General R&D activities

Rien Hoogerbrugge

Licensees' Conference 2015
Interact. Inspire. Innovate.
INTERLAKEN
6–9 SEPT 2015

RTX4 to RTX6 Conversion

Core R&D activities are centred in Winterthur

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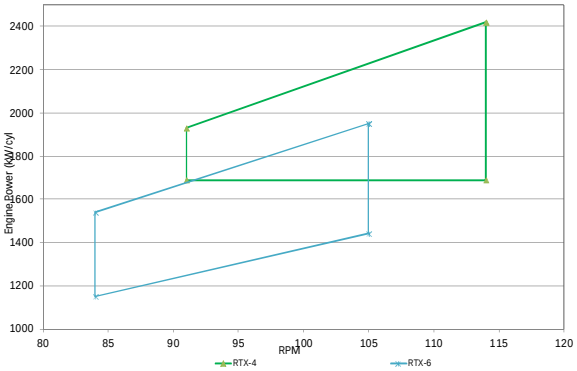
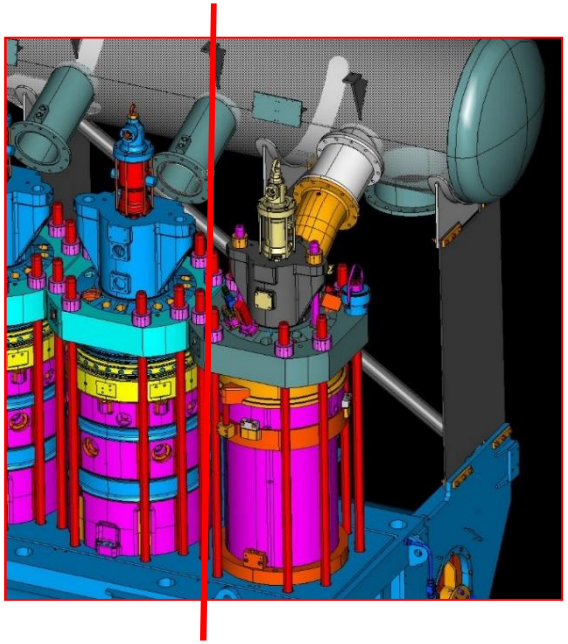
RTX4 to RTX6 Conversion

	RTX-4	RTX-6
Cylinder bore	600 mm	500 mm
Piston stroke	2250 mm	2250 mm
Speed	91-114	84-105
Stroke / bore	3.75	4.5
Max. firing pressure	180	230 bar
Compression ratio	17	23
Mean eff. Pressure at R1	20.0	25
Mean eff. Pressure at R2	14.0	18.6
Mean eff. Pressure at R3	20.0	25
Mean eff. Pressure at R4	17.5	18.6

- *Reduced bore size to allow higher maximum firing pressure without excessive bearing loads*
- *Higher stroke to bore ratio*
- *New liner cooling concept*
- *Various injector arrangements can be tested*



Old design RTX-4 → *New design RTX-6*



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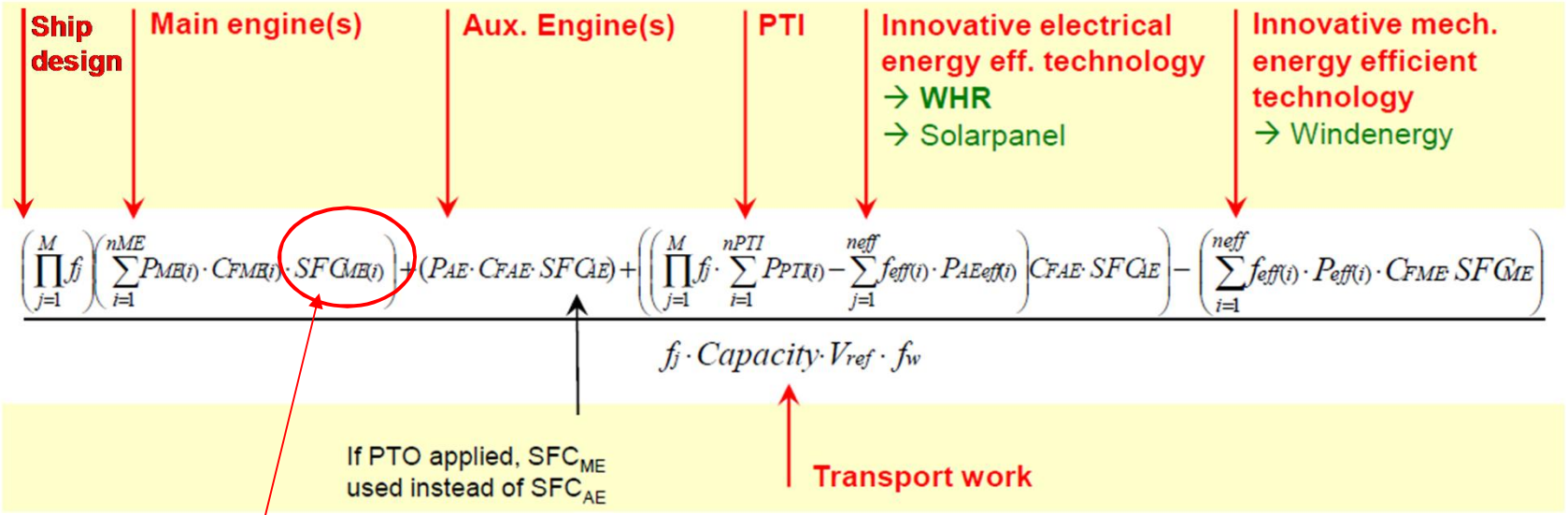
Fuel Consumption Driving CO_2 Emissions

Energy Efficiency Design Index (EEDI)



A lower main engine fuel consumption is reflected in a lower EEDI which provides operational cost benefits.

