HERCULES-B Logo 

HERCULES-B List of Participants

No.	Partner organisation name	Partner Short Name	Country
1	ULEME E.E.I.G.	ULEME	Germany
2	Aalborg Industries A/S	AALBORG	Denmark
5	Bohler Schmiedetechnik GmbH & Co KG	BSTG	Austria
7	Danish Technical University	DTU	Denmark
10	Delft University of Technology	TUDELFT	Netherlands
12	ECKA Granulate GmbH & Co. KG	ECKA	Germany
13	EMPA, Swiss Federal Laboratories	EMPA	Switzerland
14	ETH Zurich	ETHZ	Switzerland
16	IAV GmbH Ingenieurgesellschaft Auto und Verkehr	IAV	Germany
17	MAN Diesel & Turbo SE - CPH	MDT-CPH	Denmark
18	MAN DIESEL SAS	MD-FR	France
21	Miba Gleitlager GmbH	MIBA	Austria
22	National Technical University of Athens / LME	NTUA-LME	Greece
23	Paul Scherrer Institut	PSI	Switzerland
24	PBS Turbo s.r.o. Velka Bites	PBST	Czech Rep.
25	Praxair Surface Technologies GmbH	PST	Germany
27	Sandvik Powdermet AB	SANDVIK	Sweden
29	Tampere University of Technology	TUT	Finland
30	Technical University of Munich	TUM	Germany
31	Karlsruhe Institute of Technology / IfKM	UNIKARL	Germany
33	University of Siegen	UNISIEGEN	Germany
34	Vansco Electronics Oy	VANSCO	Finland
35	VTT Technical Research Centre Of Finland	VTT	Finland
36	Wartsila Finland OY	WFI	Finland
37	Wartsila Schweiz AG	WCH	Switzerland
39	Federal Mogul Friedberg GmbH	FMO	Germany
41	ABB Turbo Systems AG	ABB	Switzerland
42	Itä-Suomen Yliopisto	UEF	Finland
43	Aalto-Korkeakoulusaatio	AALTO	Finland
44	MAN Diesel & Turbo SE	MDT	Germany
45	Wartsila Netherlands BV	WNL	Netherlands
46	Componenta Finland Oy	COMPONENTA	Finland

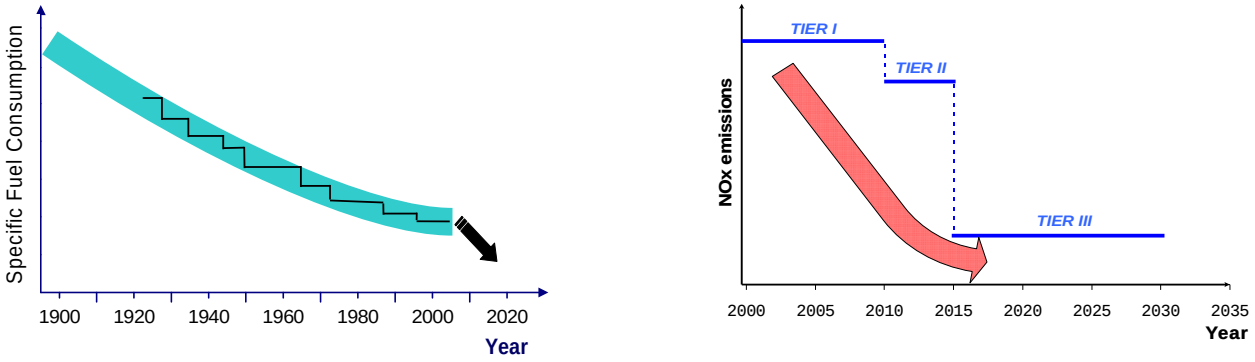

Figure Ia. Hercules-B targets in fuel consumption and emissions

H-B	Workpackage Title	Representative Objectives (within the H-B Project)	Status 12/2011
WP 1	**Extreme parameter engines**	▪2-S engine, PMAX: 220 bar, Mean piston speed: 10 m/s ▪4-S engine, PMAX: 300 bar, Mean piston speed: 12 m/s	**200 bar, 9 m/s on test** **Achieved (300 bar and 12m/s)**
WP 2	**Combustion**	▪Transparent cylinder cover with optical access; 2-stroke, 500 mm bore engine, 4-stroke, 320 mm bore engine, firing conditions, 200 bar, 2000º C ▪Measured injection and combustion full-scale spatial data, for CFD engine simulation validation	**Manufactured** **Achieved**
WP 3	**Turbocharging**	Multistage turbocharging, with 8 bar charging pressure on test engine	**Achieved**
WP 5	**Emission reduction methods**	▪EGR / CGR / Scrubbing for NOx reduction > 50%, wrt IMO Tier I on test. ▪Engine application for SCR with fuel of high sulphur content	**Achieved** **Achieved**
WP 6	**Overall powertrain optimization**	High pressure boiler compounding system, to achieve overall powerplant efficiency 60% on test.	**On test**
WP 7	**Advanced materials, friction and wear**	Reduction 25% in piston ring friction and guide shoe friction	**Achieved**
WP 8	**Electronics and control**	Installation on test engine of intelligent management system with self learning and fault tolerant capabilities.	**On test**

