HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Progress review of all Work packages

Revision Final

Nature of the Deliverable:	Report
Due date of the Deliverable:	01.05.2016
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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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Summary

The objective of the current report is to present briefly the progress of all Work Packages of the HERCULES-2 Project at the end of the 1st Year of the Project (1/05/2016). 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 1
- Preliminary Results
- Next steps / future work

The Reports are prepared by the respective Work Package Leaders of each Work Package.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP1**

Revision Final

Nature of the Deliverable:	Report
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Work Package Leader Responsible: Andreas Schmid (Winterthur Gas & Diesel)

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. Work package 1 is divided into two sub packages, SP1.1 and SP1.2, whereas SP1.1 is again divided into a focus on two-stroke engines (handled by Winterthur Gas & Diesel AG) and a focus on four-stroke engines (handled by Wärtsilä Finland Oy). The first year objective on the two-stroke side of SP1.1 was to get an overview of possible future fuels. A fuel injection system, capable of handling alternative fuels will be designed, based on the results of this review of fuel alternatives.

For four-stroke engines, the first year objectives were as follows:

- Numerical modeling studies for liquid bio-fuels, methanol, or DME
- Spray chamber studies for various new fuels and for different DF pilot setups
- Ignition studies for non-auto-igniting fuels
- Development of new in-cylinder measurement and diagnostics sensors

In order to enable fundamental research of the combustion process particularly associated to increased fuel flexibility (Dual-fuel, gas) sub-project 2 addressed the demands of an appropriate experimental test facility. In particular, the feasibility of a dedicated "rapid compression expansion machine" (RCEM) shall be assessed.

2 Progress

In Work package 1 several steps toward the development of a fuel flexible engine have been accomplished during the past year:

- Literature study on future fuel candidates
- Layout, design and manufacturing of a new chamber geometry for the Spray Combustion Chamber
- Evaluation of concepts for the new injection system
- Review of existing Rapid Compression and Expansion Machines RCEM
- Feasibility study and rough estimation of the costs of two concepts was made
- Numerical modelling studies for liquid bio-fuels, methanol, or DME
- Spray chamber studies for various new fuels and for different DF pilot setups
- Ignition studies for non-auto-igniting fuels
- Development of new in-cylinder measurement and diagnostics sensors

A literature study was performed which highlighted the different characteristics of possible candidates to replace/extend the current fuel choices such as Heavy Fuel Oil, Marine Diesel Oil or Light fuel Oils. Based on the findings of this study specification sheet has been created and different concepts – capable of fulfilling the specifications – have been selected and compared.

For the Spray Combustion Chamber – WinGD's constant volume chamber representing the condition of a modern two-stroke marine diesel engine – a new set of covers was designed and manufactured.

A master thesis on 1-D simulation of the effect of the methane and methanol on pre-combustion in-cylinder conditions has been initiated and is ongoing. Besides that, planning and development of research environment for dual fuel pilot spray studies is started, validation completed for Engine Combustion Network (ECN) target condition 'Spray A' for diesel fuel. The work continues with different liquid bio-fuels. Finally, at WFI an online gas quality sensor was installed with testing starting in November.

Figure below shows an evaporating diesel spray with Lambda (λ) = 1 contour using an accurate turbulence modeling approach (LES).

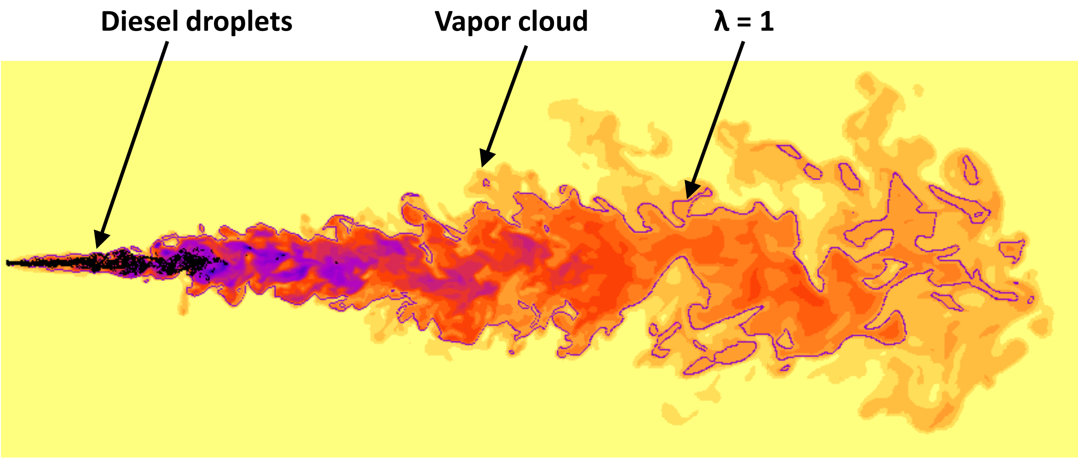

Figure 1: LES simulation of an evaporating diesel spray

The RCEM feasibility study (sub-project 2) could be accomplished in the first project year. Different technical concepts for a RCEM representing a (large) two-stroke marine diesel engine were explored, particularly in regard to the drive concept giving maximum of operational flexibility. In addition, selected possibilities of optical accessibility into the combustion chamber were considered, already taking into account the applicability of numerous optical measurement methods. The two favourite concepts of a hydraulic or crank driven piston were further investigated in regard to system specific requirements, operational control possibilities and required sub-systems as well as in view of optical access.

3 Preliminary results

Firstly, a comprehensive assessment of existing systems was performed. Figure 2 illustrates a defined classification of possibilities to examine the internal combustion processes based on which the findings of the thorough literature review were consolidated.

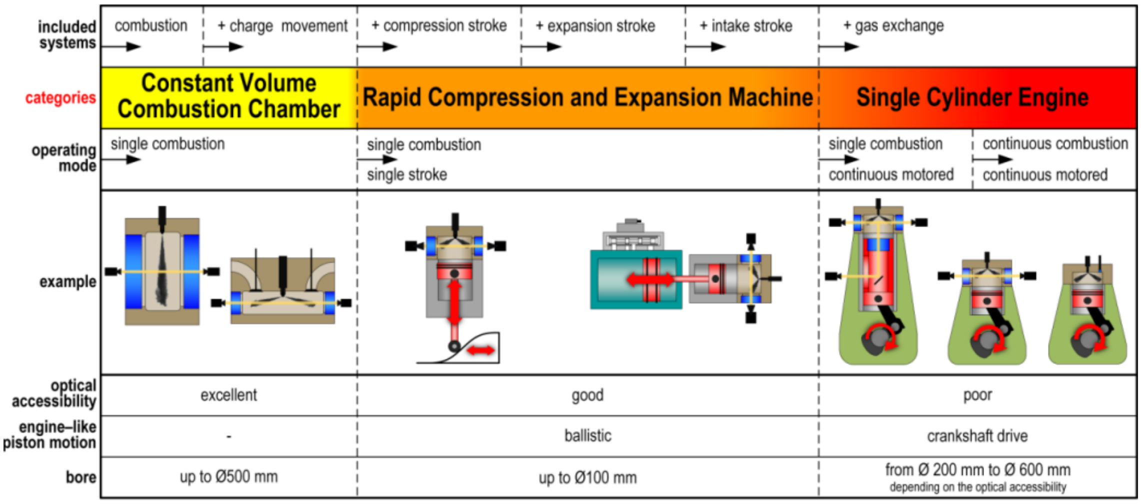

Figure 2: Classification of different possibilities to examine internal combustion processes.

In order to obtain a better understanding of in-cylinder phenomena involved and to enable advanced "fuel flexible" combustion process development, the head of the RCEM should provide optical accessibility for the application of non-intrusive measurement methods. In particular, visualization of spray/gas injection, fuel/vapor phase and mixture fraction, determination of ignition delay/location, combustion formation as well as emission formation is of interest. Figure 3 shows general layouts of possible configurations related to 2-stroke marine diesel engines: type (a) represents an original cylinder cover which can be modified to facilitate optical access via borescopes; type (b) includes an (exchangeable) optical spacer ring which features a number of holes for larger windows; type (c) shows an example of a special cover design (only for cyclic operation) with maximized optical accessibility. In addition, also optical access through the liner/piston has been considered (not shown here).

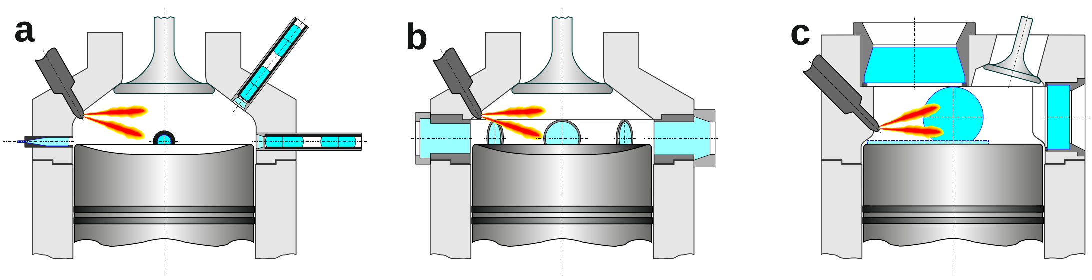

Figure 3: 2-stroke marine diesel cylinder covers with various potential optical accesses.

In general, there is a strong trade-off between quality of the optical access and grade of "realism" regarding engine operation conditions which have been critically examined in detail within the study. Moreover, the applicability of different optical measurement methods from pure imaging to rather sophisticated spectroscopic techniques in regard to flow, injection (sprays), mixture and combustion processes (ignition, flame propagation) as well as emission formation have been evaluated and assessed.

In the drive concept evaluation for such a large RCEM various approaches have been considered where finally a crank driven piston (close to a "classical" single cylinder research engine) has been compared to a hydraulic system. The latter turned out to be a quite innovative concept which offers some benefits compared to a classical crank drive, particularly in regard to a higher flexibility in operation modes.

Figure 4 shows a sketch of a direct hydraulic driven RCEM with its key components and sub-systems: piston type pressure accumulators can store large amounts of energy in relatively small spaces. Fast acting servo-valves regulate the flow from the accumulators to the hydraulic piston within milliseconds. This allows an extremely fast start of the flexible configurable piston stroke and offers some opportunities in regard to a single measurement cycle for non-intrusive optical measurements – in contrast to starting up a crank drive, for instance less difficulties with pollution of the windows due to idling. An additional advantage might be the possibility to hold the piston "locked" at top dead centre to even enable constant volume combustion chamber investigations. On the other hand, due to the compressibility of the hydraulic oil, the piston stroke trace is more influenced by the combustion pressure. Therefore, detailed simulations were performed to assess the performance and evaluate the limits of such a hydraulic piston drive concept in regard to achievable representative "engine speeds", achievable operation parameters (e.g. flow, pressure, temperature, etc.) and the impact of combustion variations on the piston stroke.

