WP Leader: M. Damani
WP Deputy: Sebastiaan Bleuanus

Objectives

Subproject 3.1:

Novel materials for engine applications

Examine possibilities of using novel materials in engines to facilitate the development of components that enable higher engine loads, hereby increasing efficiency and lower emissions. Ensure proper lifetime performance and durability.

Subproject 3.2:

Novel materials for turbine casing

Material of turbine casing is reviewed in respect of material and design in order to meet requirements needed for higher exhaust gas temperatures in steady state load profile (i.e. cruise vessels).

Structure: partners, roles

Max Planck Institut für Eisenforschung Düsseldorf:
Materials selection & optimization; materials investigation and testing activities

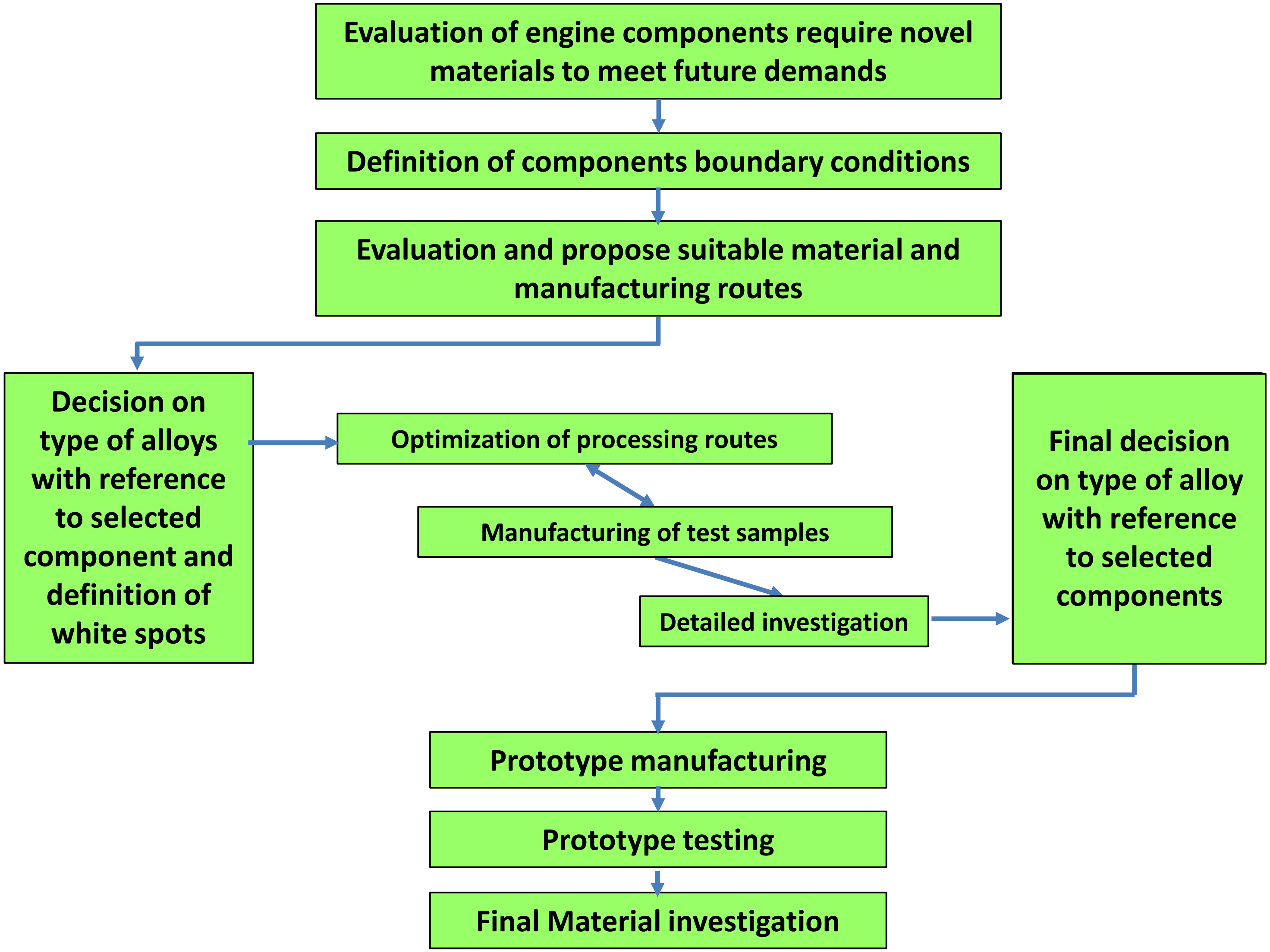
Deloro Koblenz:
Materials selection and optimization of processing and joining technologies. Manufacturing of sample materials