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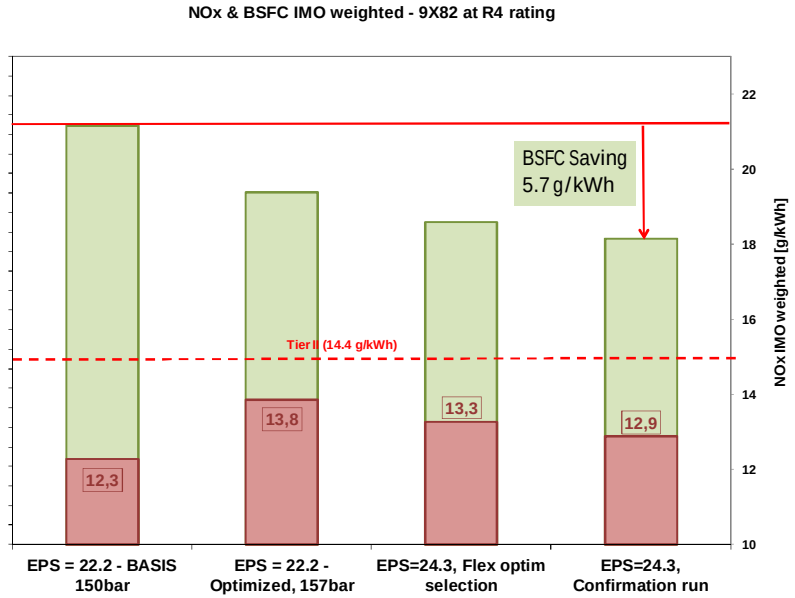
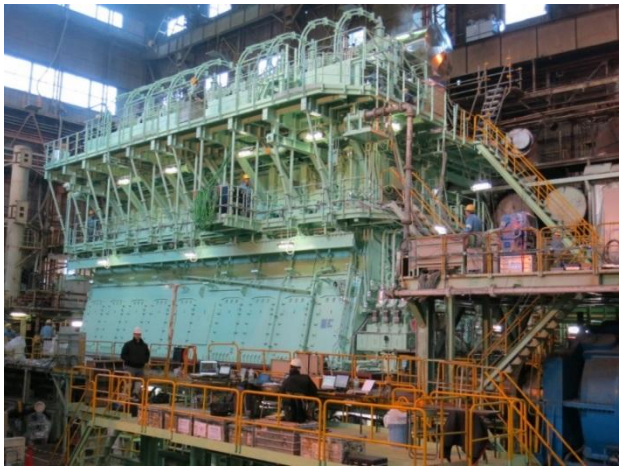
BSFC Reduction 9X82 / 5X72 and Other X-generation Engines

New combustion pack

- *High firing pressure*
- *High compression ratio*
- *Larger nozzle execution*
- *Flex optimisation*





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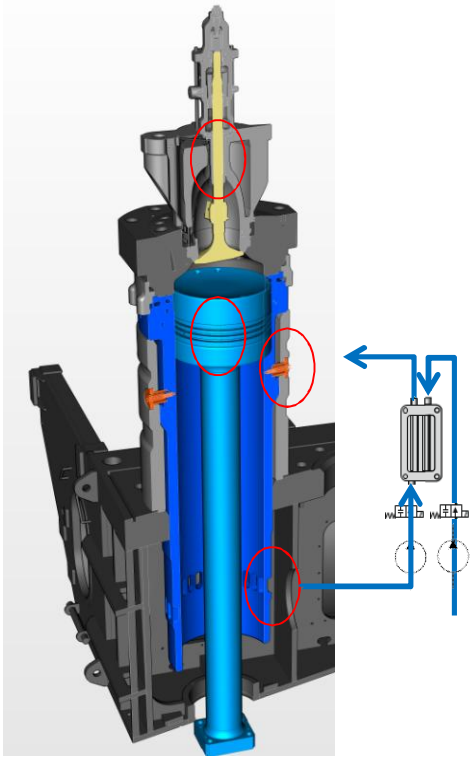
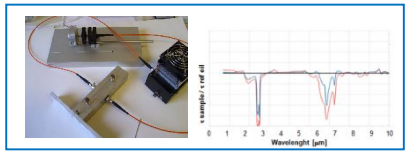
In-cylinder Tribology Research

Research activities

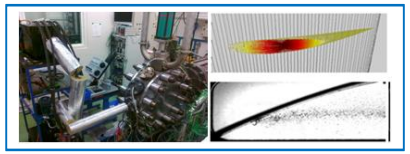
– *Work on updated/new cylinder lubrication & tribology concepts*



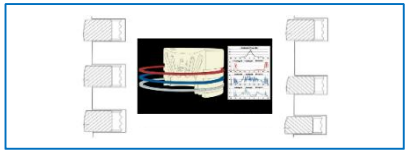
Lube Oil Property Monitoring



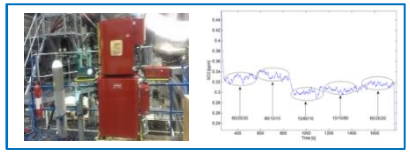
Lubrication System Tuning



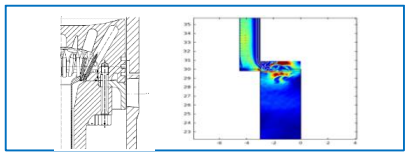
Piston Ring Pack Design



Full Scale Engine Test



Lube Oil Re- Circulation



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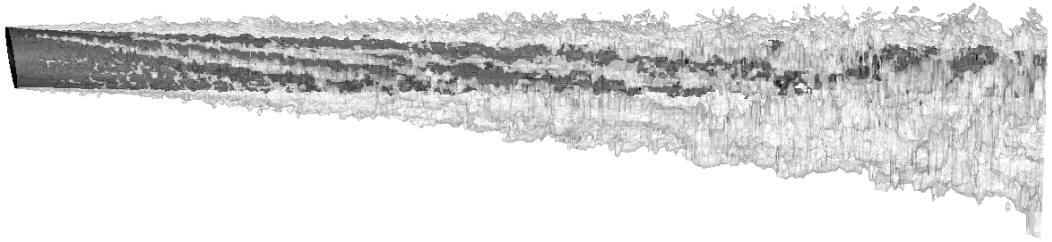
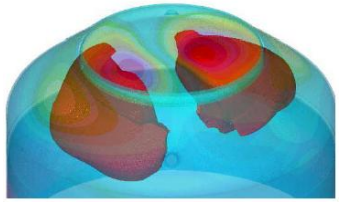
Tool and Model Development

