 WP10 Objectives

The overall objective of the Work Package 10 is to carry out the technical management of the project.

2 Progress

The main activities of WP10 for the 2nd Year of the Project were:

- Monitoring of the Work Packages and Subprojects overall progress regarding the technical implementation of the work, in relation to the specified deadlines and milestones, based on Deliverables, presentations of WP Leaders, as well as a direct contact to WP Leaders.
- Review and Assessment of Deliverables prior to final submission to EC.
- Submission of Deliverables to EC via the Participant Portal EC website. The following Deliverables were submitted to the EC during Year 2:
    - D1.2, “RCEM – feasibility study”
    - D3.2, “Report on sample tests”
    - D4.2, “TMF test rig for TMF loaded component like specimen”
    - D5.1, “Concept report on optimized engine knock control”
    - D5.2, “Concept report on engine control parameterization”
    - D5.3, “Concept report on robust control of hybrid engine propulsion”
    - D7.1, “Literature review regarding SCR engine integration and particulate abatement”
    - D8.1, “Measurement techniques in High Pressure SCR system”
    - D10.1, “Progress review of all Work packages”
    - D10.2 “Interim presentation of overall project results”
    - D11.2, “Report on Dissemination Activities at Mid-Term”
- Preparation, execution and post-processing of the following Project Technical Board meetings.
    - 3rd Project Technical Board Meeting, 12/05/2016, Athens
    - 4th Project Technical Board Meeting, 6/10/2016, Helsinki
- Follow-up and resolution of Beneficiaries’ problems and issues related to performance, scope of work, changes in work programme and schedule, reallocation of resources, changes in personnel.
- Handling of intra-project correspondence and day-to-day issues from partners regarding technical matters.
- Supervision of the project global critical path.

3 Preliminary results

N/A

4 Next steps / future work

In addition to the activities mentioned above that will continue during the 3rd Year of the Project, the following actions will also be performed within WP10:

- To prepare Guidelines and to compile the scientific / technical part of periodic reports to be submitted to the EC.
- To prepare and post-process the scientific part of EC reviews.
- To post-process any technical comments of EC reviewers on the submitted Deliverables.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.3**

Input for **WP11**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	29/4/2017
Dissemination Level:	Public

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Start date of Project: 01/05/2015 Duration: 36 months

Grant Agreement No: **634135-HERCULES-2**

HORIZON 2020
The EU Framework Programme for Research and Innovation

1 WP11 Objectives

The overall objectives of the WP11 (Dissemination Activities) are:

- Disseminate information about the project and its results
- Ensure the results of the project are appropriately recognized on a wide scale at sectoral, European and World levels.
- Share the technical results of the project with the scientific community interested in the topics addressed by the project.
- Organize external Liaison activities observing confidentiality, non-disclosure agreements (NDA) and business standards (B.S.)

The HERCULES-2 Dissemination Activities during the 2nd Year of the Project have taken various forms such as scientific papers, publications, presentations in Conferences, Congresses and meetings, poster exhibitions and press releases. The main Dissemination gateway is the Public Section of the HERCULES-2 website, which is operational since Month 6 of the Project. A summary of all activities performed for WP11 is presented in the next chapter.

2 Progress

During the 2nd Year of the Project, the main activities within WP11, categorized on a Sub-Project basis are presented below.

<u>2.1. SUB-PROJECT 11.1 HERCULES-2 Website</u>

A major development for the Project management and dissemination to the public is the HERCULES-2 web site. The specification, design, development, deployment, evaluation, refinement and update of the site and its contents were provided by the Coordinator during the 1st Year of the Project.

The site has two parts:

1. A section open to the public (www.hercules-2.com) with information about the structure, objectives, contents, Work Packages and Partners of the project. It is regularly updated with highlights of developments in all Work packages. It also contains all external publications and presentations of the Project, as well as all Public Deliverables.

   Besides the general Project information, by the end of the 2nd Project year the "Publicity" page of the web-site contains:

   - 21 References for HERCULES-2 in Press and Media
   - 1 general Presentation
   - 7 Public Deliverables
   - 17 Scientific Publications coming from the Project.
   - Progress Highlights at October 2015, May 2016 and October 2016 for all scientific Work Packages.

- videos from the 1st Partners' Forum of the Project in Copenhagen (23/10/2015) and the 2nd Partners' Forum in Helsinki (06/10/2015).

2. A Members Area section where the partners can communicate, submit Progress Reports and Deliverables and any documents pertinent to the Project. The Members Area has document Repository libraries and has strict access and visibility control to the various subsections, to ensure confidentiality.

2.2. SUB-PROJECT 11.2 Publications

According to the HERCULES-2 Consortium Agreement, any scientific publication in Scientific Journals and Conferences with results from the Project work is distributed to all partners and EC. The Coordinator is handling the vetting procedure by partners and related objections, if any.

During the 2nd Year of the Project, 17 papers have been approved for publication. These papers refer to important achievements of the Project and have been presented in Congresses, Conferences and Meetings worldwide.

2.3. SUB-PROJECT 11.3 Dissemination

In line with the European Commission policy on dissemination, during the 2nd Period of the Project, upon request from the European Commission, a 4 page leaflet with the general description of the HERCULES Programme and photos that illustrate parts of the progress made, was prepared and sent to the EC for publicity and communication reasons. They focused mainly on the most important results and applications without reference on specific technical details, as they were not oriented to experts, but to a more general public with some knowledge on the topic.

Dissemination related to major project meetings was also made through the Project web-site in the "News" page, while a brief overview of results and preliminary achievements of the project was also presented in the website, categorized per Work package, in the "Work Structure" page. Also there are 21 references and/or articles about the HERCULES-2 project in the scientific & technical Press and Media.

Furthermore, methodology, objectives and other details regarding the HERCULES-2 Project are open to public with the information provided to the "Transport Research & Innovation Portal (TRIP)", which is a database that gives an overview of research activities at European and national level.

An overview of the HERCULES R&D programme was presented in the 28th World CIMAC Congress, which took place in Helsinki, June 2016. This event, which takes place every 3 years, is of great importance, as it has worldwide recognition and is attended by more than 1000 international experts in the field of large engine research.

The title of the Paper was: " From HERCULES A-B-C to HERCULES-2: A classic cooperative programme in large engine R&D “. The paper referred to all the milestones that have been achieved during the whole HERCULES Programme, as well as the latest accomplishments of the HERCULES-2 Project.

In addition, the Deliverable D11.2 titled “Report on Dissemination Activities at Mid-Term” was delivered on month 18 (03/11/2016), as planned in Annex I.

3 Preliminary results

N/A

4 Next steps / future work

During the 3rd Year of the Project, the HERCULES-2 web-site will be continuously updated with information. The dissemination activities to all other means will continue and in fact increase as the project will produce its results.

The Project Final Forum will include a seminar with webcasting open to the public where the Project results will be presented, including a round table discussion on marine engine efficiency and emissions and the Project contribution.