Figure Ib. H-B project targets and achievements with respect to Annex I

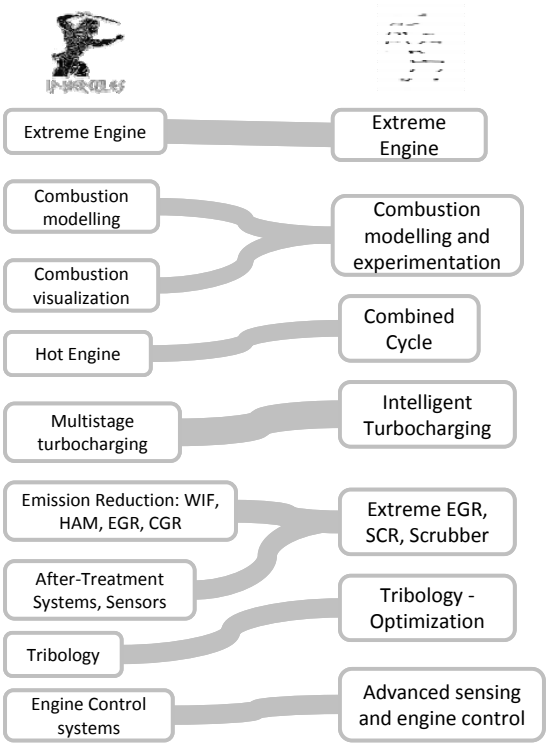

Figure II. Research areas, from Hercules-A to Hercules-B project

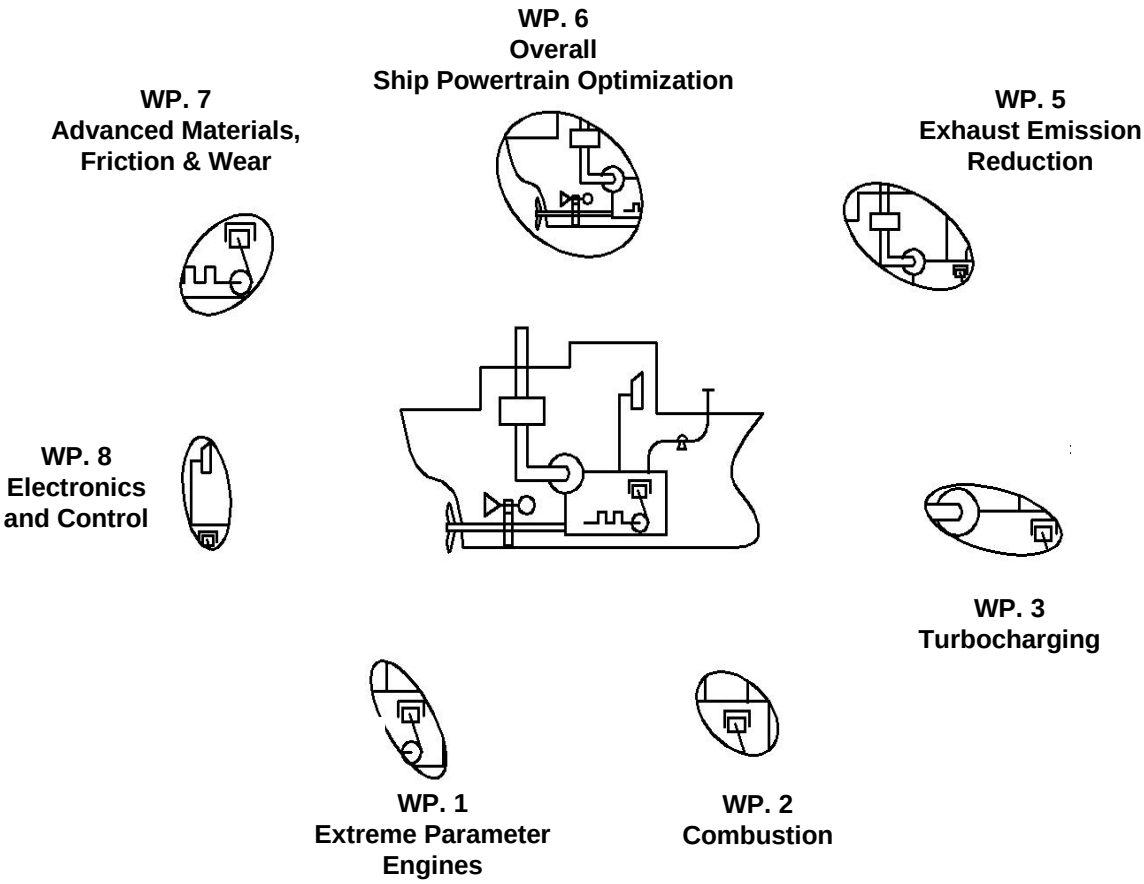

Figure IIIa. Overview of Hercules-B structure of work

No	WP TITLE	TASK TITLE	PARTNERS
1	Extreme Parameter Engines	**Task 1.1: Development of engines for extreme load conditions**	COMPONENTA, TKK, WFI
		Task 1.2: Mechanical design of engines with extreme parameters	BSTG, ECKA, IAV, MD-DK, MD-FR, MD-DE, MIBA, PST, SANDVIK
2	Combustion	**Task 2.1: Combustion process modeling and development**	ETHZ, PSI, WFI, WCH
		Task 2.2: Experimental and numerical combustion analysis	MD-DK, MD-DE, NTUA-LME, DTU, UNIKARL
3	Turbocharging	**Task 3.1: High efficiency and low emission TC concepts**	ABB, ETHZ, PSI, TUT, WFI, WCH
		Task 3.2: Advanced intelligent turbocharger	MD-DE, PBST
5	Exhaust Emission Reduction	**Task 5.1: Emission reduction methods**	EMPA, UKU, VTT, WFI, WCH
		Task 5.2: Emission reduction - Exhaust Gas Recirculation and After-treatment	AALBORG, MD-DK, MD-DE, TUM-LVK
6	Overall power train optimization	**Task 6.1: Overall ship power train optimization**	TUDELFT, NTUA-LME, WPNL
		Task 6.2: Combined cycle with boiler for high pressure side	AALBORG, MD-DK
7	Advanced Materials, Friction and Wear	**Task 7.2: Tribology-Optimization**	DTU, MD-DK, WCH, FMO
8	Electronics and Control	**Task 8.1: Advanced sensing and reliable adaptive control**	TUT, VANSCO, WFI, WCH
		Task 8.2: Intelligent Engine	MD-DE, NTUA-LME, UNISIEGEN
9	Project Management		ULEME E.E.I.G.