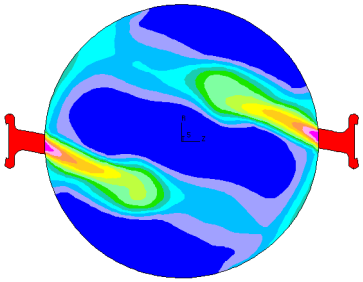
CFD model development

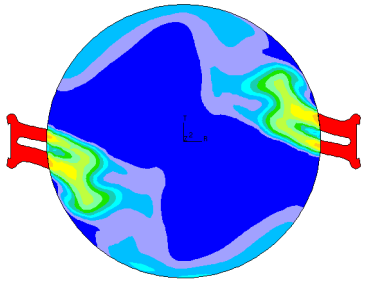
– *Advanced spray modelling for 2-stroke marine diesel engines to enable a reliable layout of the combustion systems*

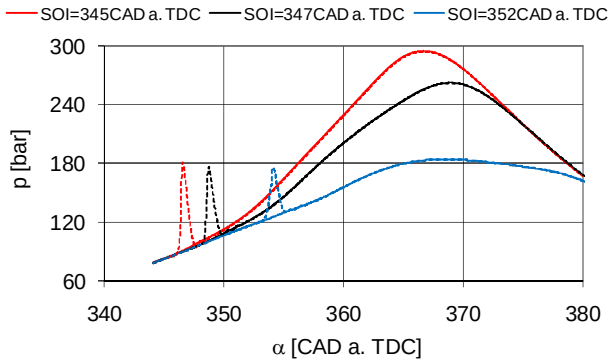


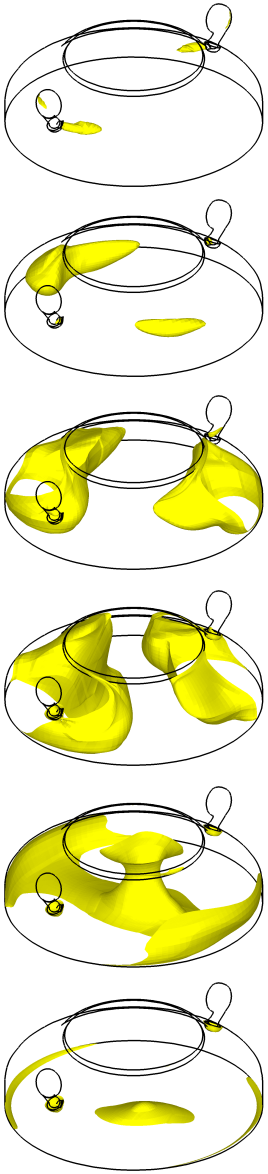


– *Under-expanded gas jets & DF combustion and ignition model*









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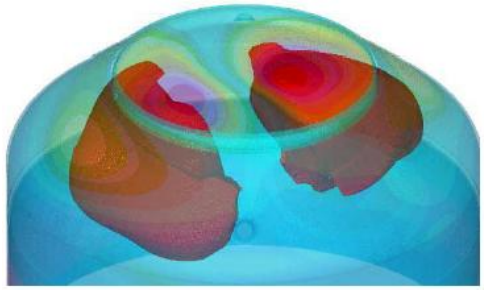
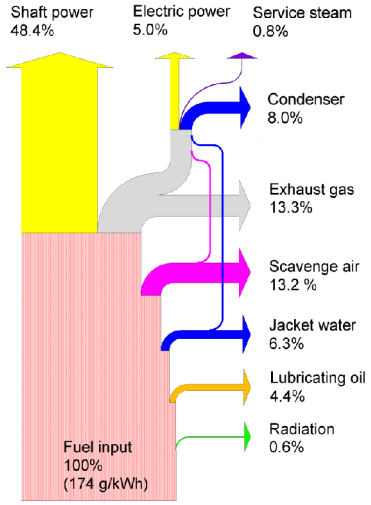
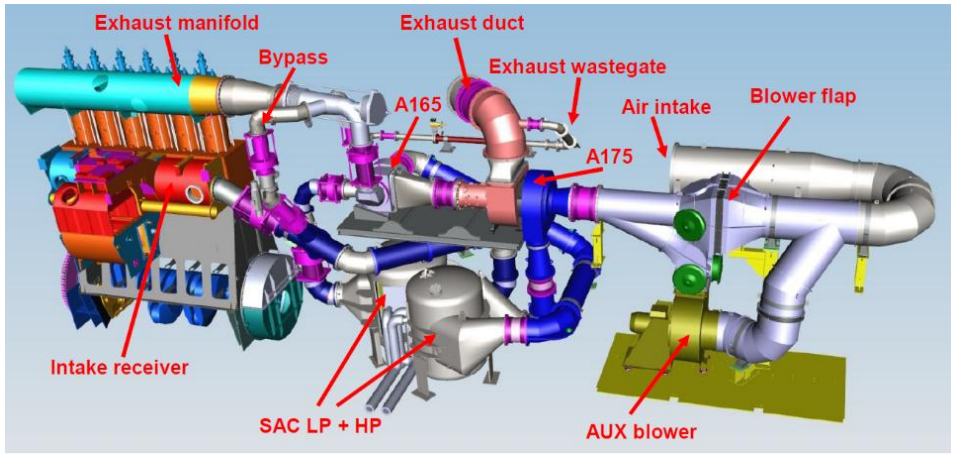
Fuel Consumption Reduction

Efficiency improvement potential

- *Combustion system layout*
- *Waste heat recovery systems*
- *Turbocharger cut-out*
- *2-stage turbocharging*