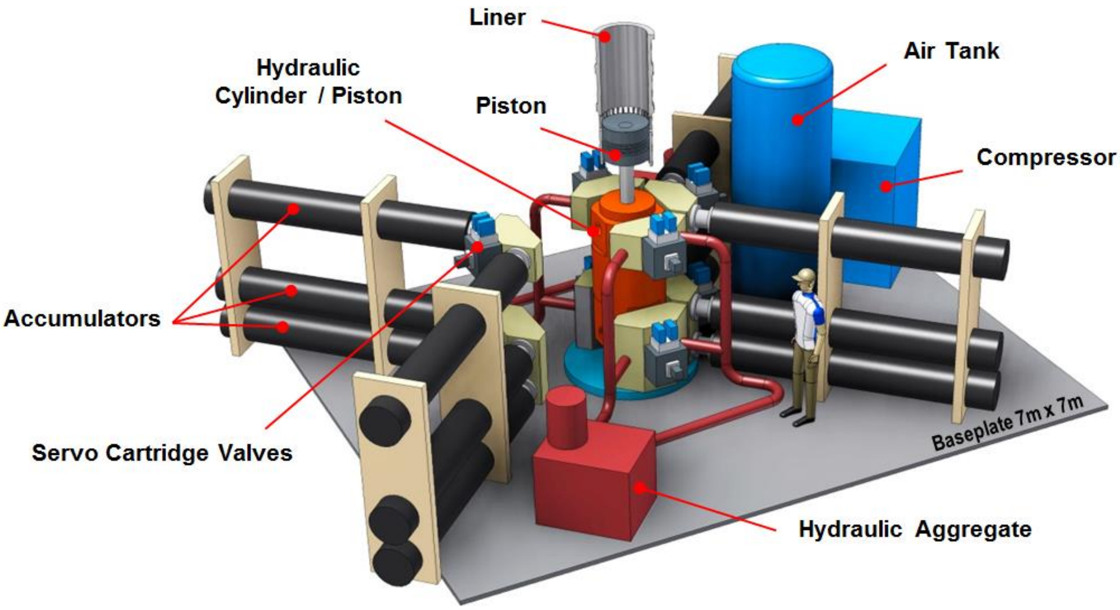

Figure 4: Sketch of a direct hydraulic driven RCEM with its key components and sub-systems.

Based on requirement specifications in regard to adapt a 2-stroke marine diesel engine, the limits of the key components were determined. Finally, two concepts have been elaborated in detail: 350 mm bore size with corresponding "original" stroke dimension compared to 500 mm bore size with reduced stroke dimension. The piston displacement volume of the hydraulic piston, the number of strokes and the simulated "engine speed" defines the required number of servo valves and the stored oil volume in the accumulators. As conclusion, the 350 mm bore size system (with original stroke) seems to be the limit of a direct hydraulic driven RCEM device in regard of technical feasibility, costs and "handling" aspects.

For both concepts of crank and hydraulic driven RCEM, all specific major components and sub-systems have been evaluated. Particularly for the crank drive device, also mass balancing, flywheel and possible electrical propulsion have additionally been examined. Moreover, in regard to process gas charging and operation concepts, technical feasibility has been assessed. In addition, the evaluated optical accessible cylinder covers have been considered, yielding in various combination possibilities with different characteristic features (limitations, operation and conditions close to the "real engine") with corresponding advantages or disadvantages, respectively. Figure 5 shows an exemplary combination of optical accessible cover, piston/liner and drive units of the two extreme cases: a crank driven RCEM close to a single-cylinder engine (left) versus a hydraulic driven RCEM with optimized optical accessibility (right).

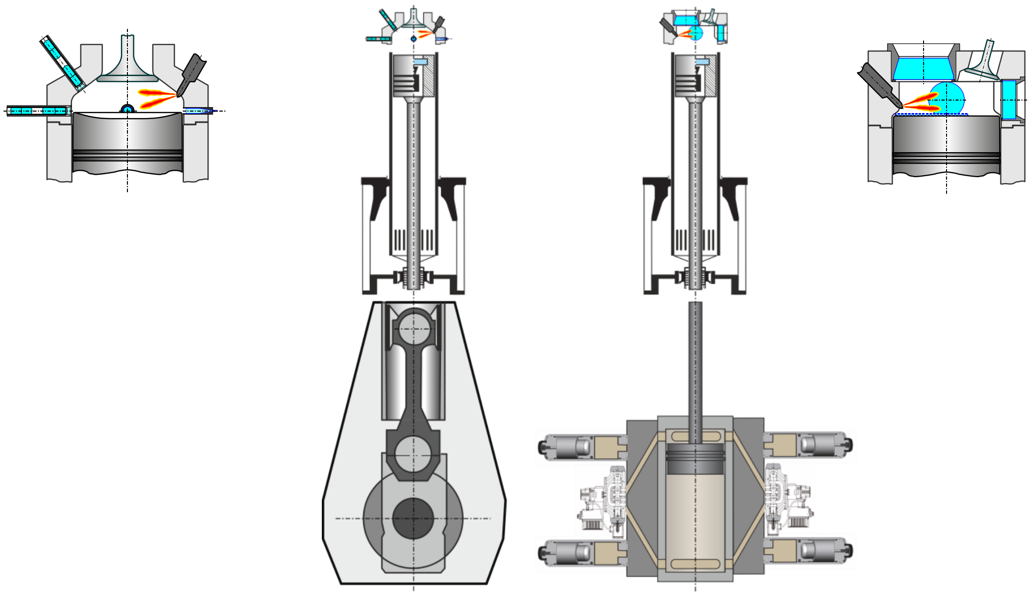

Figure 5: Exemplary combination of optical accessible cover, piston/liner and drive units.

As a result of sub-project 2, the feasibility study gives an assessment related to an employment of a RCEM in regard to adapt a 2-stroke marine diesel engine, particularly also considering the application of optical non-intrusive measurement techniques. Obviously, a setup closer to a crank driven single cylinder (2-stroke marine diesel) research engine is not limited in size. On the other hand, the interesting concept of a large hydraulic driven RCEM exhibits certain features, in particular also the option to perform specific single cycle investigations. However, the comprehensive detailed investigations in the study give an insight into various aspects to consider and is a basis for a recommendation if/how to go ahead with the development of such a research test facility.

Online gas quality measurement results in year one were as follows:

- Continuous logging of data to the laboratory measurement system November-February and on biogas February – April
- Calculations for LHV and Methane Number were added in the system
- Possibility for portable measurement added
- Additional pressure sensor added for monitoring purpose
- First software development started for engine control based on measured gas composition.

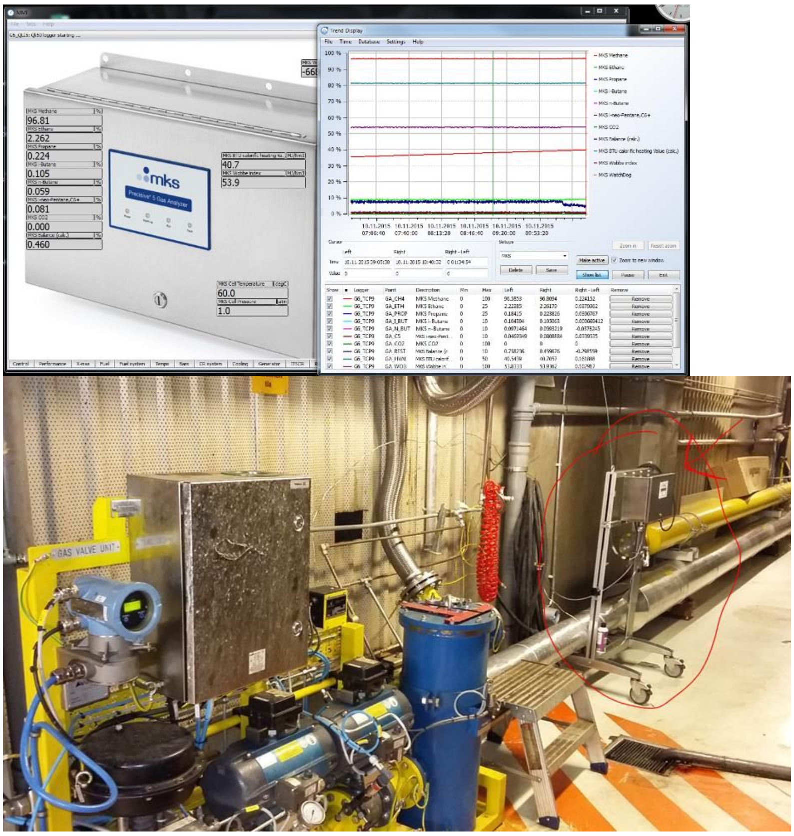

Figure 6: Exemplary online gas quality determination

4 Next steps / future work

Sub-project 2 is finished: In regard to the outcome of the RCEM feasibility study a final decision whether and how to go ahead with the development and installation of such a test facility is conceivable.

Based on last years' progress, sub-project 1 will focus on the design and the manufacturing of a fuel flexible injection system. In parallel, a set of reference measurements will be performed using the Spray Combustion Chamber, in order to compare the spray formation of the new injector design to existing installations.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP2**

Revision Final

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Dissemination Level:	Public

Work Package Leader Responsible: Dr. Johan Hult (MAN Diesel&Turbo)

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 → 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

The specific objectives for the 1st year were:

- Development of concepts for a fuel flexible test facility and an optical medium-speed dual-fuel engine.
- Development of optical measurement techniques for fuel spray and fuel distribution visualisation.
- Review and development of detailed chemical models for alternative fuel combustion and for NO_2 formation.

2 Progress

Concept designs for both the fuel flexible test facility and the optical engine have been finalized, detailed design work has started for the first and procurement of parts for the latter. Four-stroke engine tests have been delayed, while a first test of multiple-camera imaging of ethane engine operation has been performed on two-stroke. Development of optical measurement techniques has progressed, both for two- and four-stroke applications. A detailed chemical kinetic model for natural gas has been developed, and parameter studies investigating NO_2 production carried out.

3 Preliminary results

The detailed concept study for an optical fuel-flexible test facility simulating two-stroke engine conditions has identified a combustion chamber with a piston actuated by a pneumatic/hydraulic drive unit as the most promising alternative, see illustration in Fig 2:1 a.

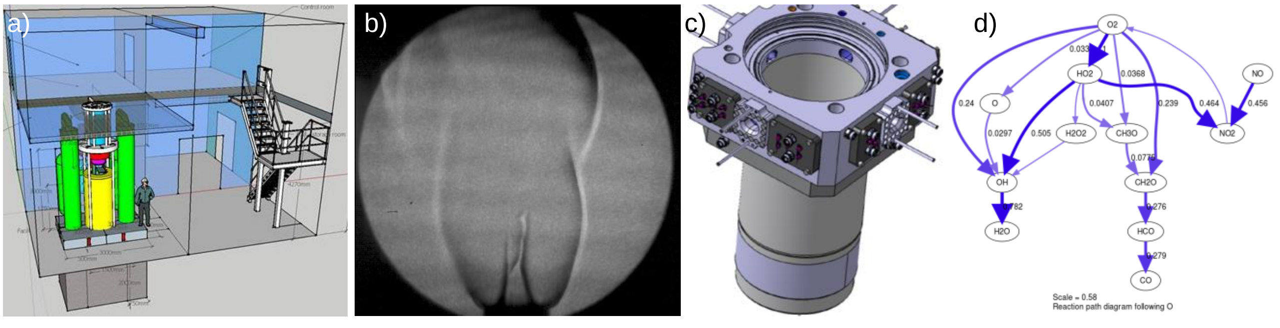

Fig WP2:1: a) Fuel-flexible test facility concept, b) high-speed Schlieren test, c) concept for optical medium-speed engine, d) reaction path diagram for NO_2.

Optical diagnostic techniques, both for use on a two-stroke test engine and on the fuel-flexible test facility, are being developed with the aim of studying both liquid and gaseous fuel jets and flame propagation. In Fig. 2:2 an example of a high-speed movie of two-stroke engine operation on ethane is shown and in Fig. 2:1 b) an example of a high-speed Schlieren image of a laboratory flame is shown.

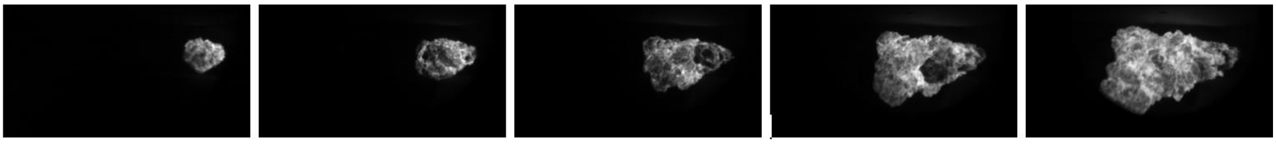

Fig WP2:2: Individual frames from a high-speed movie of two-stroke engine operation on ethane+diesel.