Figure IIIb. Overview of Workpackages and corresponding Tasks

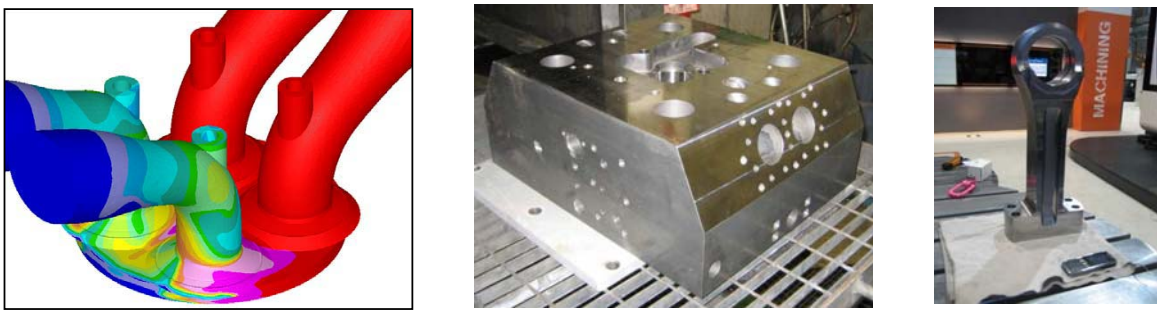

Figure 1.1a. Simulation tools, machined components and finalised components

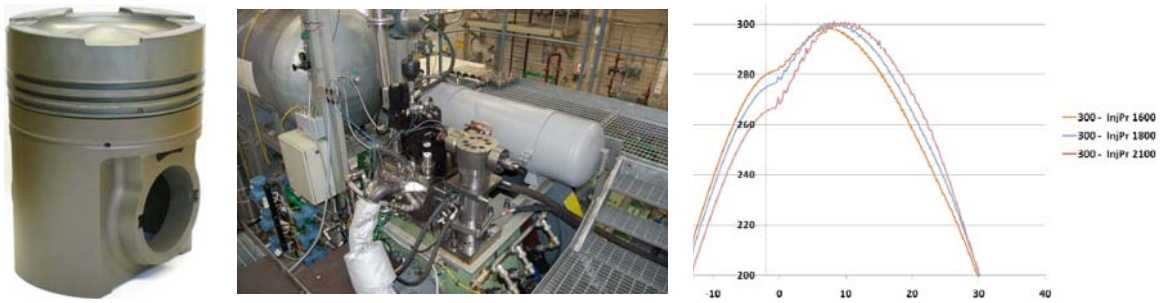

Figure 1.1b. The EVE engine and the 300bar in-cylinder pressure trace

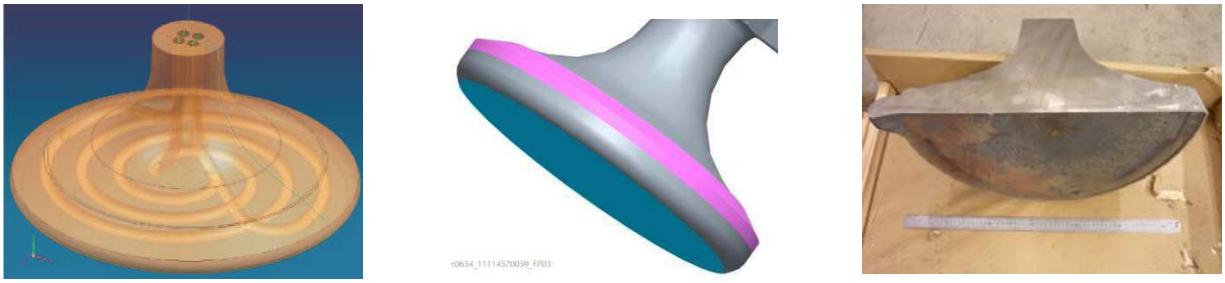

Figure 1.2a. Design concept of cooled valve, and blank component of spindle disc

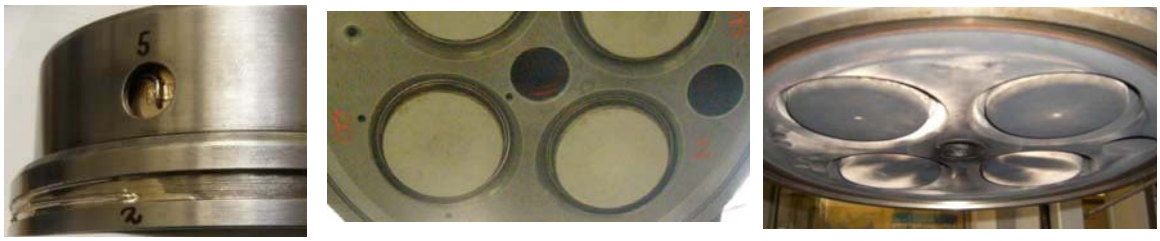

Figure 1.2b. Components equipped with instrumentation for performance monitoring

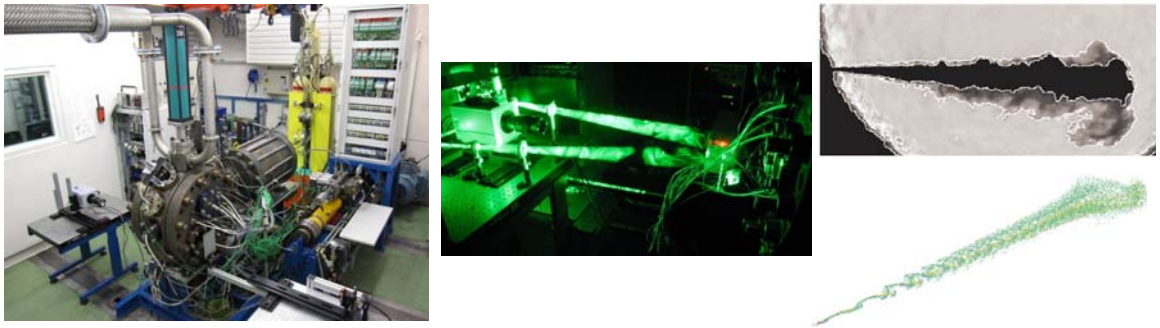

Figure 2.1a. The SCC chamber and a comparison of a spray propagation image (taken in the SCC) and simulated spray results