ABB Baden:
Evaluation, prototyping and test of new material and test of new materials for advanced turbine case.

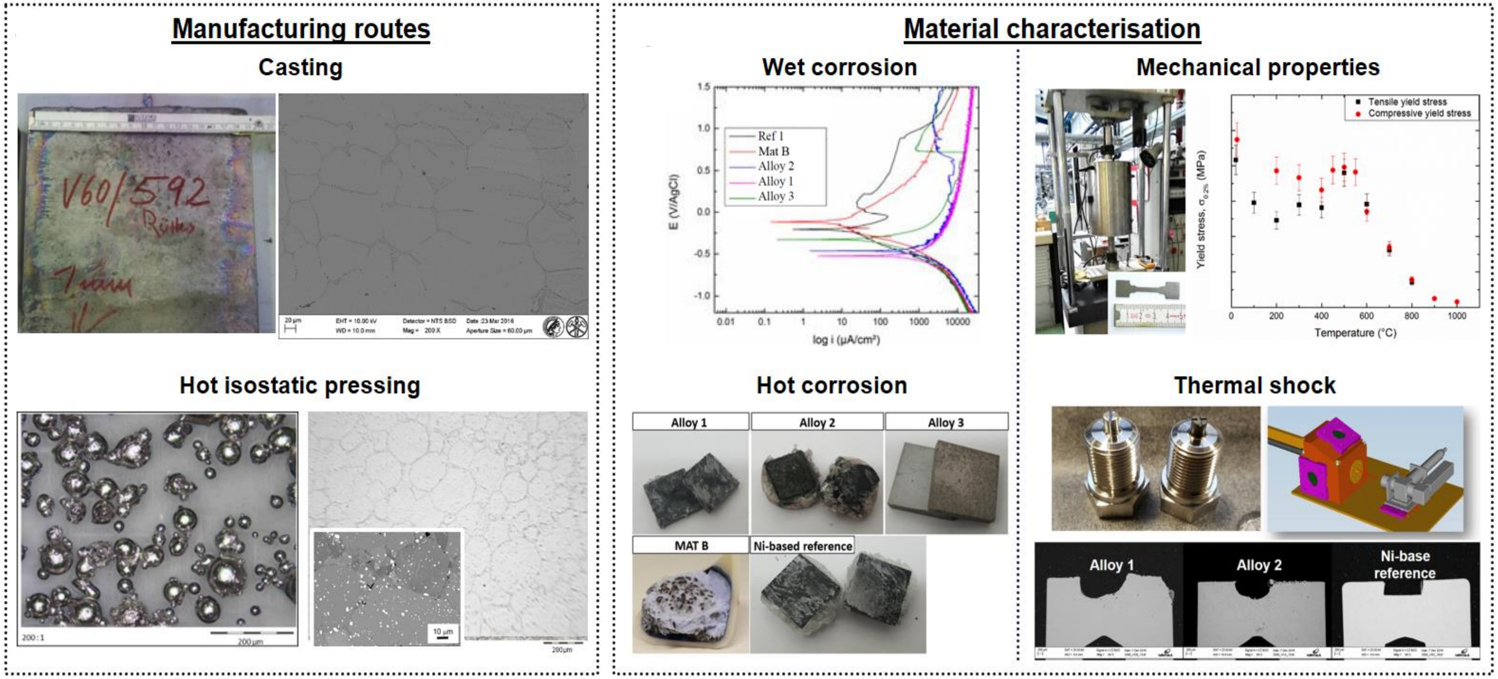
Wärtsilä Finland & Wärtsilä Netherlands:
WFI: Boundary conditions, material and processing selection; material testing activities incl. rig or engine validation; WNL: Work package deputy and coordination of research activities at partners