A detailed chemical kinetic model for natural gas components (methane, ethane, propane) has been developed and improved, also including subsets for oxygenates (methanol, ethanol, dimethyl ether). Porting to CFD has been demonstrated. A high pressure laminar-flow reactor was modified for high-pressure experiments on propane and butane chemistry.

For the medium-speed optical engine a design was implemented which gives possibilities of using state-of-the-art optical measurement techniques at high quality. A design was chosen that gives optical access to the combustion chamber by numerous windows in an optical access ring above the cylinder liner, see Fig. 2:1 c).

NO_2 formation can occur in the cylinder as well as in the exhaust pipe and its reaction rates highly depend on pressure and temperature as well as species concentrations (particularly NO, O_2 and HC). An important reaction path in the presence of hydrocarbons is the formation of NO_2 by oxidation of NO with the hydroperoxyl radical, see Fig. 2:1 d).

4 Next steps / future work

- Detailed design of an optical fuel-flexible test facility, start of procurement and infrastructure establishment.
- Procurement and build-up of optical medium-speed engine and optical measurement technique.
- Development of optical techniques for characterizing alternative fuel operation on two-stroke engines, and optical tests on four cylinder test engine.
- Single-cylinder four-stroke engine, spray chamber and CFD investigations will be performed, to guide injection strategies for reducing impact of fuel on combustion process.
- Extension of chemical kinetic model to LPG fuel, including experimental validation. Implementation into CFD model.
- CFD calculations will be coupled with detailed chemical models to NO and NO_2 formation.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP3**

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Dissemination Level: Public

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 WP 3 Objectives

The objectives of workpackage 3 are listed here per subproject

Subproject 3.1: Novel materials for engine applications

Here, we will examine possibilities of using novel materials in engines to facilitate the development of various components that enable higher engine loads, hereby increasing efficiency and lower emissions, whilst ensuring proper lifetime performance and durability.

Subproject 3.2: Novel materials for turbine casing

The objective here is to increase the exhaust gas temperature limit for the turbocharger turbine casing. (see Figure 1) The material of turbine casing is reviewed in respect of material and design in order to meet the requirements needed for higher exhaust gas temperatures. The aim is to improve performance through material optimization.

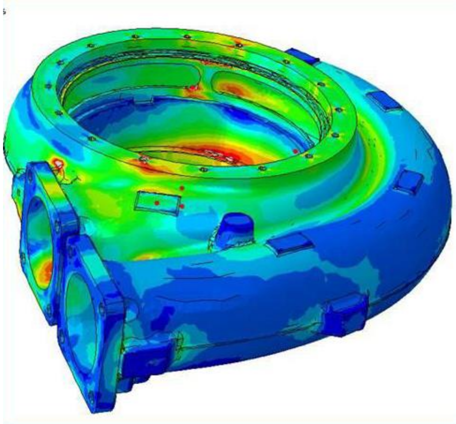

Figure 1: Turbine casing

Specific to the 1st year of the project, the detailed objectives per subproject are:

Subproject 3.1: Novel materials for engine applications

- Setting boundary conditions for operation
- Evaluate and propose suitable materials
- Investigate possible manufacturing routes
- Decide on suitable materials
- Optimize the processing routes for the chosen materials
- Manufacturing of samples for testing.

Subproject 3.2: Novel materials for turbine casing

- Evaluation of materials
- Evaluation of manufacturing routes

- Full characterisation of materials

2 Progress

Progress during the first year has been according to the planned time schedule in both subprojects and good collaboration between partners. Progress meetings have been organised at set intervals alternating between physical and web-based meetings for time and cost efficiency.

In subproject 3.1: Novel materials for engine applications, we have progressed to the point where we have manufactured a number of samples, experimenting and optimizing the processing routes at different partners.
In subproject 3.2 progress is according to plan.

3 Preliminary results

Subproject 3.1:
Most promising engine components identified and requirements / boundary conditions have been definded. Following that, the most promising new materials were chosen, along with the possible manufacturing routes. Manufacturing of samples has begun, with some materials already reaching the testing stage, slightly ahead of schedule.

Some examples from MPIE on manufacturing routes (casting tests, in this case) are shown in Figure 2 and Figure 3.

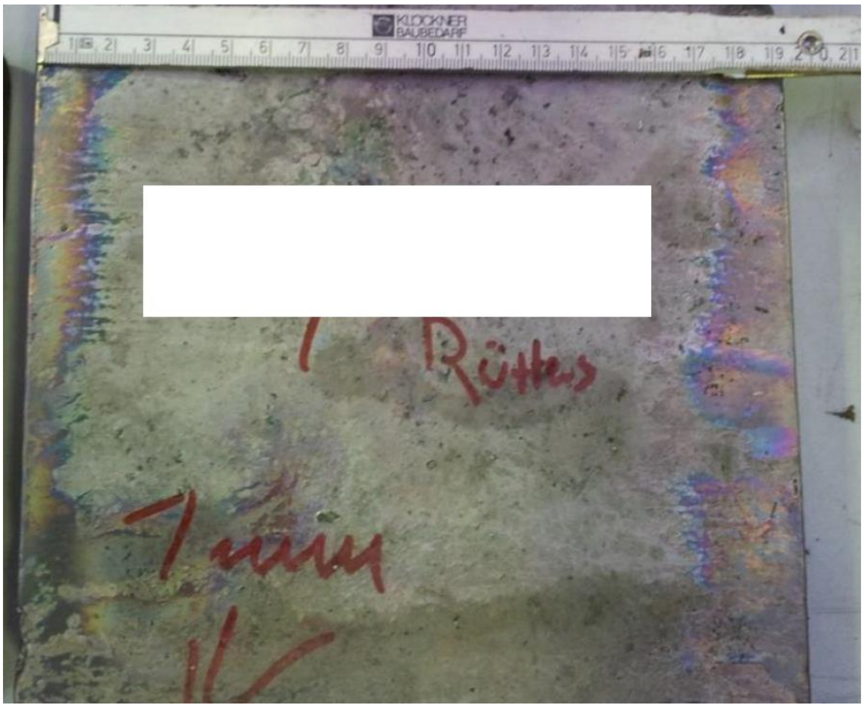

Figure 2: Casting tests conducted at MPIE (material references removed due to confidentiality)

Figure 3: Casting tests conducted at MPIE (material references removed due to confidentiality)

As an example of cross-partner collaboration, the rapid prototyping wax patterns in Figure 4 were produced at Deloro wear solutions (formerly Kennametal) and were used to cast samples at MPIE.

Figure 4: Rapid prototyping wax patterns produced at Deloro wear solutions

Wärtsilä Finland and WinGD have been involved in the initial setting of the boundary conditions, all selections and decisions made in the process and are now also starting to take part in the testing of the samples. Investigations into engine bearing materials to enable higher loads have also started, with a dedicated test rig being assembled, instrumented and calibrated, see Figure 5.

Figure 5: High load bearing materials test rig

Subproject 3.2:

A functional Specification List „Gas Inlet Casing for High Temperatures“ has been made by project partner ABB and reviewed with the other project partners, along with a list of alternative materials that could be used. The required material date parameters to enable proper design and simulation of the turbine casing have also been identified by the team at ABB and gathering of the data is ongoing.

4 Next steps / future work

Subproject 3.1:

During year two of the project, the focus in subproject 3.1 will shift to the detailed investigation of the manufactured samples, possibly revisiting parts of the process if needed or of improvements can be made. It is planned to move from the material sample stage toward the manufacturing of prototypes for rig or engine testing towards the end of the second year, and initiate testing on bearings for high engine loads.

Subproject 3.2:

During the second year of the project, subproject 3.2 will focus on the lifetime (TMF) calculations of the revised turbine casing and manufacturing of a prototype that is to be tested as validation later in the project.

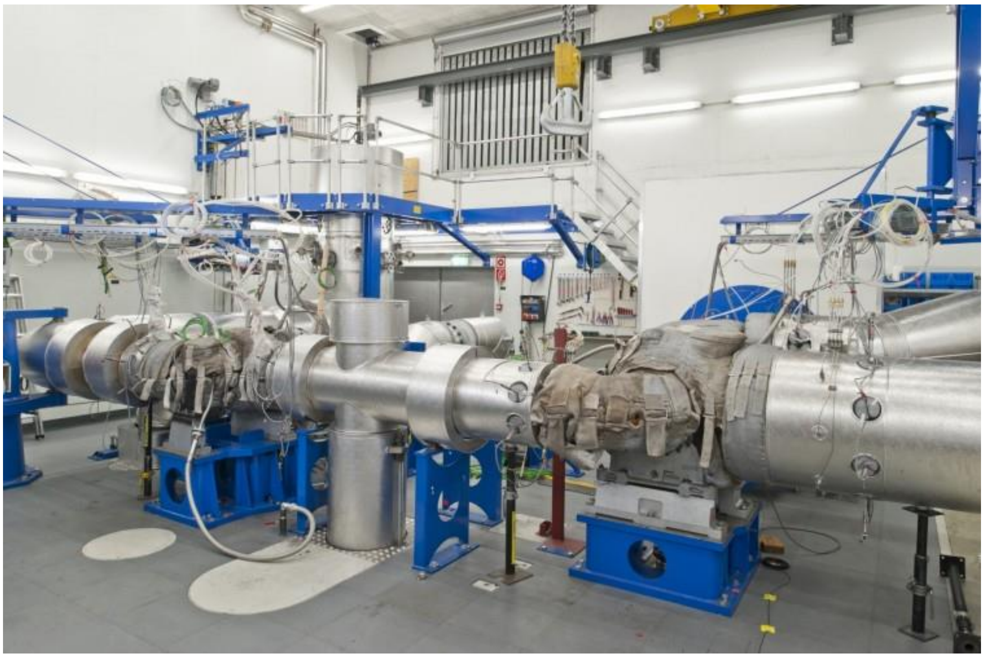

Figure 6: Example of a turbocharger testbed at the ABB Turbocharger-Testcenter

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP4**

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Work Package Leader Responsible: Dr. Rayk Thumser (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 WP 4 Objectives

The objective of this Work package is to develop the use of appropriate material for optimized combustion engines. The components are the cylinder head and the turbocharger turbine casting. These components are cyclic loaded by mechanical and thermal loads. The workpackage is divided into subtasks:

- WP 4.1 New materials and design for cylinder heads
- WP 4.2 New materials for the turbocharger turbine casing

For the first year the objective for the workpackes is the selection of appropriate casting material, production of test samples at foundry and machining. Afterwards the samples should be tested to obtain physical and mechanical properties to support the calculation procedures.

2 Progress

WP 4.1

A series of different materials for possible cylinder head application were defined. The major parts of these materials were produced at foundry. The basic characterization regarding thermal and mechanical properties is done. The design of the fatigue test rig for superimposed thermal and mechanical loading has been optimized.

WP 4.2

A series of test specimens were produced out of the selected casting material. Three different casting batches were ordered in order to include the material variations in the material test results. During production of the test specimens it was noticed that it was not possible to meet the high dimension quality required for the test specimens. After specimen production the probes showed bent shape. This shape was out of the geometric tolerances. The issue was solved. A stress relieving heat treatment on the casting material was applied before the machining process. The detailed test program for the material characterization was set up comprising low cycle fatigue, thermomechanical fatigue and creep tests. The tests have been started.