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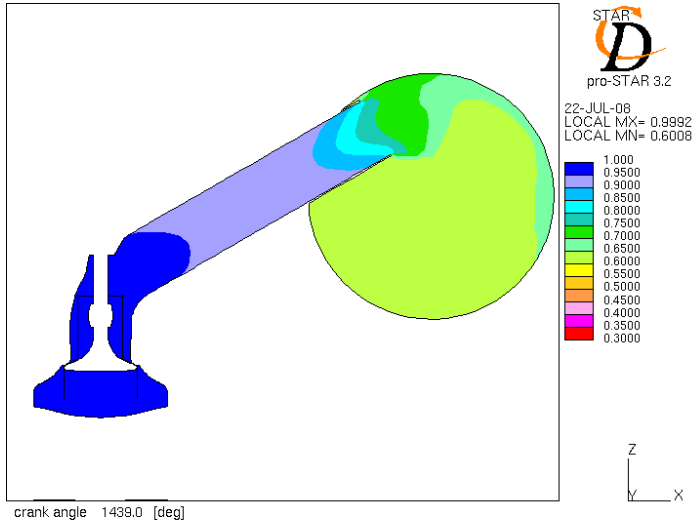
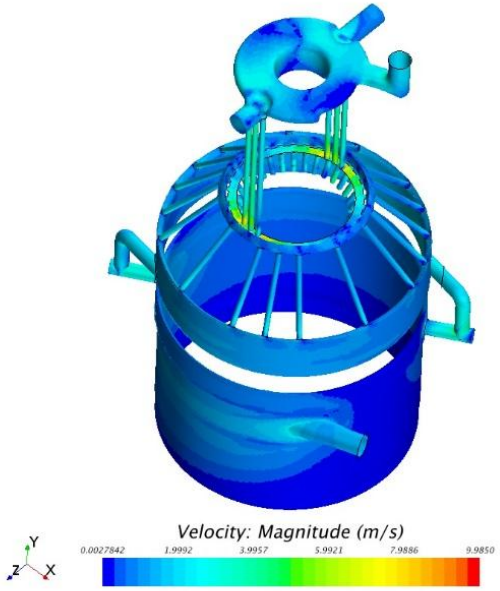
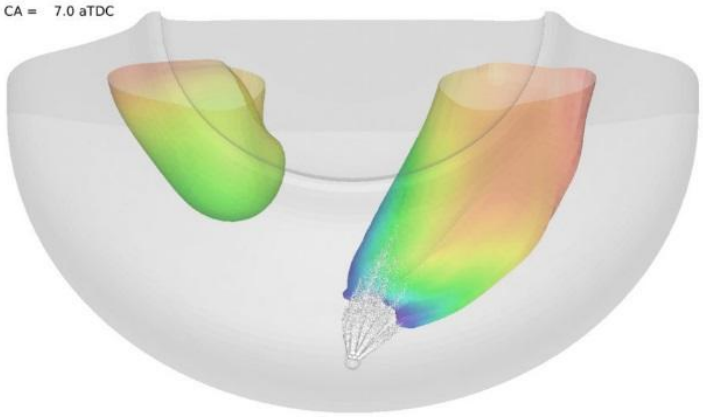
Advanced Tool Utilisation

Application of CFD

- *Flow optimisation*
- *Combustion system layout (diesel & gas)*
- *Cooling & heat transfer*







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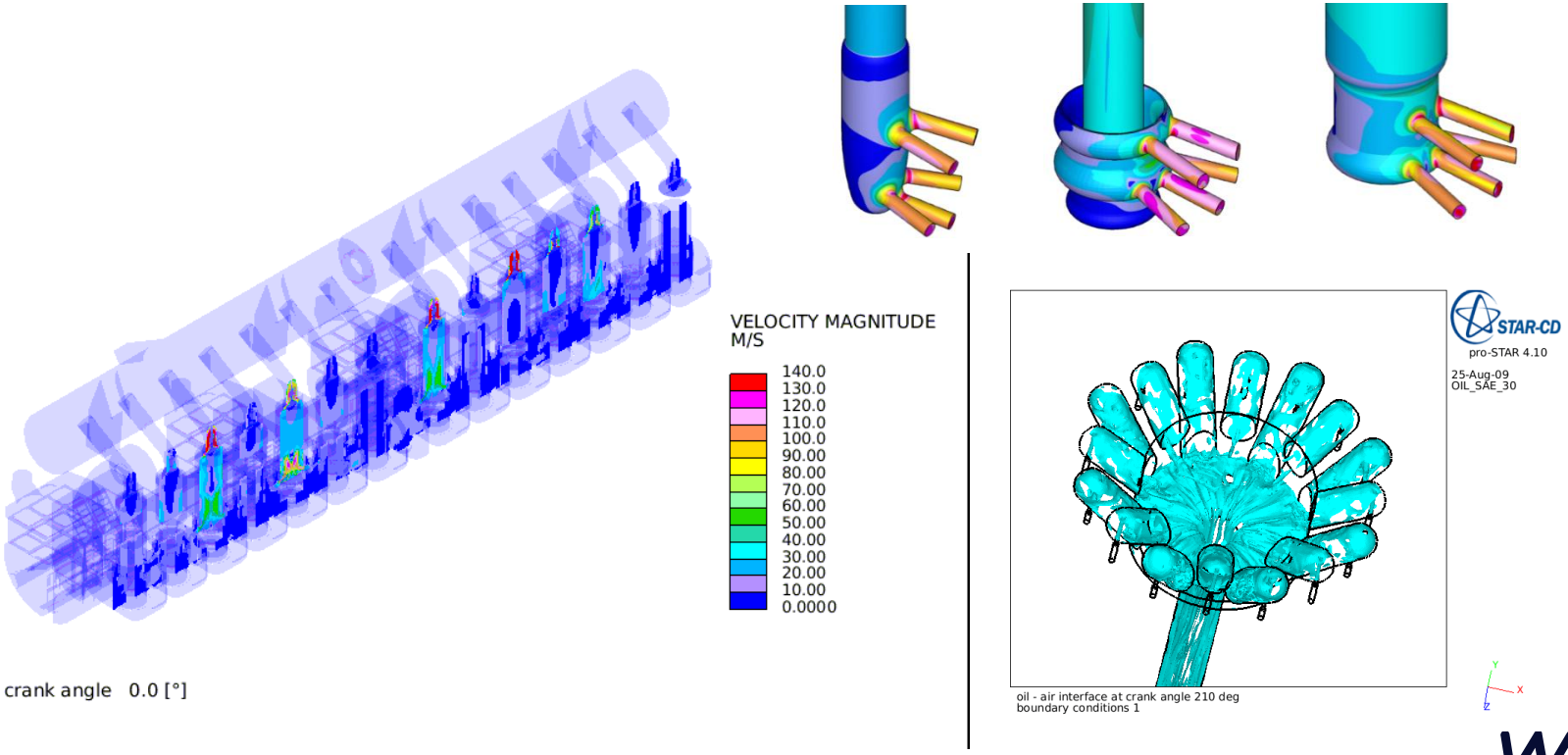
Advanced Tool Utilisation

Examples for CFD application during product development

- *Scavenging, cooling and combustion*
- *Thermal and mechanical load as boundaries for FE simulation*
- *Injection systems and nozzle designs*