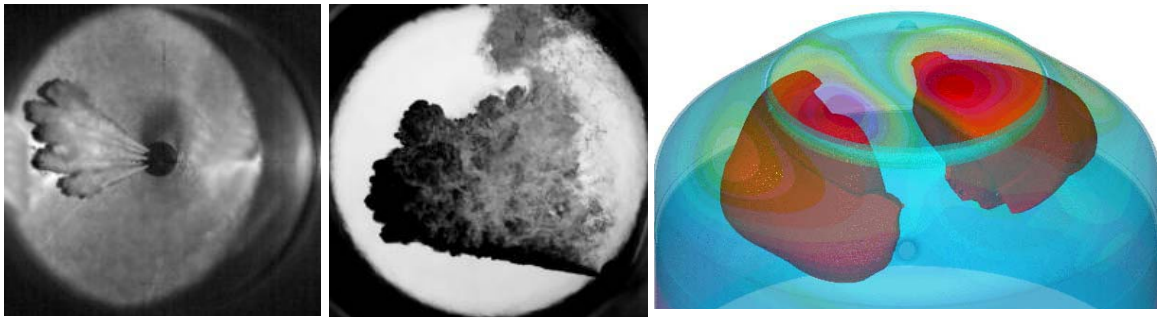

Figure 2.1b. Mie scattering and HFO combustion, along with simulations of combustion and wall heat transfer

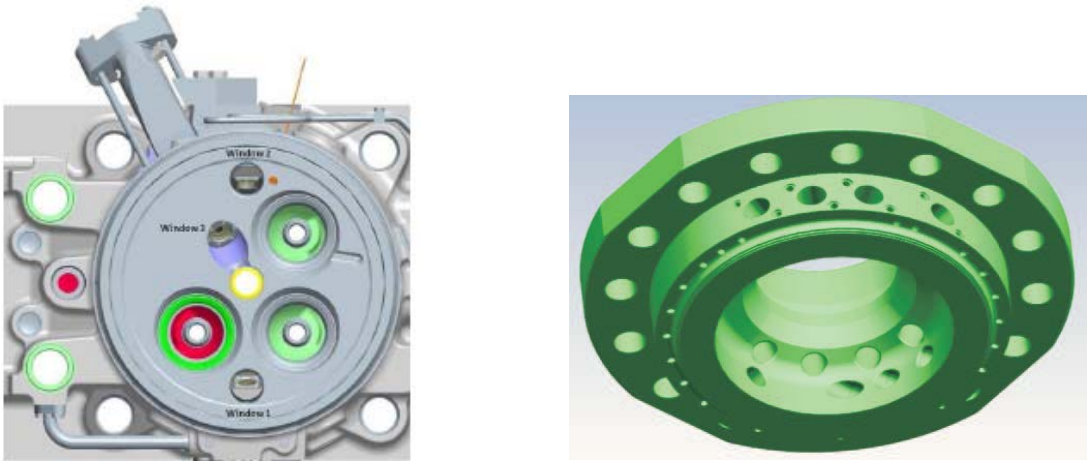

Figure 2.2a. Designs of the single optical access port (for 4s) and optical cylinder cover (for 2s)

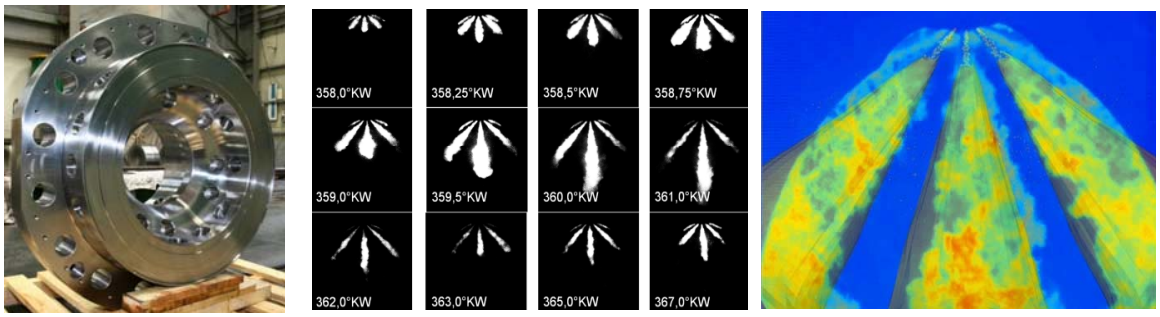

Figure 2.2b. The optically accessible cylinder cover for the 2-stroke engine, and sample spray penetration measurements along with flame propagation results

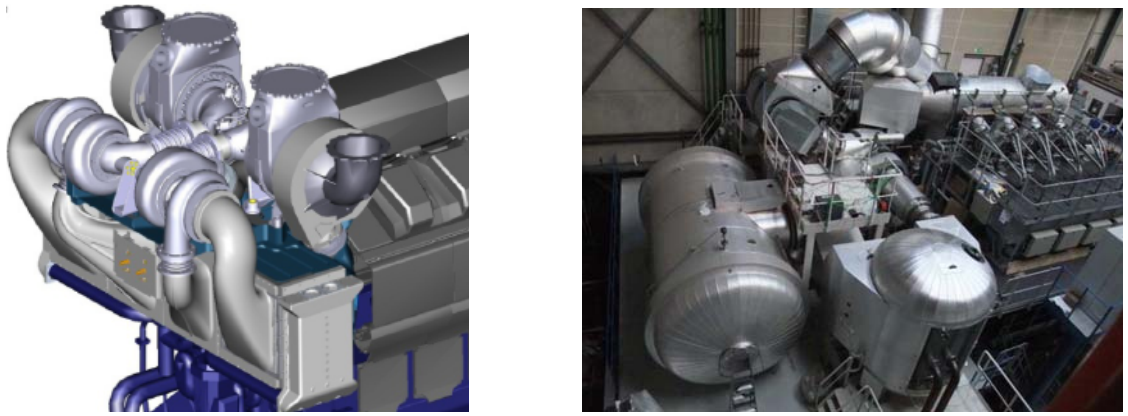

Figure 3.1a. Installation of 2-stage turbocharging system on the 4-stroke (left) and 2-stroke (right)