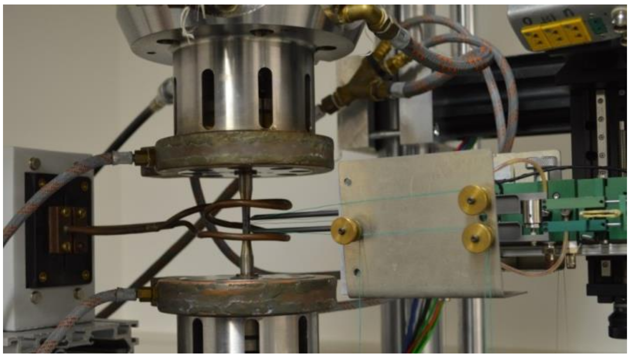
3 Preliminary results

WP 4.1

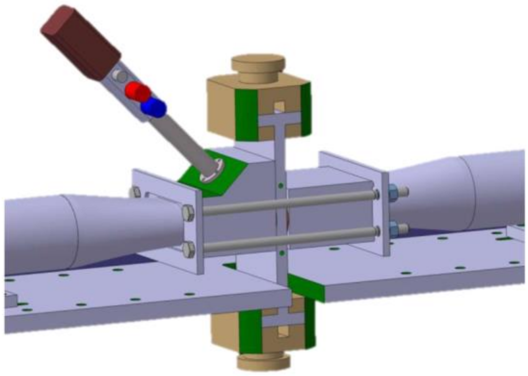
The different materials show different behaviour regarding thermal expansion, thermal conductivity and fatigue (TMF) resistance. The design of the test rig is like a multidisciplinary optimization task. The development of the test rig is almost completed.

WP 4.2

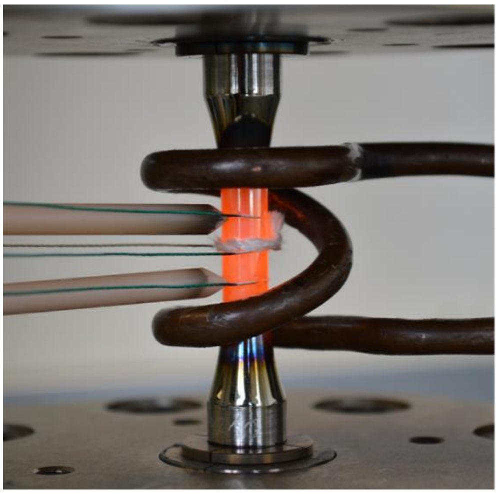
The first result is regarding the fabrication of test specimens. It was learned that a stress relieving heat treatment of the casting material is required to fulfil the dimensional tolerances of the test specimens. The effect of the heat treatment on the mechanical properties itself is worth to be further investigated.



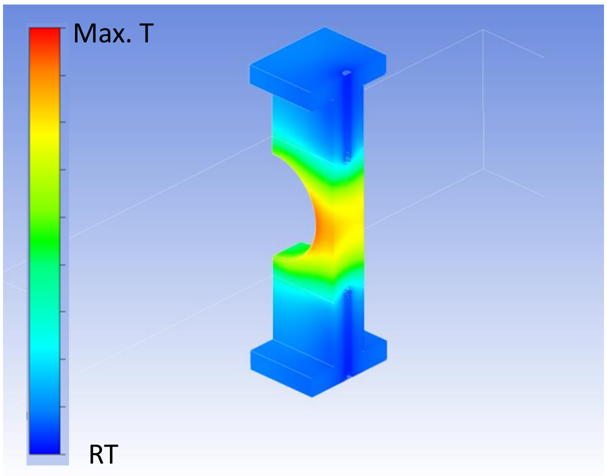
Test Setup for Material Samples under Thermal Loading



Test Rig Design Study for Component like Specimen



Detail of TMF Test



Test Rig Design Study – Corresponding CFD results

4 Next steps / future work

WP 4.1

- Finalisation of pre study
- Development of performance indicator for selection of final material investigation
- Material investigation for TMF
- First test at fatigue test rig for superimposed thermal and mechanical loading

WP 4.2

- Continuation of low cycle fatigue, thermomechanical fatigue and creep tests
- Derive of a constitutive equation for the creep behavior and the load limits of the material
- Validation of the material model

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP5**

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

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

HORIZON 2020
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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 1st Year of the Project the objectives were:

- Concept studies, development and tests of optimized control methods and parametrization, engine control system setup and control model development of hybrid engine propulsion system
- Requirements collection of tribosystem, development of simulation models as well as definition of suitable control methods to adjust lubrication system performance on basis of operational requirements.

2 Progress

Overall the progress is according to plan.

Sub-project 5.1 and 5.2

In these sub-projects, optimization of engine control and parametrization tool for reference maps shall be developed for engine operation points at both steady state and extreme transient conditions with varying quality of fuel. Furthermore, simulation and testing of multi-variable robust control of hybrid engine propulsion systems will be performed.

So far, a rapid-prototyping environment for optimized control system development is being established at Wärtsilä and Aalto. Concept and state-of-the-art studies and algorithm development, simulation and testing is being established. Validation of adaptive controllers and knock control methods has been accomplished. Robust control methods of hybrid engine propulsion system are being developed and tested.

Politechnico Di Milano (PoliMi) has successfully been included as a new member in the project.

Sub projects 5.3 and 5.4

Sub-project 5.3 encompasses design, development and validation of a new lubrication concept, comprising the development of a 1D simulation of the new lube oil injection system, as well as the development of suitable sensor technologies to monitor lube oil quality. The progress so far incorporates a pre-design of a new lube oil injection system to provide a maximum level of flexibility as well as the setup of an experiment to validate simulation results.

Sub-project 5.4 relates to the development of an advanced real time tribosystem performance monitoring system. Suitable sensor technologies are identified and subsequently explored to comply with the requirements to the application. Initial experiments provide an optimistic view upon the possibility to obtain the desired results and rig testing is currently getting prepared to validate prototype sensors for the full scale engine test.

3 Preliminary results

In order to evaluate performance of different adaptive controllers, experimental verification has been done on the hybrid testbed at NTUA which shows response of different controllers. types.

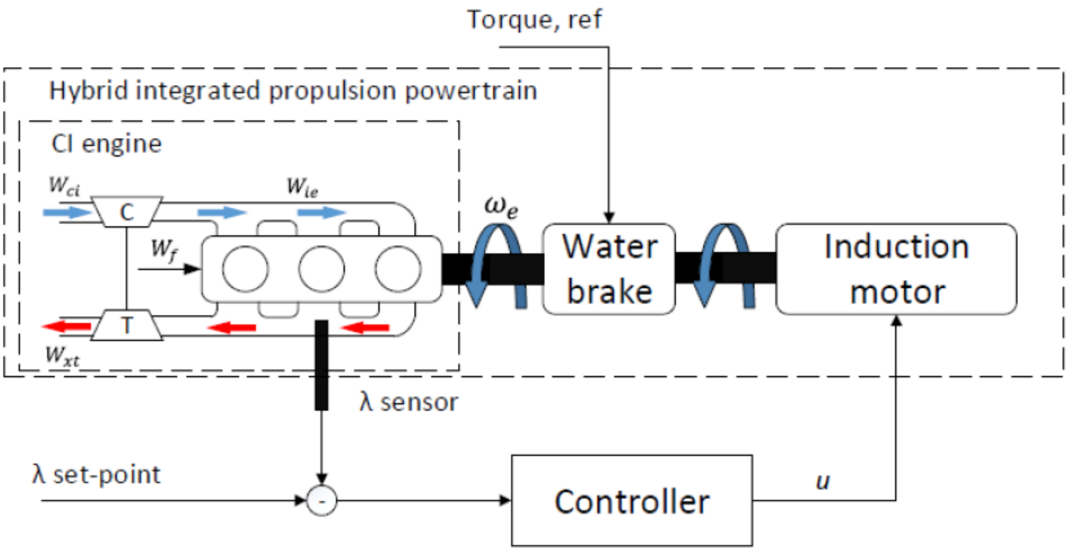


Figure 1: Lambda control diagram of the hybrid integration propulsion powertrain. C - compressor, T - turbine

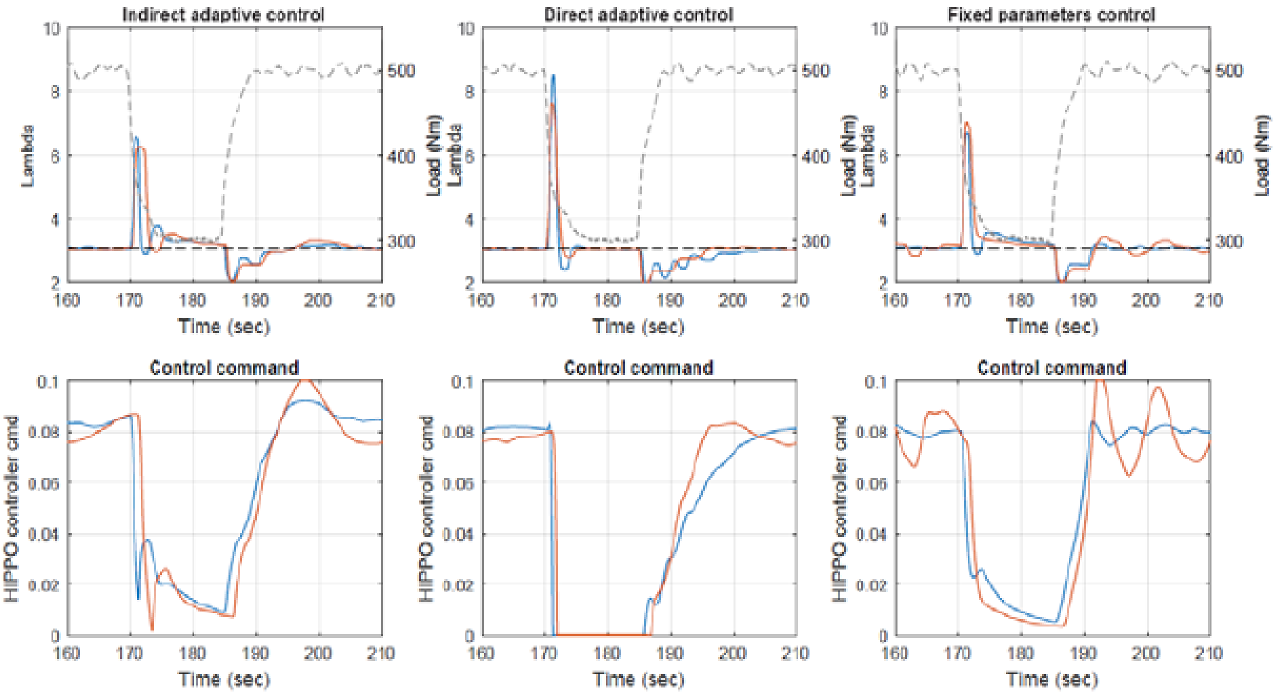


Figure 2: Experimental verification of adaptive controllers

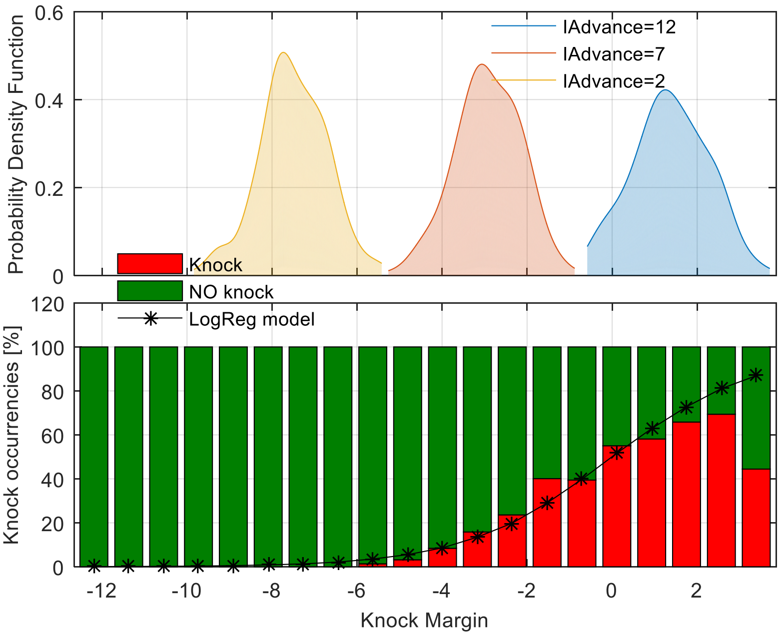


Figure 3: Experimental relationship between estimated knock margin ang knock occurrences

For optimized knock control, different control strategies has been tested. For example, a knock margin control method, where extracted information from cylinder pressure forms a synthetic indicator that is related to knock probability. Furthermore, a review of cylinder pressure measurement chain accuracy has been conducted to identify error sources and uncertainty.