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Method Development

Fatigue assessment of bearings with white metal overlay

Investigations for crank train bearings

Purpose *– Coupled EHD / fatigue analysis of crank train bearings*

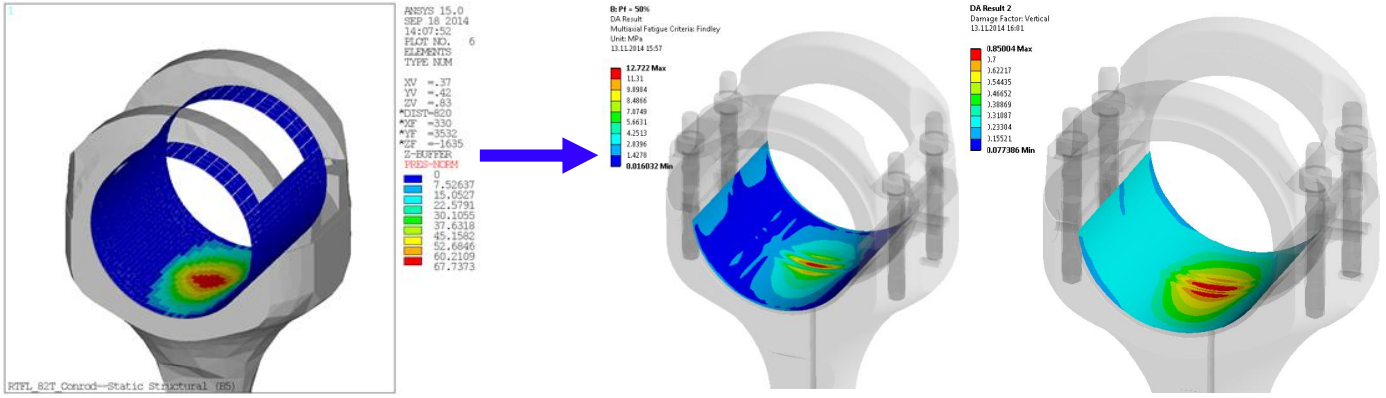
Input *– Material properties (by bearings makers)*

– Hydrodynamic pressure on bearing surface (result of EHD simulation)

Outcome *– Findley stress*

– Damage factor

– Failure probability



Hydrodynamic pressure (EHD) *Findley stress* *damage factor*

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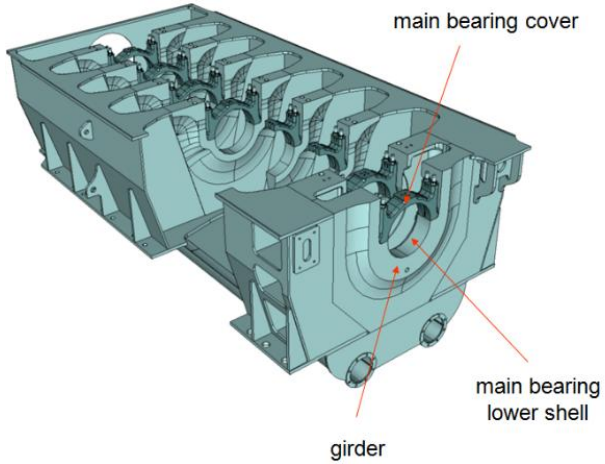
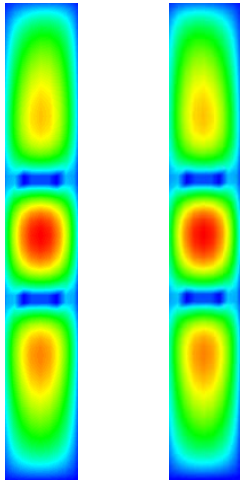
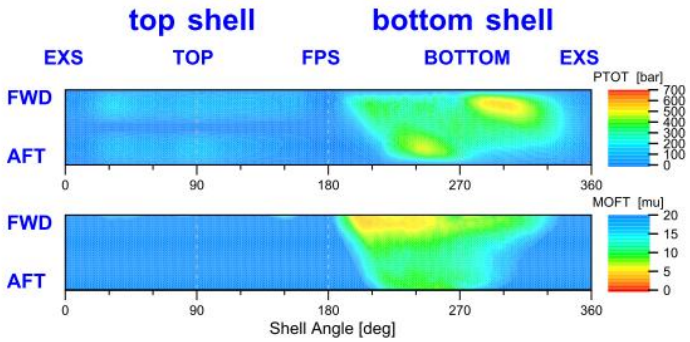
Advanced tool utilization

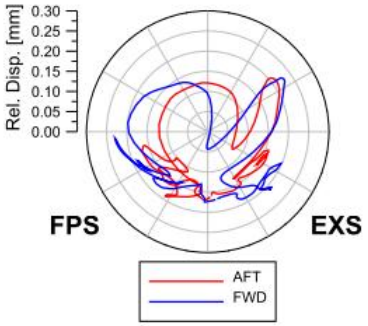
Application of EHD

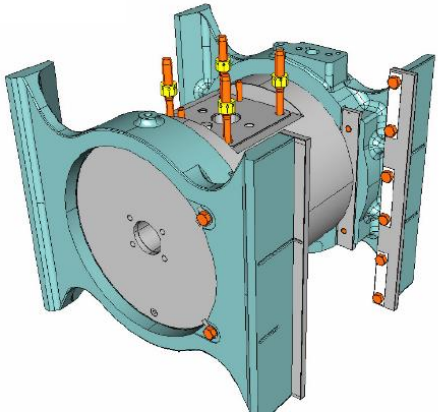
– *Basic layout of components (main bearings, cross head, etc.)*