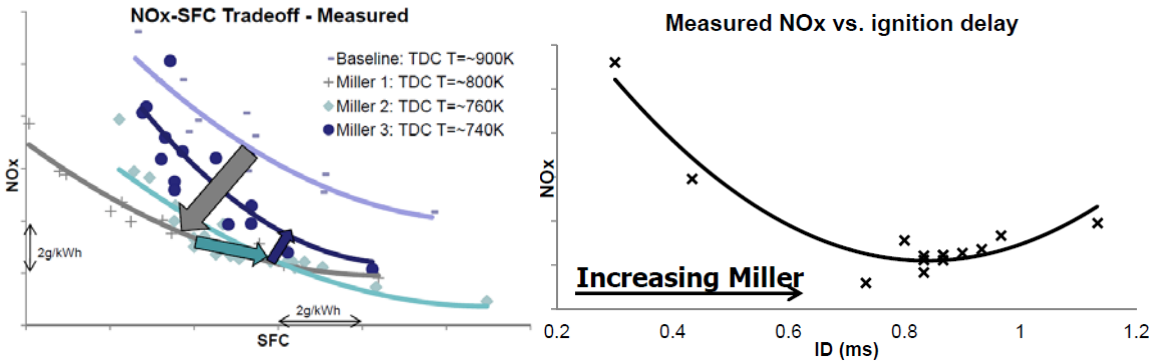

Figure 3.1b. Measured NOx vs SFC trade-off (left) and NOx vs Ignition delay (right)

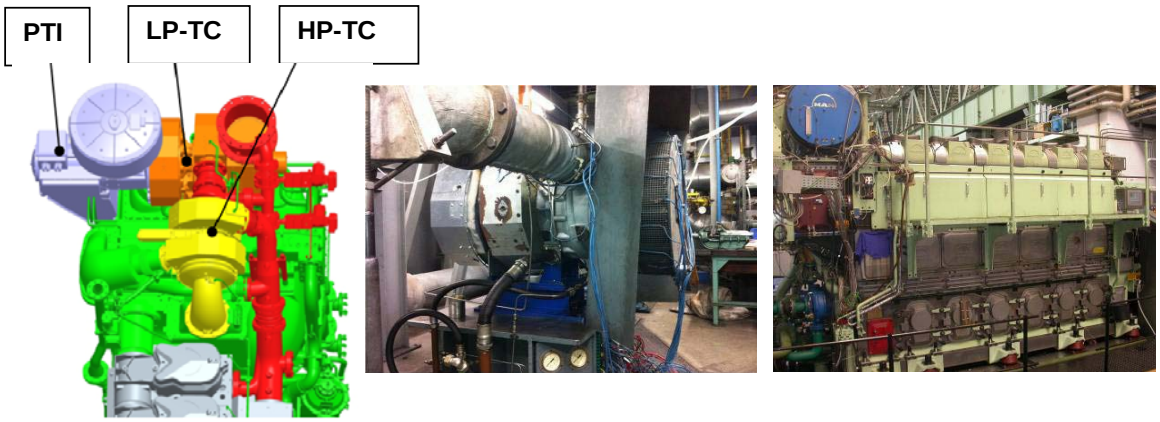

Figure 3.2a. The 6L32/44 CR T2 engine with 1- & 2-stage TC+VTA+PTI

Figure 3.2b. The 2-stroke engine 4S50ME-C9 with PTI/ PTO (left) and 4T50ME-X 2-stroke engine with 2-stage turbocharging (right)

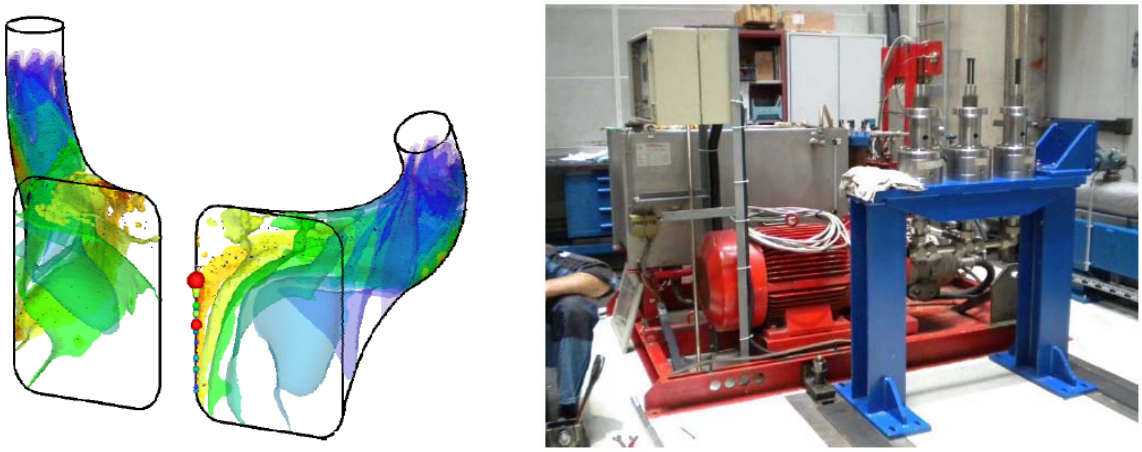

Figure 5.1a. Simulation for the charge air humidification and the DWI test rig

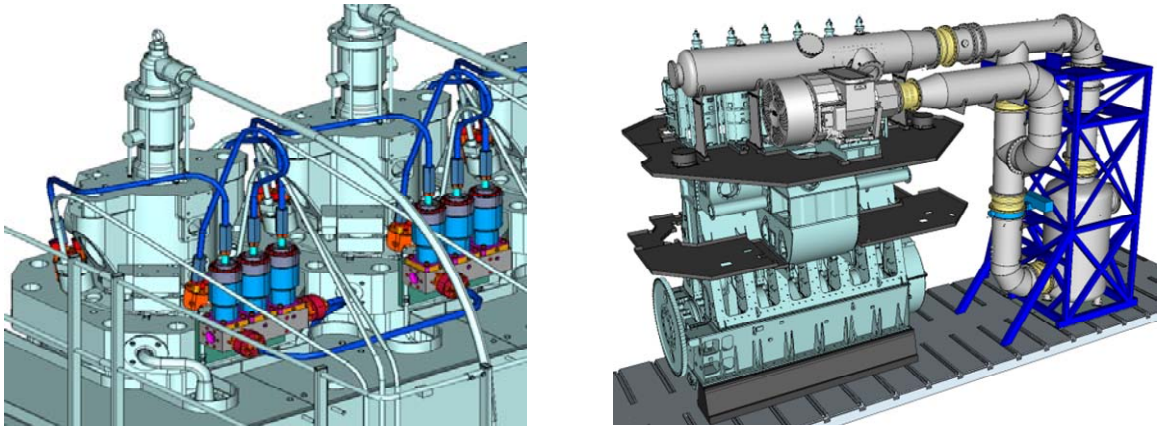

Figure 5.1b. NOx reduction technologies: CAD model of the DWI system on the RTX-4 test engine (left) and SCR system on the RTX-5 test engine (right)