Investigations related to the optimal lubrication system approach nominates a suitable method to inject the lubricant and to guarantee a maximum level of flexibility. 1D simulation of the injector is foreseen to predict kinetics of the fluid in order to obtain the possibility to optimize the injector performance and to adapt to engine requirements.

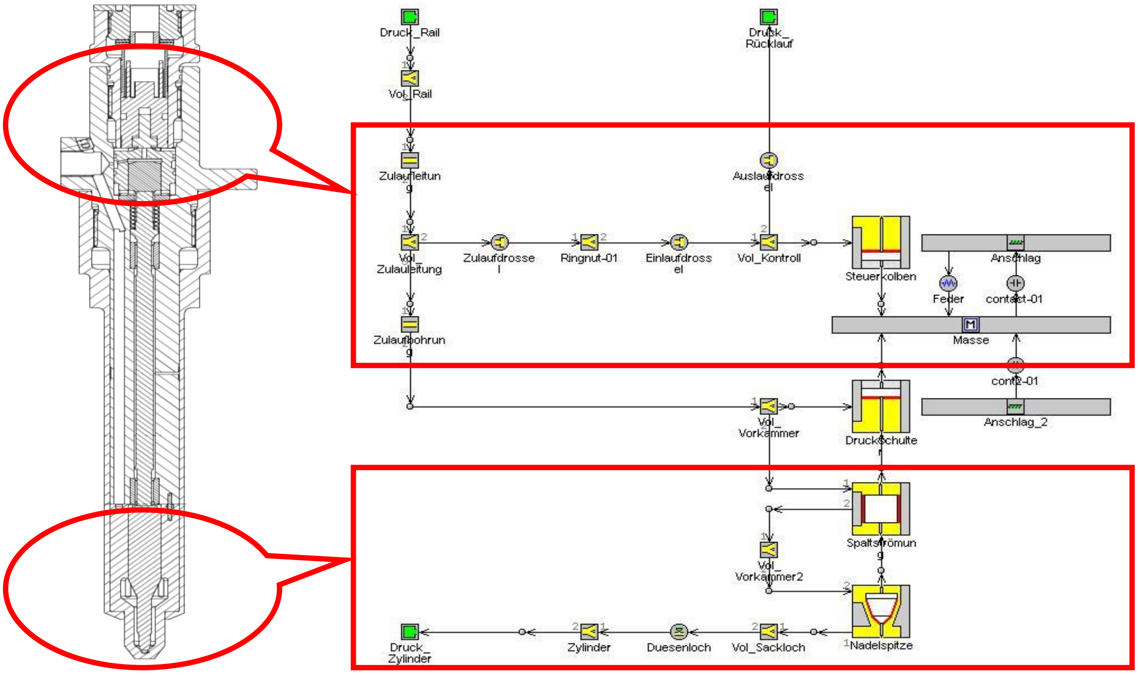


Figure 4: Schematic of the 1D hydraulic simulation model of the new lube oil injector

An experiment to validate the lube oil injector simulation results was designed during the last period of the project and brought to a level close to readiness for use. Fig.5 shows the step from a 3D model to the almost operative test cell. Minor adjustments need to be done to obtain the possibility to quantify spray patterns of different lube oil injection system executions.

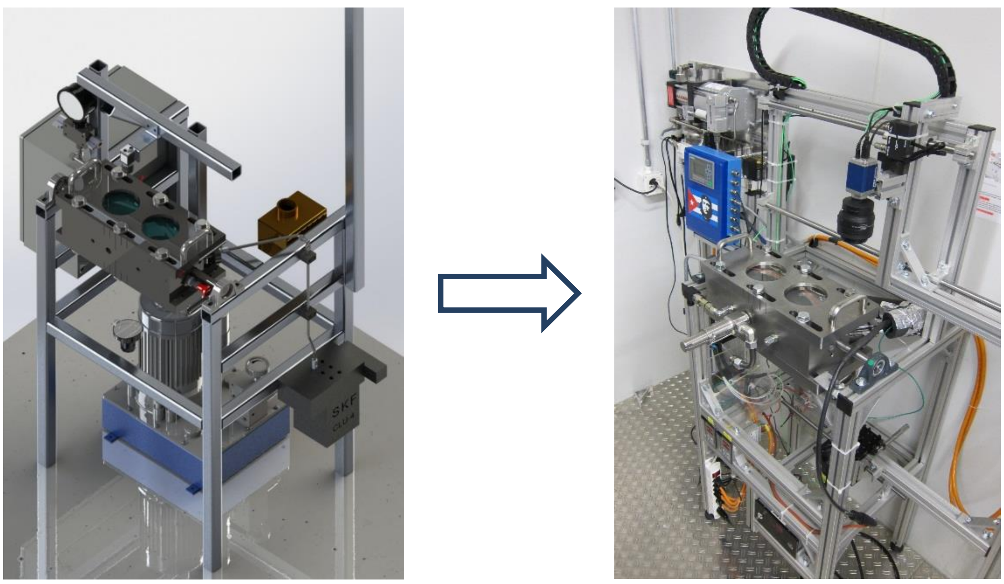


Figure 5: Lube oil injection system validation test rig

Developments pertaining to the application of tribosystem monitoring possibilities demonstrate the feasibility to cover most significant parameters with a single sensor approach. Detailed investigations reveal the possibility to measure residual film thickness, lube oil viscosity and wear permanently and at the same time detect scuffing once it occurs.Fig.6 schematically demonstrates sensor positions and the application of a prototype sensor based on ultrasound reflectometry.

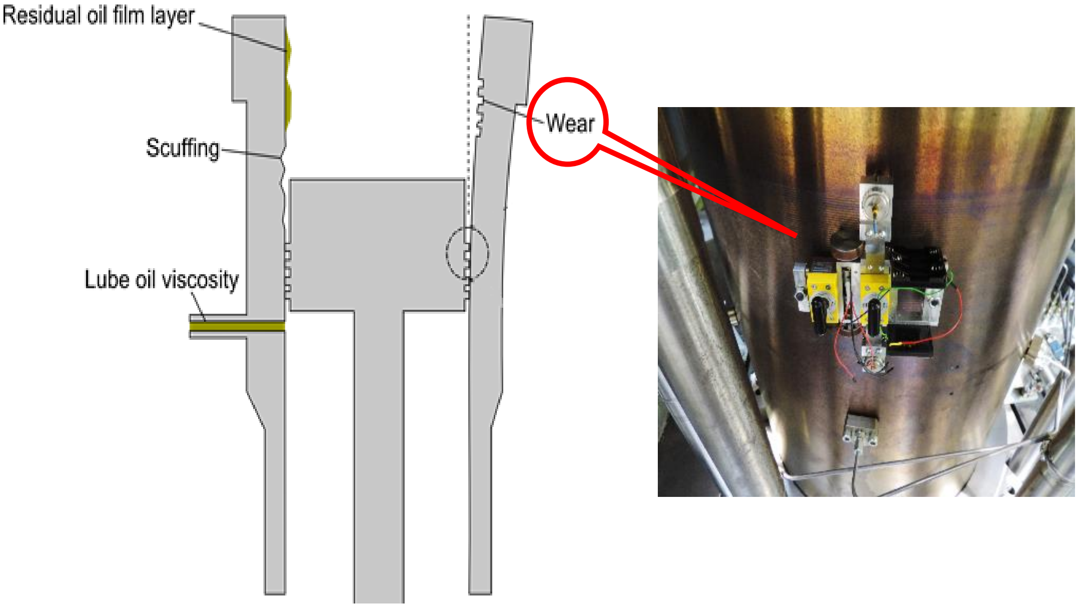


Figure 6: Tribosystem monitoring on basis of ultrasound reflectometry

4 Next steps / future work

For the 2nd Year of the Project, the activities will proceed with advanced control methods development and testing. Concept- and state-of-the art studies on control maps for parametrization will continue. It is estimated that testing possibilities at the single cylinder engine at University of Vaasa will be somewhat delayed. Overall, this is not seen to impact the project objectives.

Development of the fully flexible oil injection system and advanced tribosystem performance monitoring system will continue with design of experiments, sensor development and testing.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP6**

Revision Final

Nature of the Deliverable: Report

Actual Submission Date: 29.04.2016

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**

HORIZON 2020

The EU Framework Programme for Research and Innovation

1 WP 6 Objectives

The objective of WP 6 is to develop systems, methods and processes 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 there is a strong decrease in NOx emissions expected.

Through development of condition monitoring and diagnostics for optimized lifetime performance, maintenance and operating cost - through fuel savings - are estimated to be reduced compared to current engine systems.

This leads further to reduction of harmful pollutants - hydrocarbons, carbon monoxide, particulate matter and oxides of nitrogen - via early detection of creeping failure modes. With the help of new methods for evaluation of engine performance including handling and analyses of large data amounts these objectives can be fulfilled.

Novel control algorithms based on Model-based control will lead to an enhanced dynamic performance and part load efficiency without deteriorating the control-stability at constant load.

2 Progress

For the upcoming development steps simulation models are necessary which were established in the 1st year of the project. Therefore different models were created. Depending on the aim one engine model was design in a commercial software tool in order to investigate and optimize low operation behaviour of the engine and another model was designed in a mathematical language based on physical laws. Both models will lead to improved control algorithms and will help to enhance engine performance.

Regarding condition monitoring and diagnostics different prediction frameworks were evaluated in order to quantify the gain in result quality by using subspace search. Out of seven frameworks developed and studied, the one giving way to the best results uses change detection scores within certain subspaces of high contrast. The quality of each framework was measured with multiple metrics.

For secure remote system maintenance of system software, a framework for a hardened onboard engine management platform has been designed, including mechanism for software update synchronisation.

3 Preliminary results

Based on physical laws it was started to build up a mean value model. With the help of some assumptions first simulations are performed. Figure 1 depicts the behaviour of the model during a load increase in comparison to measurement results. There it can be seen that the simulations shows quite promising results but further work to increase the prediction quality has still to be done.

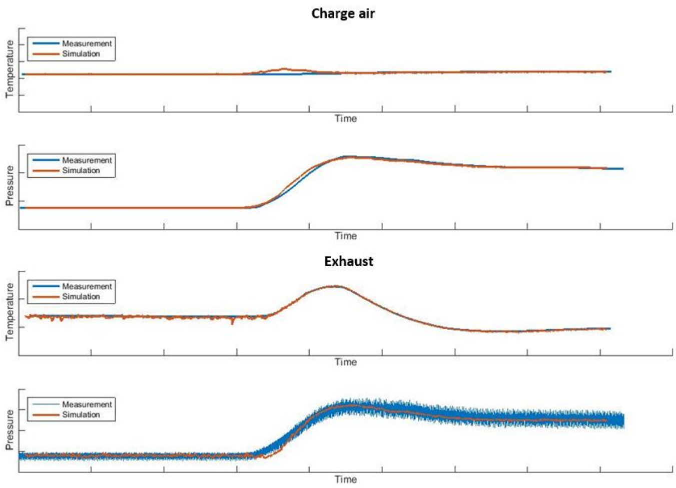


Figure 1: Comparison measurement vs. simulation

Within the investigated framework the most promising was HiCS-mCD. This model performed best regarding the specified evaluation metrics. This framework is based on multivariate change detection using Hotelling's T-square statistic in such subspaces identified by the HiCS subspace search algorithm. This framework is especially useful because of the inherent scalability; the subspace search step ensures that only a limited number of high contrast subspaces is used for further steps. Additionally, searching for multivariate changes within subspaces or combinations of attributes has shown good results. Hence, subspace search seems to improve prediction quality.The system hardening solution has been implemented and successfully verified one a key engine network device, and is being introduced to the remaining engine management network components.