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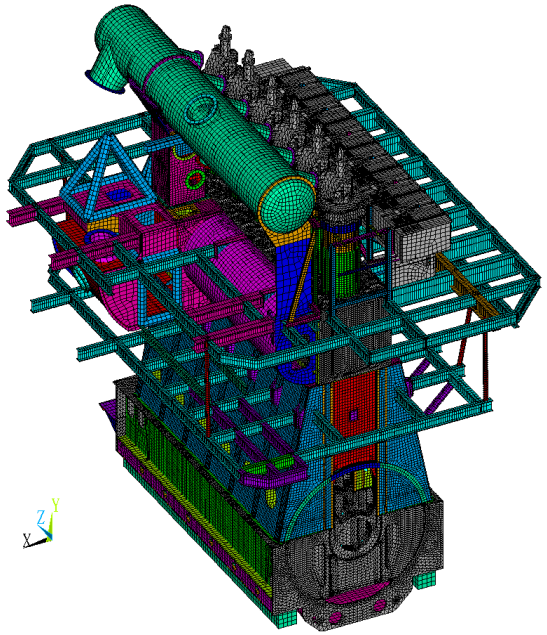
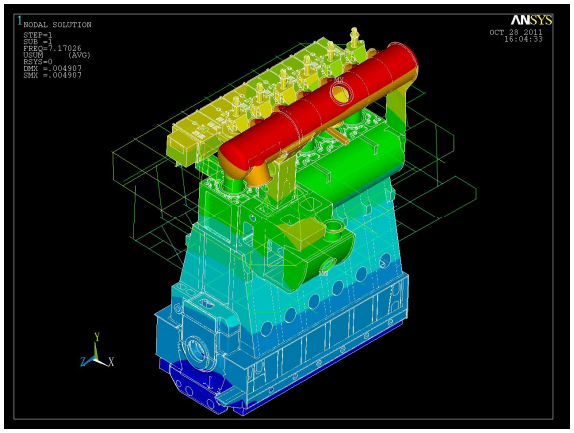
Advanced tool utilization

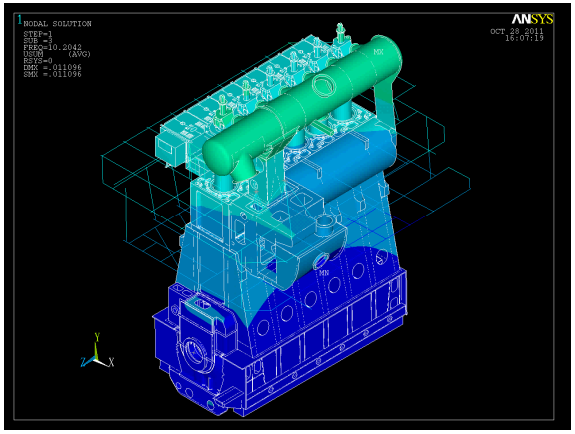
Modal analysis



Optimized FE-model is built



Engine's H-mode shape (transversal)



Engine's L-mode shape (longitudinal)

The applied harmonic response analysis by modal superposition is the fastest method for assessing the vibration response of a complete 2-stroke engine.

As base for this response analysis the first n mode shapes (100 superposed mode shapes describe the dynamic properties of a 2-stroke engine accurately enough) are determined by means of a modal analysis.

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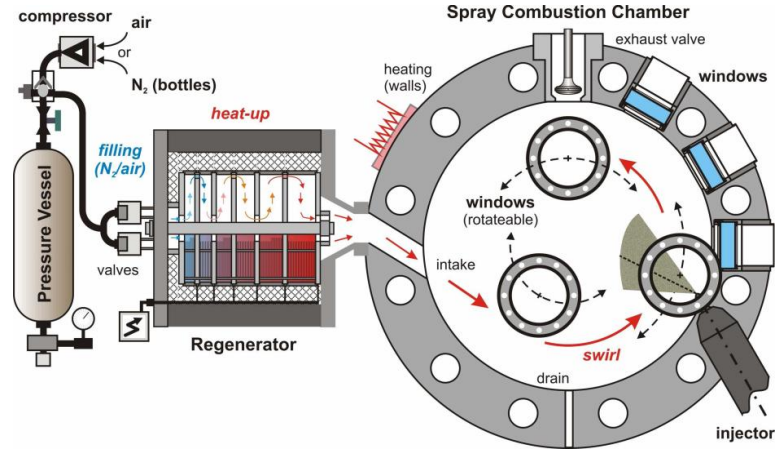
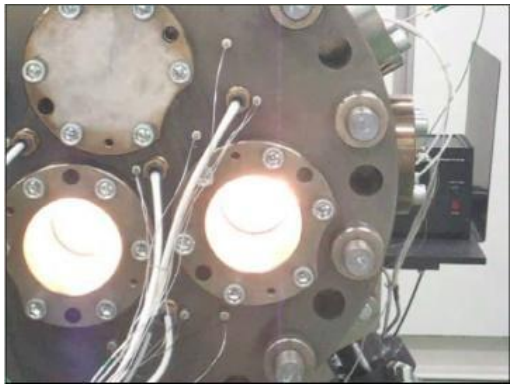
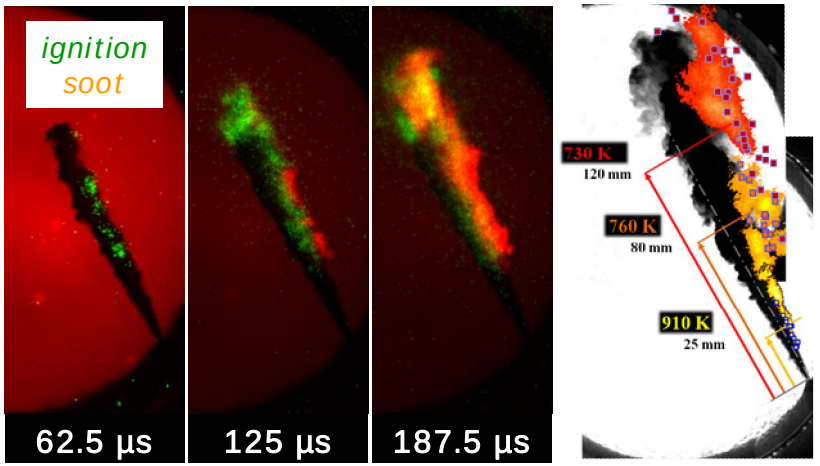
Fundamental Research

Joint spray and combustion investigations





Simultaneous shadow-imaging and chemiluminescence/incandescence



- *Spray visualization by shadow-imaging*
- *Ignition location can be determined by OH radical chemiluminescence*
- *Soot formation detectable by soot incandescence*