Figure 5.2a. The EGR installed on-board Alexander Maersk (left) and the High Pressure Boiler installed on the 4T50ME-X 2-stroke test-bed engine (right)

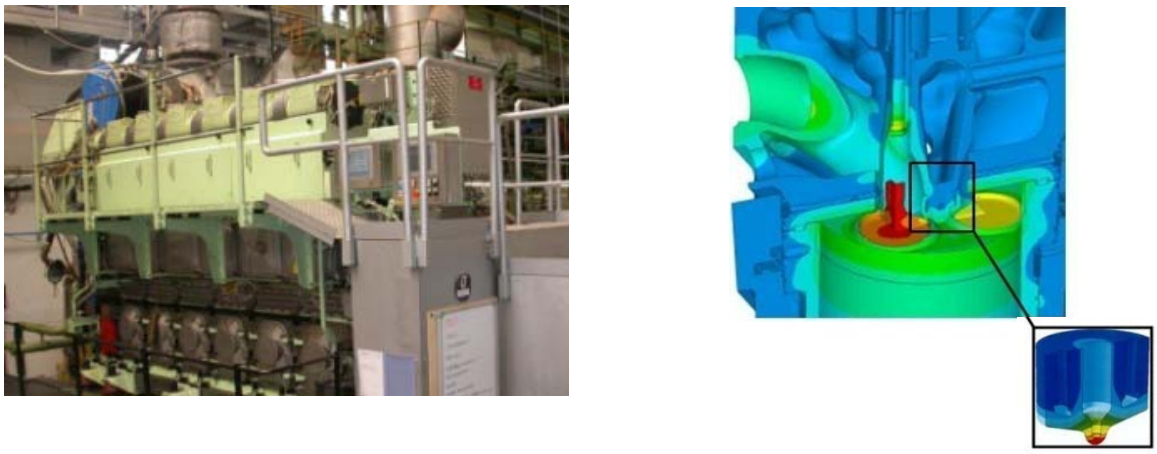

Figure 5.2b. The 4-stroke test engine with the SCR unit (left) and the temperature study on that SCR engine (right)

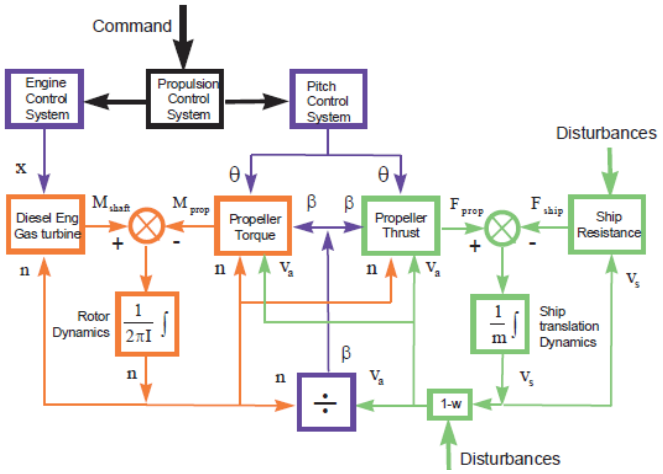

Figure 6.1a. General block diagram of ship propulsion dynamics

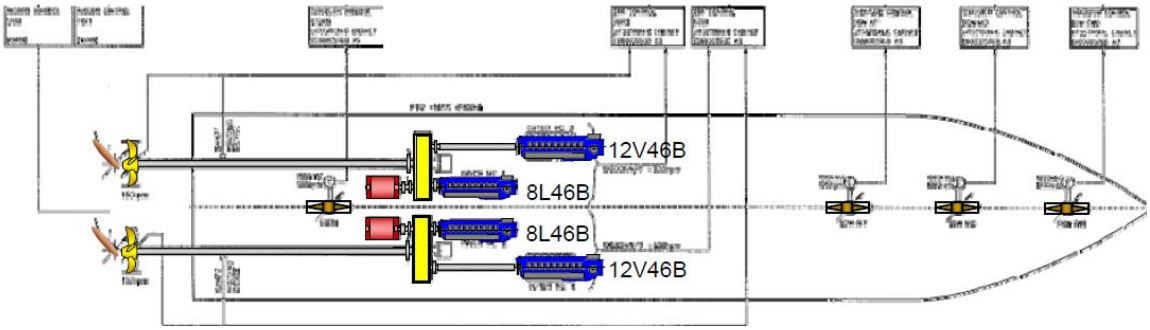

Figure 6.1b. Ferry reference model - Twin-shaft configuration Father-son engine set-up