4 Next steps / future work

In the 2nd year the combustion will be investigated and modelled. In the physical based model as well as in the commercial software tool the quality of the combustion models will be enhanced. For the low load operation there will be a study of promising operation scenarios.

Regarding condition monitoring and diagnostics in the 2nd year the most promising framework will be further evaluated with additional input data and the quality will be further improved. Furthermore tailored subspace-search methods will be investigated.

During 2nd year, the remaining security and legal aspects for remote engine software maintenance are to be clarified and implemented.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP7**

Revision Final

Nature of the Deliverable: Report

Actual Submission Date: 29.04.2016

Dissemination Level: Public

Work Package Leader Responsible: Jukka Leinonen (Wärtsilä Finland)

Work Package Deputy: Daniel Peitz (Winterthur Gas & Diesel)

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 1st year of the WP7 were:

- Literature review regarding SCR engine integration and particulate abatement
- Investigate, plan and start work for emission measurement systems for SO3, NH3 and PM emissions to support integrated after-treatment technologies
- Start experimental assessment of integration of methane and ethane abatement technology into gas engine
- Plan work for experimental assessment of SCR reduction agent injection systems with sensors for feedback control
- Definition of a vibration test cycle by measurements from engines
- Investigate durability of SCR catalysts when operating with high sulphur fuels
- Development of prototype vibration resistant extruded ceramic catalysts modules
- Development of prototype vibration resistant modular catalyst supports for coating

2 Progress

Literature reviews regarding particulate abatement including particulate filter and SCR integration with engine was started as planned. First deliverable regarding literature reviews will be ready as planned.

Investigation about available NH3 sensors were made, procurement for sensors were made and initial plans for sensor testing was also made. Also PM emission testing plans was made and testing will be completed at the end of the first year of the project.

Experimental assessment of integration of methane abatement technology into gas engine planned and needed test equipment procured and commissioned at Wärtsilä Spain. Testing started and will continue as planned.

Feasibility and demonstration of NOx and particulate reduction with tests on test engine was started and work has gone as planned and will continue according to plan.

Feasibility and demonstration of selected optimum set-up for the combined on-engine after treatment solution tests on test rig/engine work started ahead of original schedule and best solution for demonstration was selected. Test equipment was also installed and commissioned. Testing started and tests will now continue as planned.

Vibration profiles from engines running in the field were recorded and from these measurements a test cycle was defined in order to assess components on vibration test rigs for their suitability in later applications.

SCR catalyst activity tests were conducted to assess the robustness during operation on high sulphur fuels and to determine suitable operation parameters, also for catalysts operating at elevated pressures.

Prototype vibration resistant catalyst modules containing extruded SCR catalysts and metallic supports for SCR catalysts were designed, produced and tested on vibration test benches for suitability in aftertreatment systems when integrated in the 2-stroke engine structure.

3 Preliminary results

A literature review was conducted. This part serves as a general technology guide for particulate emission abatement from diesel engines. In the second part of the study, different supplier technologies were evaluated. A number of companies active within the exhaust gas after-treatment field were contacted and requested to send a proposal for the particulate filtering system for a 1 MW dual fuel engine. Based on the replies, passive diesel particulate filter systems with catalytic coating or/and an upstream diesel oxidation catalyst can be regarded as the primary choice for particulate matter emission control in EU inland waterway transport.

On activity, regarding methane and ethane abatement technology, test equipment was designed, installed and commissioned at Wärtsilä Spain (see figure 1)

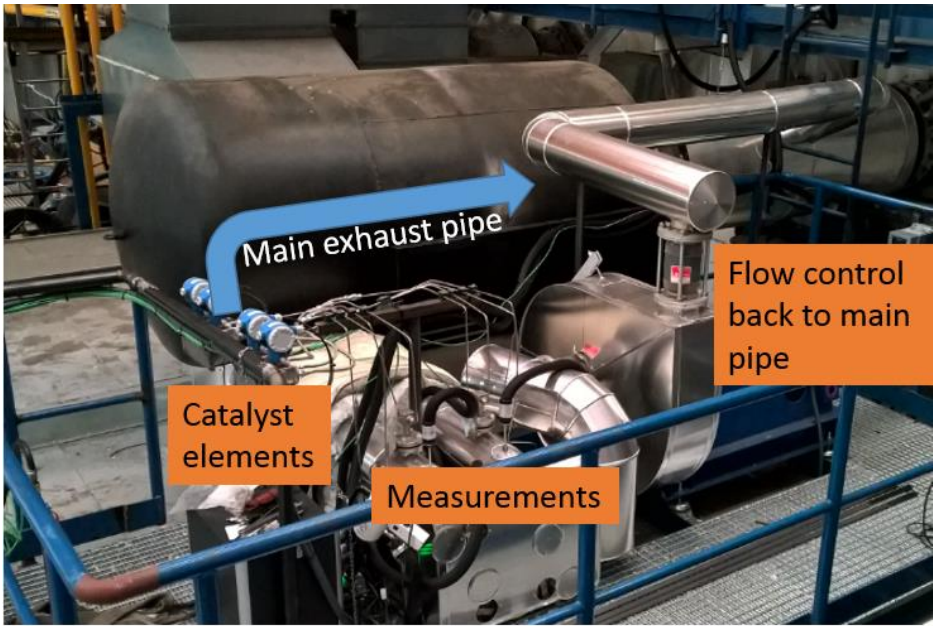


Figure1: Test equipment for methane abatement tests

For combined on-engine after treatment solution, test equipment was installed and commissioned to the roof of Wärtsilä Finland laboratory (see figure 2).

Figure 2: Test equipment for combined on-engine after treatment solution

For the reduction of the NOx a semi-short route EGR configuration is installed on the test engine. Thereby a part of the exhaust gas is cooled and led back into the charge air just before the high pressure compressor (see figure 3). In order to operate the engine on the entire load range the TC-system has to be re-matched, accordingly.

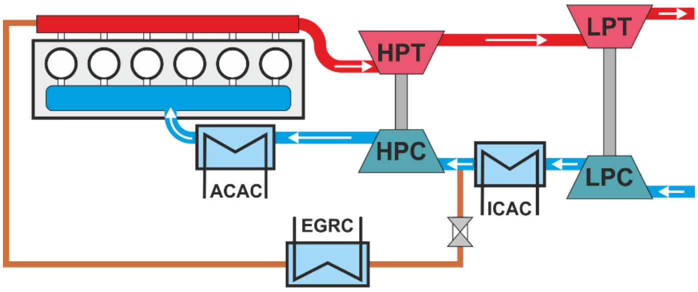
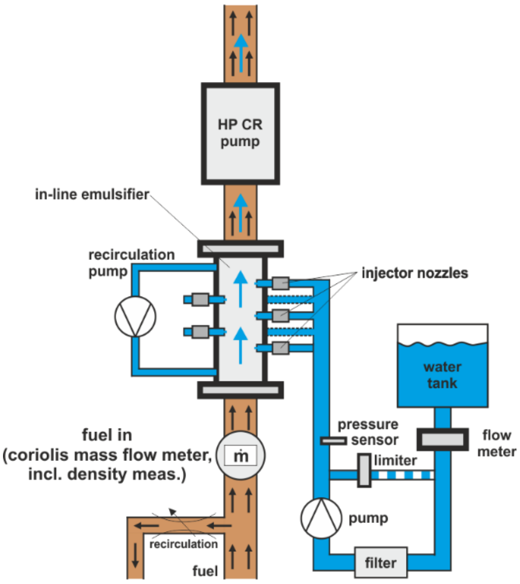


Figure 3: Illustration of semi-short route EGR system.

The application of the WFE is employed by a self-developed in-line emulsifier which is located just upstream the CR pump (see Figure 4). This allows an operation of the engine on the emulsion with a minimal lag time and without contamination of the peripheral fuel systems (i.e. day tank, booster pumps, filters etc.). The WFE system incorporates a high pressure volumetric water pump and a series of small diameter injection nozzles (ø150-500 µm) to ensure high water injection velocities onto the strain plates opposing the injection nozzles. The variability of the water injectors enables an operation with the smallest diameter for the desired water demand. The installed strain plates serve two purposes: Firstly, creating an impingement strain field to further reduce the water droplet size and secondly, to initially distribute the water droplets over the fuel line cross section by having a small angle between the strain plate normal to the injector axis.



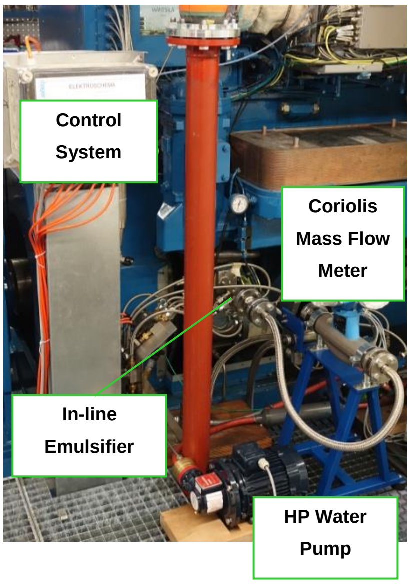


Figure 4: Schematic of in-line water fuel emulsifier (left) and installation on W6L20CR test engine at LERF, PSI (right).

At present, the commissioning of the in-line WFE system has been accomplished and initial operational tests have been performed. Finally, the controls system (PID loop based) adjusts the water flow rate according to fuel flow and magnetohydrodynamic water flow measurements to match the demanded water-to-fuel ratio (0-30% by volume). Furthermore, the fuel consumption measurement system has been upgraded by – additionally to the volumetric measurements – Coriolis mass flow meters (incl. density measurement). This allows an improved BSFC indication and the density information is applied to the WFE control system.

Vibration profiles were measured on various engines running in the field (see Figure 5 as an example setup) and vibration profiles were elaborated. From the determined vibrations a test cycle specification was written by Winterthur Gas & Diesel in order to allow the evaluation of components from SCR suppliers concerning the suitability for future 2-stroke marine diesel engine SCR applications.

Figure 5: Picture of vibration measurements on an engine in the field

Also, the durability of SCR catalysts in terms of resisting ammonium bisulphate (ABS) deactivation as typically occurring during operation with high sulphur fuels was investigated on a test engine in collaboration with researchers from the Paul Scherrer Institute. The general system setup is depicted in Figure 6. As indicated, a small scale SCR system mounted on a 2-stroke marine diesel engine was utilized for the investigations.

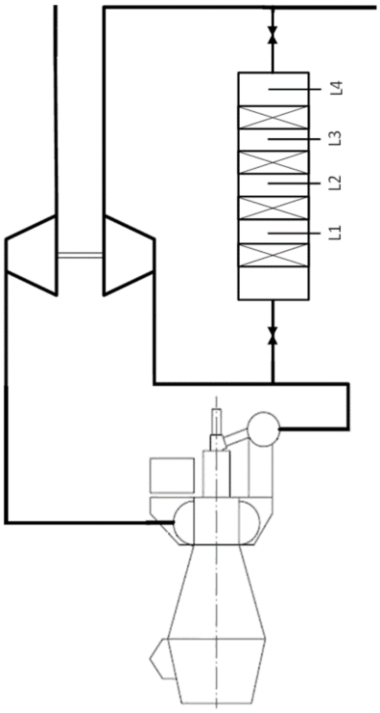


Figure 6: Scheme of the SCR system used for the catalyst deactivation experiments.