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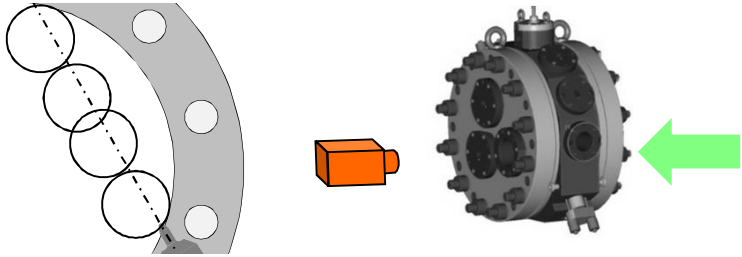
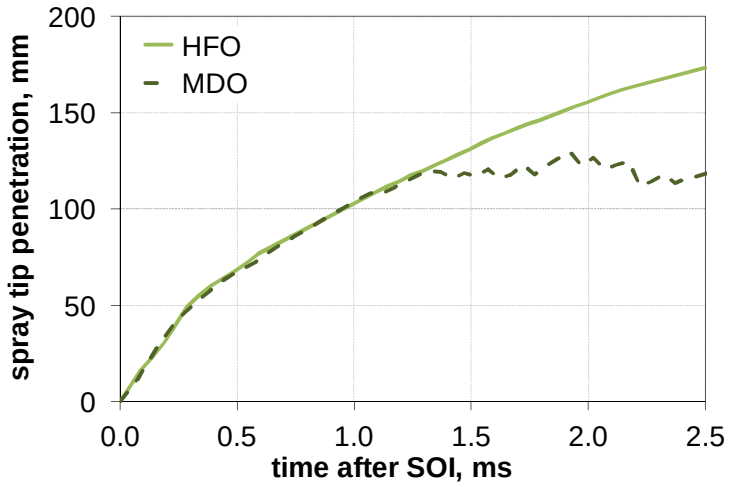
Fundamental Research

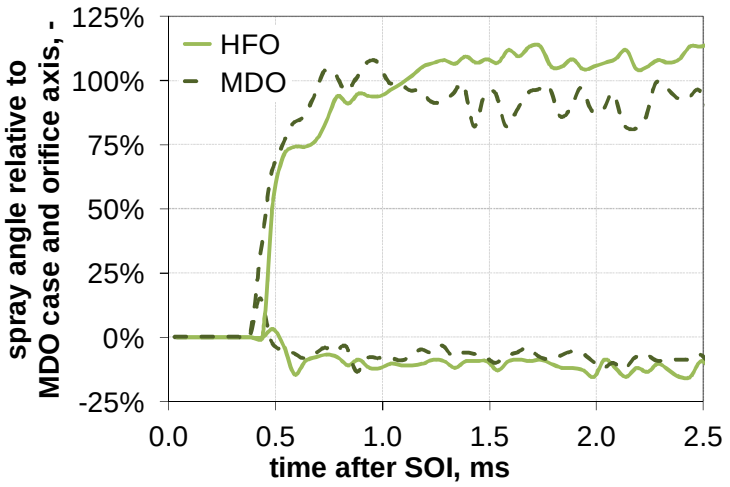
Spray and Combustion Chamber

Parameter investigations

- *Fuel type impact at evaporating conditions on spray tip penetration and spray angle relative to reference and orifice axis*







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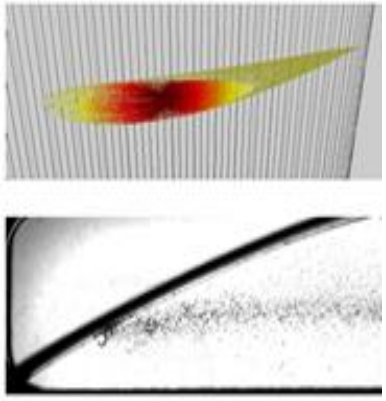
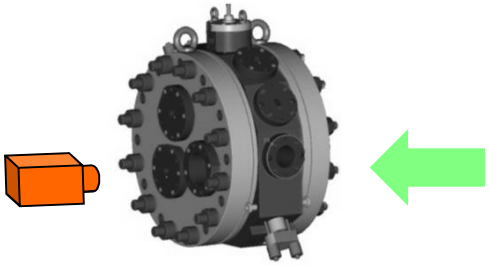
Fundamental Research

Spray and Combustion Chamber
- *Cylinder Lube oil injector optimization*





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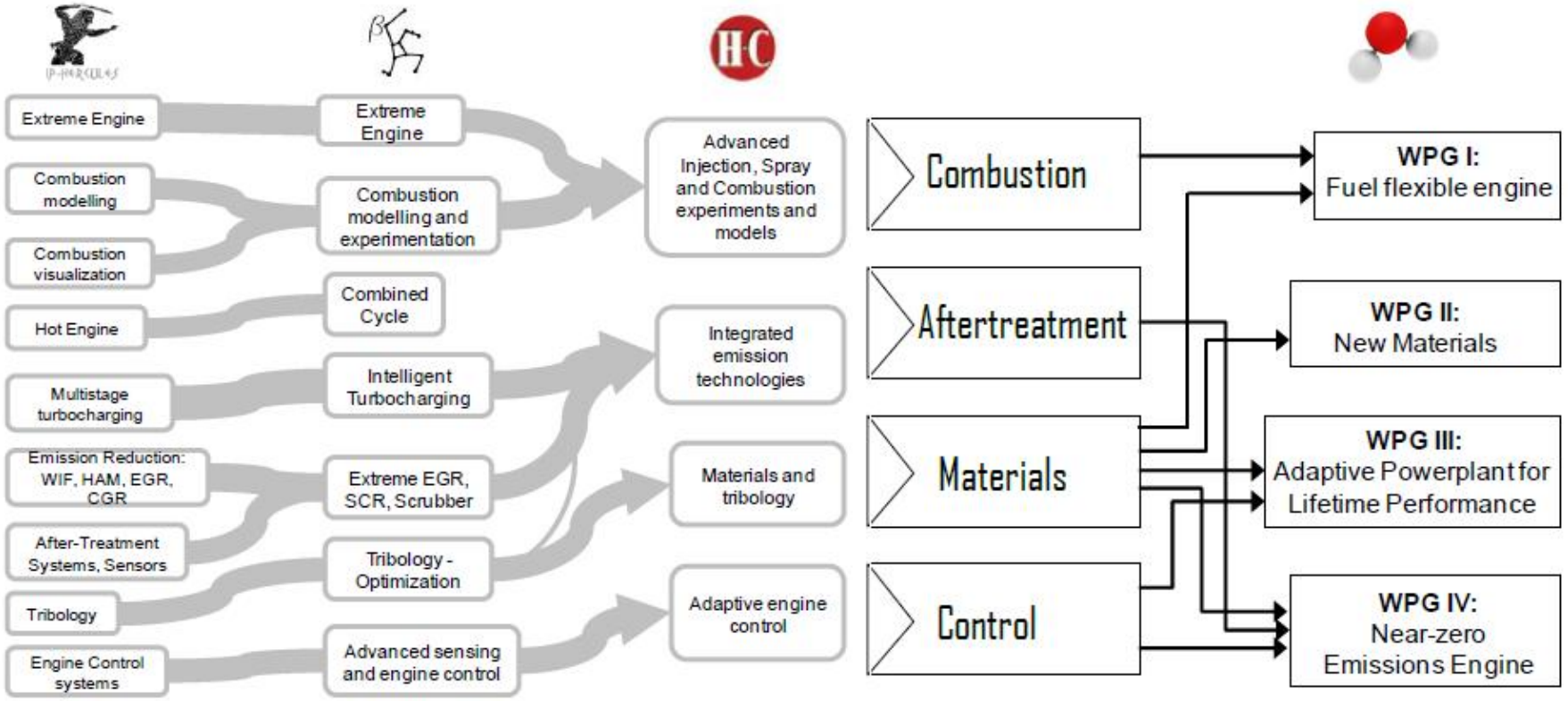
Hercules-2