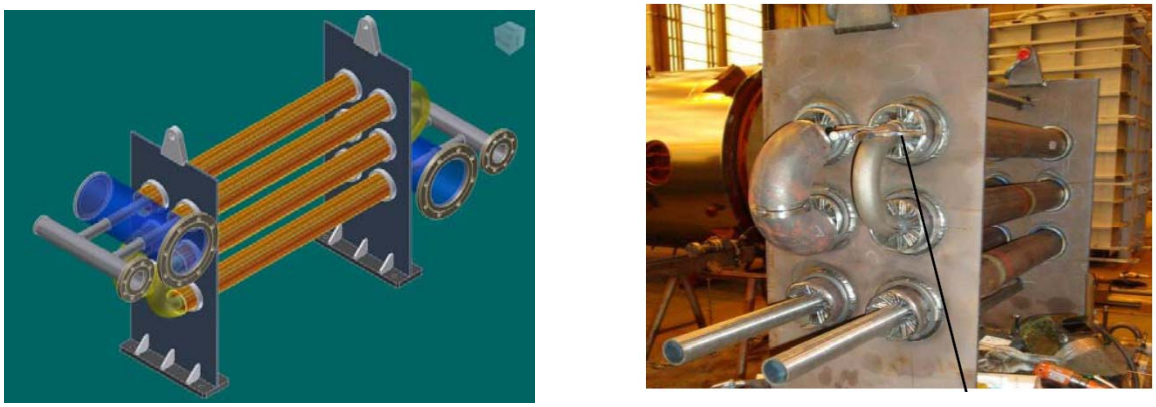

Figure 6.2a. The HP Super Heater CAD model and component

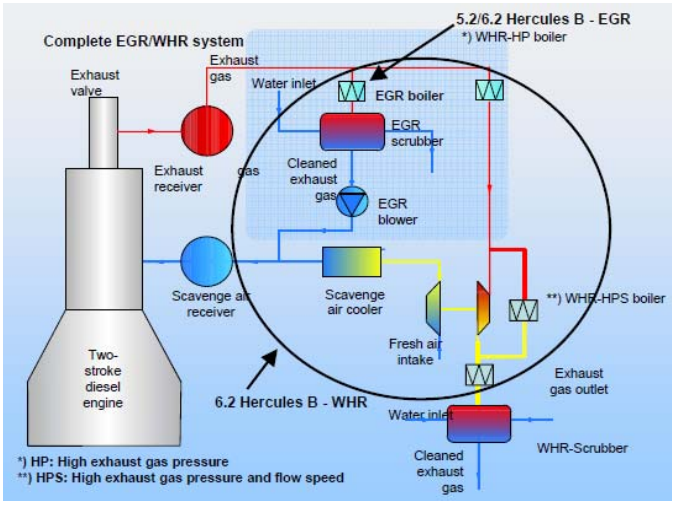

Figure 6.2b WHR HP boiler system schematic and calculation model

Figure 7.2a (i) The Reciprocating Test Rig (left) and the L16/24 test rig with a new liner mounted (right)

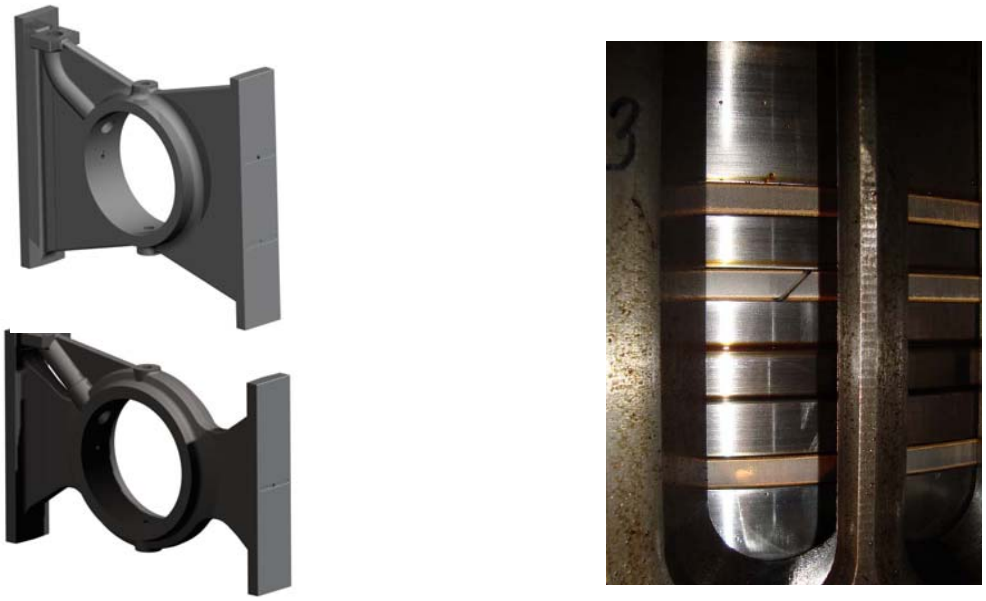

Figure 7.2a (ii) The old guide shoe (top) and the updated low friction version (bottom), and the new three piston ring pack installed on piston (right)

Figure 7.2b(i) The CAD model of the rig and the actual lube oil distribution test rig

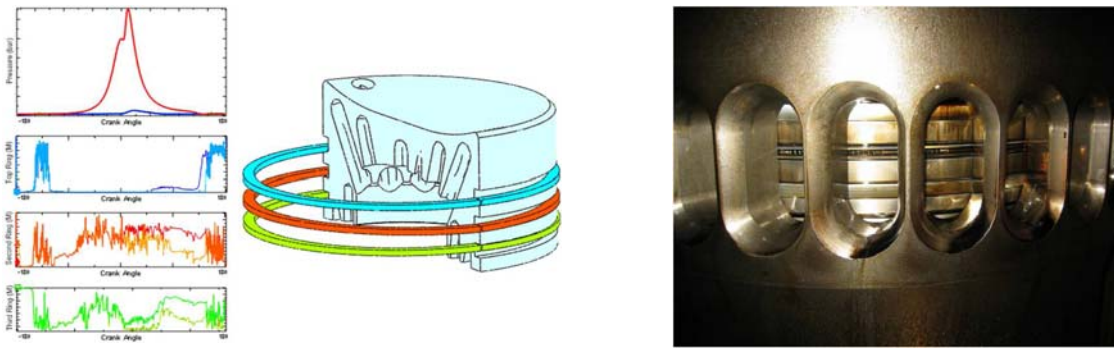

Figure 7.2b(ii) Typical results of the piston ring pack simulation tool (left) and the piston ring pack in service (right)