The catalyst activity was monitored during the experiments and a decline due to ABS was determined (see Figure 7). From the test campaign SCR catalyst operation parameters could be obtained. A more detailed document describing the conducted tests and results will be published at the CIMAC congress 2016 in Helsinki as paper No. 111.

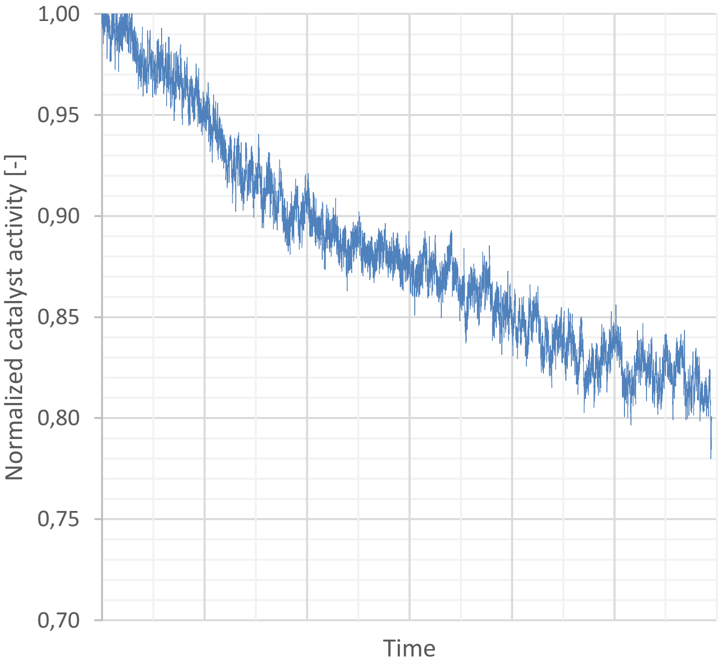


Figure 7: Graph of the measured decline in catalyst activity during high sulphur fuel operation.

Various canning concepts were designed and manufactured by Johnson Matthey to protect the ceramic extruded SCR catalyst from vibrations. Modifications included the outer canning as well as damping materials, in Figure 8 one modification of the outer caning is shown as an example.

Figure 8: Picture of a catalyst canning with stiffening structure in the metal frame.

Metallic SCR catalyst supports were designed (Figure 9) and manufactured by Dinex Ecocat after receiving the vibration test cycle specifications. The design was adapted for the application in a future 2-stroke marine diesel engine SCR system.

Figure 9: 3D model of a prototype metallic SCR catalyst support.

The prototype metallic SCR catalyst supports were tested at ambient temperatures on a vibration test bench as shown in Figure 10. Preliminary results indicate the supports passed the testing procedure.

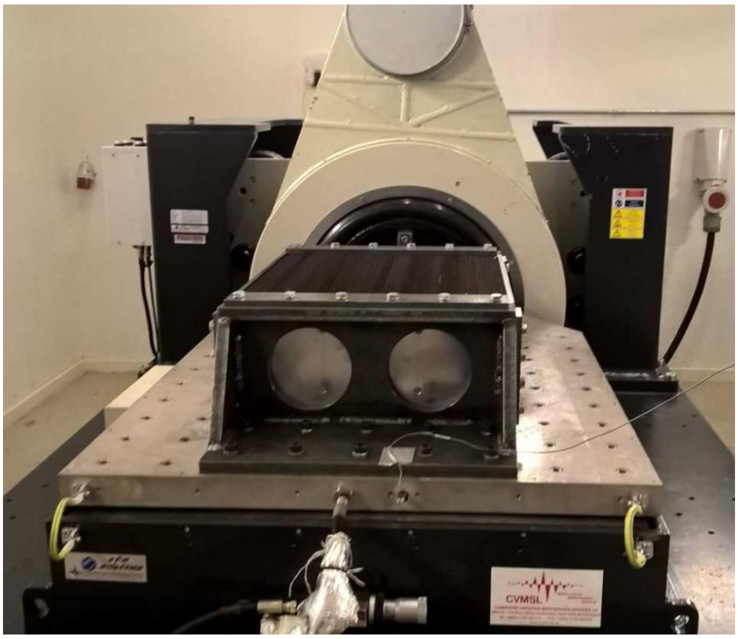


Figure10: Vibration test bench for testing metallic SCR catalyst supports.

4 Next steps / future work

During the next year, the focus will be to start and continue testing with installed and commissioned test equipment's 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
- 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

VTT will focus NH3 sensor testing and doing PM measurements with help of Wärtsilä Finland. PSI will continue demonstration of NOx and particulate reduction test with W20 test engine. Wärtsilä will concentrate to continue testing with installed test equipment at Spain and Finland.

WinGD will focus on the design, development and validation of robust catalysts.

Publication:

SCR under pressure – pre-turbocharger NOx abatement for marine 2-stroke diesel engines, CIMAC Congress 2016 Helsinki, Paper No. 111; K. Sandelin, D. Peitz.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP 8**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	April 29th, 2016
Dissemination Level:	Public

Work Package Leader Responsible: Hanne Hostrup Poulsen (MAN Diesel & Turbo (Cph))

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 WP 8 Objectives

Overall objectives:

Two-stroke:

- 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

Four-stroke:

- 80% PM reduction with after-treatment system (based on IMO Tier II 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 on a marine Diesel engine

Objectives for the first year of the Project:

Two-stroke:

- Test of emission control setup for NH_3 control
- Development of measurements equipment with traversing mechanism for NO_X and ammonia slip measurements
- Design and build testbed for study compact SCR processes; injection, mixing, urea decomposition.

Four-stroke:

- Preparation of the hot gas test rig for high pressure investigations including the measurement techniques
- Design of a synthetic gas test bed for filter testing
- Specification of the SCR on DPF system for marine Diesel engines

2 Preliminary results

Two-stroke:

A laser for NH_3 slip measurements has been tested and used on shop test for a high pressure SCR system on a two-stroke marine engine. Basic principles of MDT SCR control system has been further evaluated and optimized on shop test for a LP SCR system.

For the traversing measurement mechanism for high pressure SCR, the overall working principle has been chosen, see Figure 1. Drawings for the probe system have been made and the first prototype is in production.

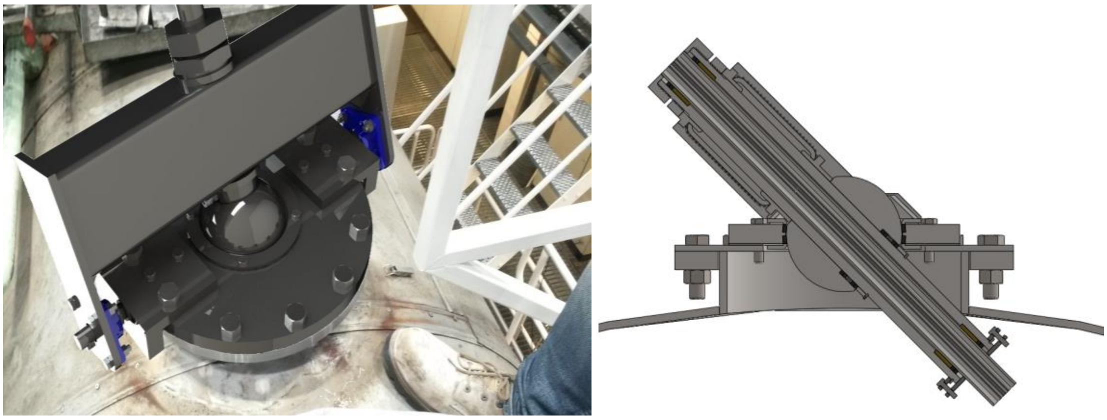


Figure 1: Mechanism for NO_x/ NH_3 measurements inside the SCR system

A first series of measurements are completed in a simple setup and demonstrate (as expected) challenging flow conditions in a SCR system. A new and more detailed setup is being built at the moment.

Design and procurement of a mini SCR test rig for 4T50ME-X Test Engine at the DRC in Copenhagen, including urea supply system, has been undertaken. The test rig has been designed and is under construction. The test rig can run on ammonia as well as urea as reducing agent and will be used for testing possibilities for SCR system downsizing. CFD calculations have been used for design evaluation, see Figure 2.

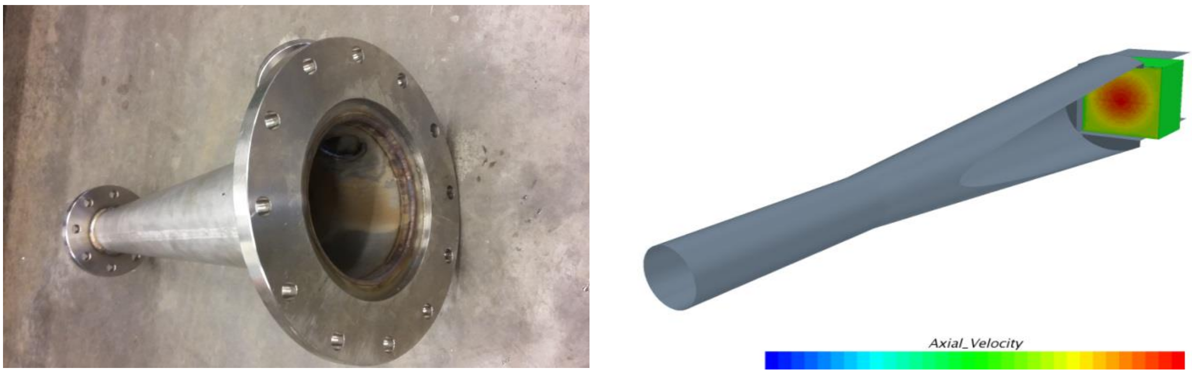


Figure 2: Left: Reactor casing and inlet for mini SCR ready for assembly. Right: axial velocity in mini-SCR inlet as calculated by CFD.

Four-stroke:

In order to prepare the hot gas test rig (see Figure 3) for investigations under pressure, the test stand was set up and its infrastructure was improved to match these requirements. This includes the measurement techniques which will be used to investigate both the spray processes and the urea decomposition.

During the 1st year of the project a synthetic gas test bed for filter testing was designed (see Figure 4). Furthermore, the high porous DPF substrates and the coating for the SCR on DPF system was specified.

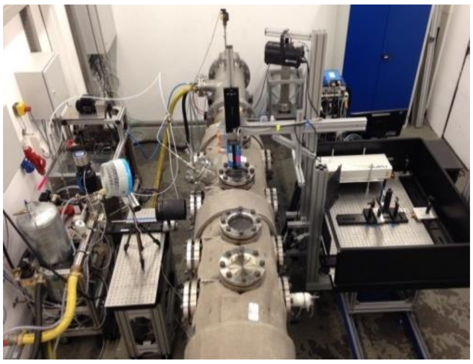


Figure 3: Hot gas test rig

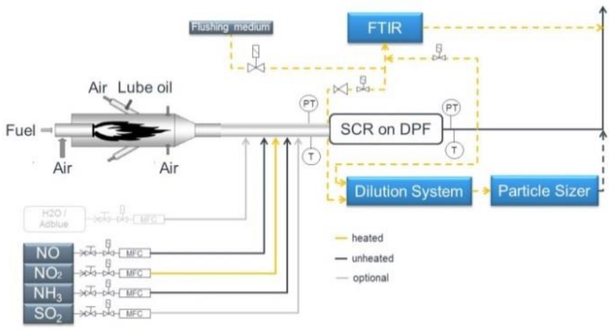


Figure 4: Synthetic gas test bed for filter testing

In order to investigation of the pressure influence, various measurements to determine the flow and spray properties for the injection of urea solution have been carried out. Figure 5 shows the averaged spray propagation in the near field of the nozzle, derived by planar laser imaging.