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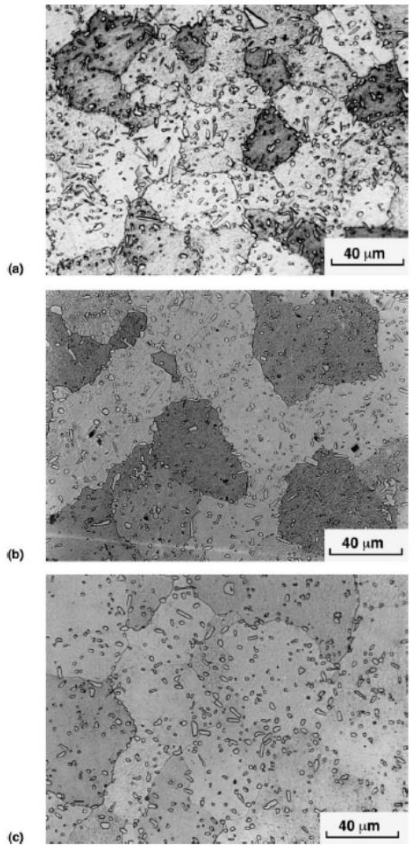
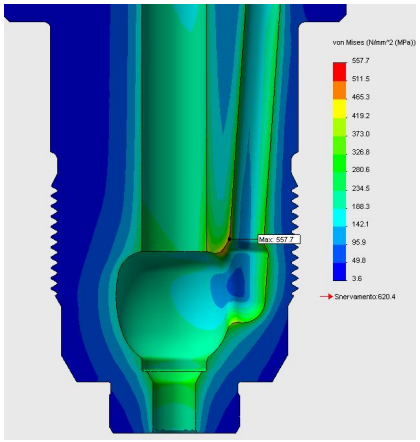
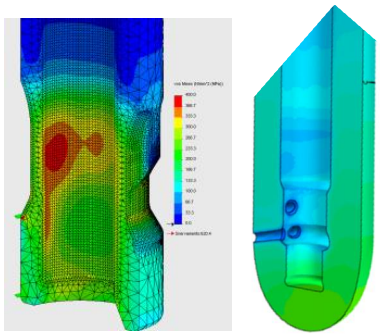
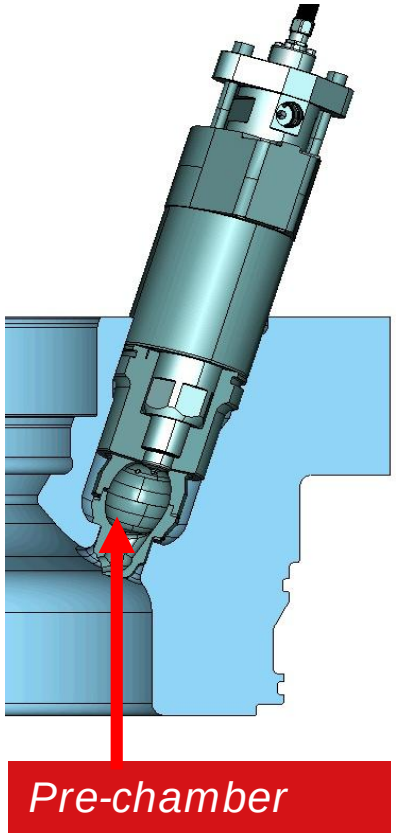
Hercules-2, Material Research

Intermetallics and advanced materials for marine engines









Microstructure of FE-Al-Ti-B alloy after heat treatment at different temperatures
B. Zeumer et al. / Intermetallics 7 (1999) 889-899

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Hercules-2, Lube-oil Related Emissions

Lubrication System Effects on Exhaust Gas

- *Real Time Determination of the Amount of Lubricant Fractions in the Exhaust Gas*

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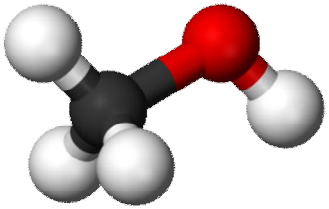
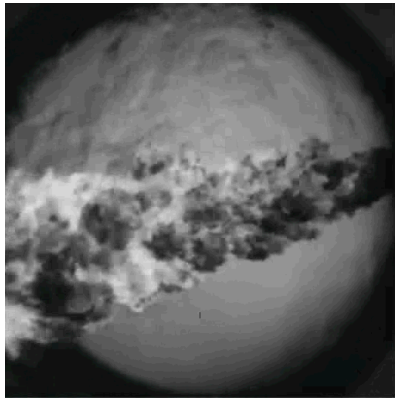
Fundamental Research

Development of a fuel flexible injection system

- *Liquid fuels from HFO to methanol*
- *Closed-loop control*





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Conclusion

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Conclusions

- *WinGD offers options and support for all Tier III emission abatement technologies*
- *WinGD will continue to reduce fuel consumption and offer full fuel flexibility*
- *WinGD will use the most advanced tools and method to provide competitive technologies and designs*
- *WinGD will cooperate with industry partners and universities to meet future demands*

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