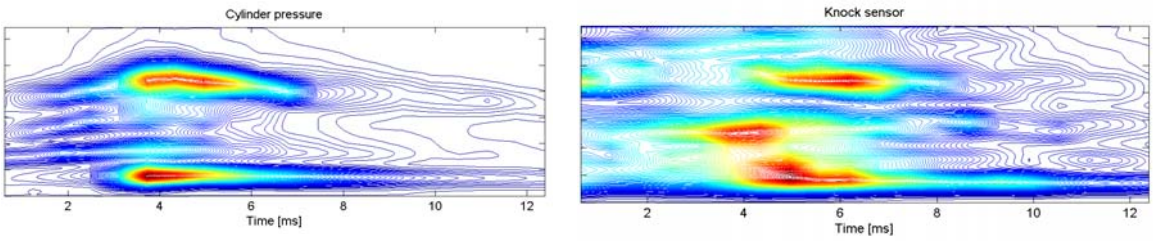

Figure 8.1a The spectrogram of the cylinder pressure signal in case of knock (left) and the spectrogram of the knock sensor signal in case of knock (right)

Figure 8.1b. The Common Rail (CR) test rig for 2-stroke engine application

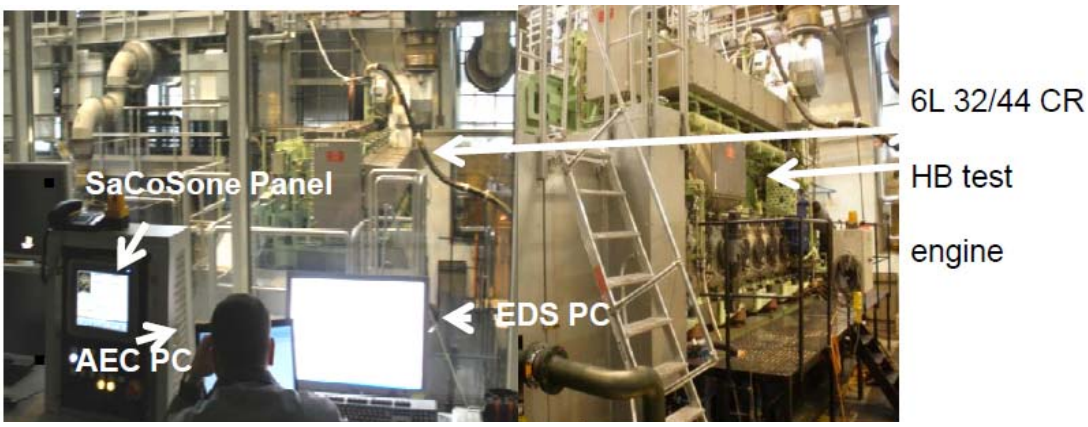

Figure 8.2a. Engine tests on the 4-stroke medium speed diesel engine

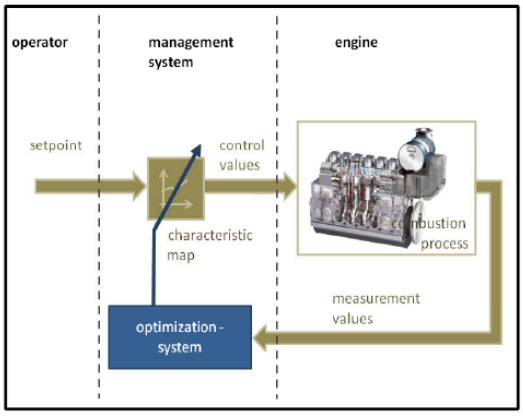

Figure 8.2b. Schematic of the engine control optimisation system

Table 1

HERCULES VISION	***Year 2020***
Reduction of fuel consumption and CO_2 emissions	*-10%*
Reduction of NOx (Relative to IMO 2000 standard)	*-70%*
Reduction of other emission components (PM, HC)	*-50%*

Table 2

POTENTIAL EXPLOITATION ITEMS (TIMESPAN: SHORT=S, MEDIUM=M, LONG=L)		
WORKPACKAGE	**ITEM**	**TIME**
WP1 Extreme parameter engine	Engine components for extreme value operation (pistons, rings, bearings).	M
	Extreme parameter marine engine	L
WP2 Combustion	Combustion models	S
	Chemical kinetics and pollutant formation models	S
	Fuel injection patterns and arrangements	M
WP3 Turbocharging	Variable geometry turbocharger	S
	Power take-in, take-out systems (Integration motor/generator/turbocharger)	S
	Multistage intelligent turbocharger	M
WP5 Exhaust Emission Reduction	SOx full exhaust gas scrubber	M
	EGR / CGR Components	M
WP6 Overall powertrain optimisation	Close coupled exhaust gas boiler and compounding system,	M
	Ship power train optimisation tool	S
WP7 Advanced Materials, Friction and Wear	Low friction engine components (cylinder guide shoe, piston rings)	M
	Low friction marine engine	L
WP8 Electronics and Control	Optimisation algorithms for marine engine control	S
	Intelligent, adaptive marine engine management system	M

Notations

BOR – Block-On-Ring
CAD – Computer Aided Design
CGR – Combustion Gas Recirculation
CFD – Computational Fluid Dynamics
CR – Common Rail
DoE- Design of Experiments
DF – Dual Fuel
DWI – Direct Water Injection
EGR – Exhaust Gas Recirculation
EVE – Extreme Value Engine
FEM – Finite Element Method
HFO – Heavy Fuel Oil
HP- High pressure
I.P Hercules – Integrated Project Hercules
IMO – International Maritime Organisation
IMEP – Indicated Mean Effective Pressure
LP – Low pressure
LIF – Laser Induced Fluorescence
LTC – Low Temperature Combustion
NOx – Nitric Oxides
PDA – Phase Doppler Anemometer
PIV – Particle Image Velocimetry
PM –Particulate Matter
PTI – Power Take In
PTO- Power Take out
RTR – Reciprocating Test Rig
SCC – Spray Combustion Chamber
SCR – Selective Catalytic Reduction
SFOC- Specific Fuel Oil Consumption
SOx – Sulphur Oxides
TC- Turbocharger
VGT – Variable Geometry Turbine
VIGV – Variable Inlet Guide Vanes
VTA – Variable Turbine Area
VVT – Variable Valve Timing
WHR – Waste Heat Recovery
WP- WorkPackage