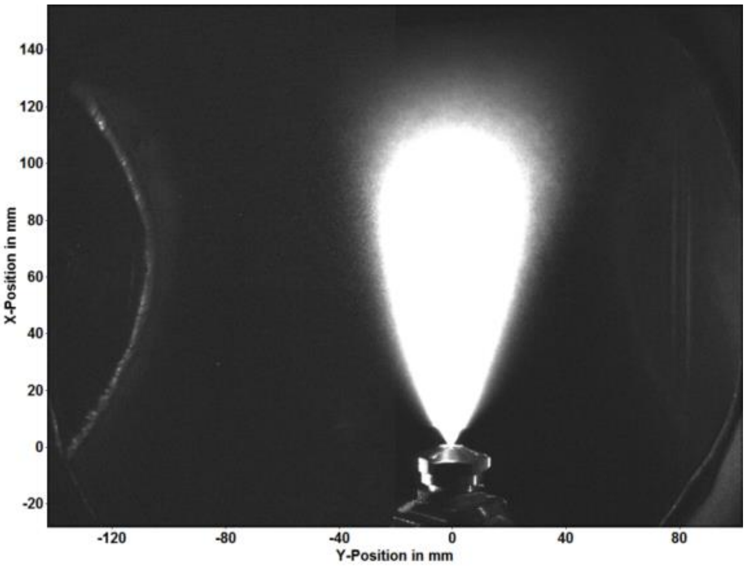


Figure 5: Exemplary spray configuration

Further, evaluation and procurement of additional particle measurement equipment, especially a particle size spectrometer, has been completed. During the evaluation process test measurements were realized on an engine test bench equipped with a flow-through DPF (see Figure 6).

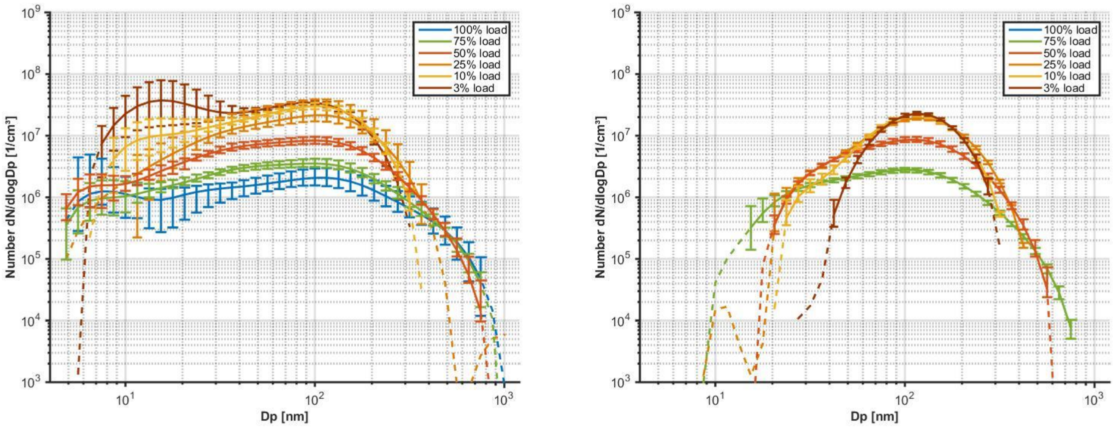


Figure 6: Particle number concentration engine out (left) and flow-through DPF out (right)

It is apparent that the flow-through DPF reduces especially the particles smaller than 100 nm significantly.

3 Next steps / future work

Two-stroke:

Within the 2nd year of the project, the traversing probe system will be assembled and tested at the 4T50ME-X Test Engine. For SCR flow investigation, a more detailed experimental setup will be build, with measurements and CFD validation running in parallel to this task. The mini-SCR high-pressure test rig will be used for testing different SCR reactor configuration and catalyst types. Further, a compact mixing and injection system will be designed, built and tested. Test of urea evaporation, including CFD validation, will be undertaken, along with the first part of detailed design of the engine integrated high pressure SCR for 4T50ME-X.

Four-stroke:

The validation measurements of urea decomposition under pressure will continue until July 2016. Apart from the actual spray measurements, the investigation of the chemical decomposition will be of particular interest for the next months. Another task of the 2nd year is the investigation of the impact of mixing elements on the process chain.

In the 2nd year of the project it is planned to carry out investigations of a DOC system on a marine distillate engine, which will be equipped with the SCR on DPF system for the verification tests during the 3rd year. Simultaneously the SCR on DPF samples will be tested in small scale in the laboratory.

HERCULES-2 Project

Fuel Flexible, Near Zero Emissions, Adaptive Performance Marine Engine

Deliverable: **D10.1**

Input for **WP9**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	29/4/2016
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 1st Year of the Project were:

- Arrange for partners to sign Grant Agreement and the Consortium Agreement
- Distribution of the EC pre-financing to the Project Consortium
- Preparation, execution and post-processing of major project meetings
- Preparation and Submission of Grant Agreement Amendment #1

2 Progress

During the 1st Year of the Project, the main activities within WP9 were:

- Establishment of intra-Project communications (partners groups, administrative and technical contacts, database with names, and coordinates of all persons related to the Project).
- Arrange for partners to sign electronically the Grant Agreement. Arrangements for partners to sign also the Consortium Agreement.

  Following the Grant Agreement (GA) signing by Coordinating partner NTUA (02/04/2015) and countersigning by the EC (17/04/2015), the NTUA arranged for all Partners to sign electronically the Grant Agreement, as well as the Project Consortium Agreement (CA).
- Handling of EC pre-financing, prepare distribution chart for pre-financing to partners, obtain approval from the Project Steering Committee (PSC) and distribution to all partners. Keep records and financial accounts of the distribution of the Community financial contribution.
- Preparation, execution and post-processing of the following major project meetings
  - Kick off Meeting, Zurich, 06/05/2015
  - Partners' Forum, No. 1 in Copenhagen, 22-23/10/2015

  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.
- Preparation and Submission of 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. This should be done through a Grant Agreement Amendment #1. According to the HERCULES-2 Consortium Agreement, the HERCULES-2 Project Steering Committee (PSC) unanimously approved (08/07/2015) the above requested change. 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 is still pending. The partner has not provided yet the bank account details to Coordinator NTUA.

- Implementing and maintaining of a project internal database for reporting and controlling, including the adaptation of the structure after changes in the Work plan and the Consortium.
- 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 2nd 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 periodic reports.
- Follow partners’ costs, collect and submit Financial Statements / Certificates on Financial Statements.
- Preparation and post-processing of EC review.
- 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: **D10.1**

Input for **WP10**

Revision Final

Nature of the Deliverable:	Report
Actual Submission Date:	29/4/2016
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
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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 1st 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.
- Preparation of guidelines for Deliverables submission to ensure standardized format and content layout of Deliverables.
- To prepare and include in the Member's area of the Project web-site the "Deliverable Submission Status" with standard layout, used for monitoring the progress in Deliverables and update of the time chart for submission.
- 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 1:
    - D1.1, "Flex fuel pre-study"
    - D2.1, "A method for measuring in-cylinder λ-distribution in medium-speed DF engines"
    - D3.1, "Report on boundary conditions, suitable materials and manufacturing routes"
    - D6.1, "Study the result quality of existing subspace-search methods on uncertain data"
    - D11.1, "Public section of Project Website complete and operational"
- Preparation, execution and post-processing of the following Project Technical Board meetings.
    - Kick off PTB Meeting, Zurich, 06/05/2015
    - PTB Meeting Copenhagen, 22/10/2015
- 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 2nd 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: **D10.1**

Input for **WP11**

Revision Final

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Dissemination Level:	Public

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

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

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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 main objective of WP11 for the 1st Year of the Project was to develop the Project Web-site to serve as the major publicity and dissemination gateway. A summary of all activities performed for WP11 is presented in the next chapter.

2 Progress

During the 1st Year of the Project, the main activities within WP11, categorized on a Sub-Project basis are presented below.

2.1. SUB-PROJECT 11.1 HERCULES-2 Website

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:

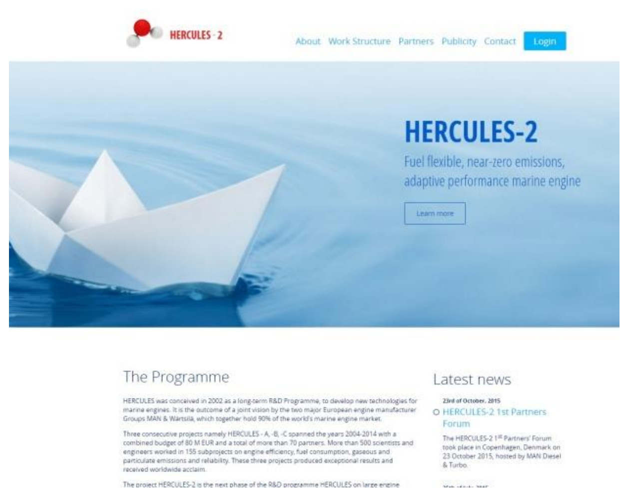
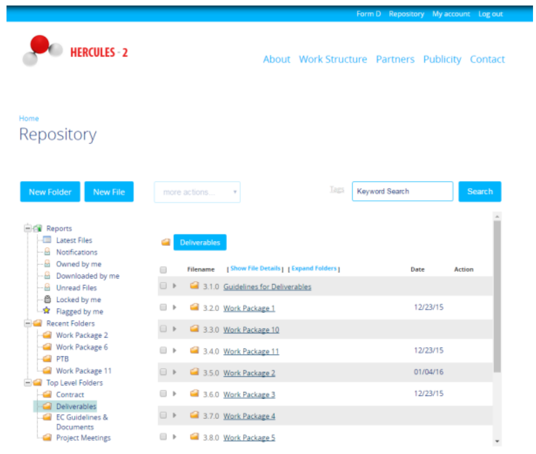
1. A section open to the public (www.hercules-2.com) with information about the structure, objectives, contents, Work Packages and Partners of the project. It is regularly updated with highlights of developments in all Work packages. It also contains all external publications and presentations of the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

   Besides the general Project information, by the end of the 1st Project year the "Publicity" page of the web-site contains: 20 References for HERCULES-2 in Press and Media, 3 Public Deliverables coming from the Project and videos from the 1st Partners' Forum of the Project in Copenhagen (23/10/2015). The web-site also contains Progress Highlights at October 2015 for all scientific Work Packages.

   The Deliverable D11.1 titled "Public section of Project Website complete and operational" was delivered on month 6 (1/11/2015), as planned in Annex I.

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.

Screenshots of the Public Section web-site home page as well as of the restricted member's area are presented below.

	
Public Section of H-2 website	Members' Area of H-2 website

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 1st Year of the Project, 1 paper has been approved for publication: Kyrtatos N.P., Stiesch G., Kallio I., "From HERCULES A-B-C to HERCULES-2: A classic cooperative programme in large engine R&D" to be presented at the CIMAC Congress, Helsinki, June 2016.

2.3. SUB-PROJECT 11.3 Dissemination

During the 1st Year of the Project, the first dissemination activity to mass media was an official Press Release was published by the major partners of the Project, namely Wärtsilä, Winterthur Gas & Diesel and MAN Diesel & Turbo, on 06/07/2015 titled "Wärtsilä, MAN Diesel & Turbo and Winterthur Gas & Diesel to collaborate on major, EU-funded project".

In line with the European Commission policy on dissemination, the project provided (23/03/2016) a document with the related details of the HERCULES-2 Project, such as the Project description and the Project website, oriented to a general public with some knowledge of the topic, to be used for the EC Project Fiches for the Horizon 2020 Transport Projects.

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 20 references and/or articles about the HERCULES-2 project in the scientific & technical Press and Media.

3 Preliminary results

N/A

4 Next steps / future work

During the 2nd 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 start to produce significant results.