Winterthur Gas & Diesel Ltd.:
Boundary conditions, material and processing selection; material testing activities incl. rig or engine validation; Project lead and co-ordination of research activities at partners

Status of Sub-project 3.1: Novel materials for engine application



Detailed investigation of chosen materials and manufacturing routes



- Different processing routes employed and detailed material investigation performed
- Due to their brittle nature or inferior hot corrosion resistance some materials had to be rejected

➡ Alloy 2 was selected for prototype manufacturing, which showed the most promising combination of processability and material properties

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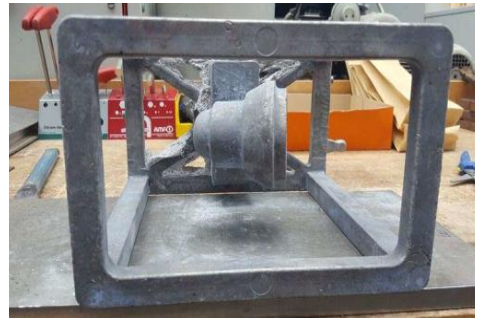
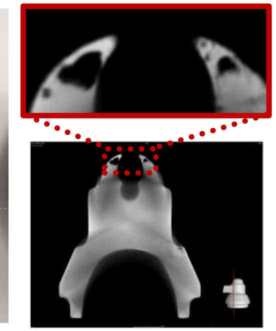
Results & Achievements: Successful Prototype Manufacturing

Castability of chosen material has been proven for larger size component

Mould design has to be optimised





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Results & Achievements: Successful Prototype Manufacturing

Castability of chosen material has been proven for larger size component
Mould design has to be optimised

Smaller size component was Machined from cast block (bulk material free of porosity)

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Results & Achievements: Successful Prototype Manufacturing

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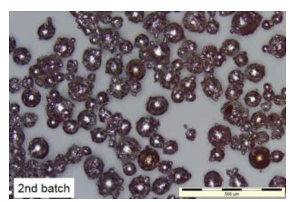
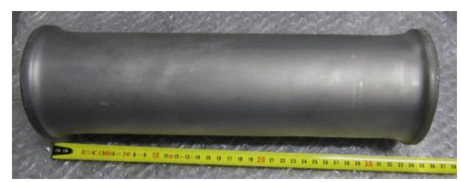
Prototype for engine testing manufactured by HIP and machining from bar



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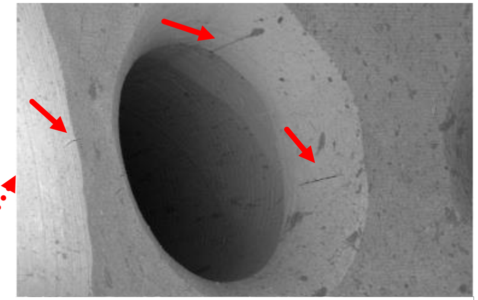
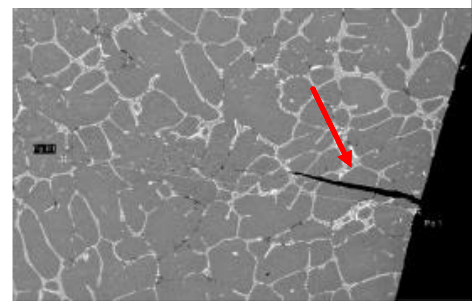
Final results & Achievements. Engine testing 1

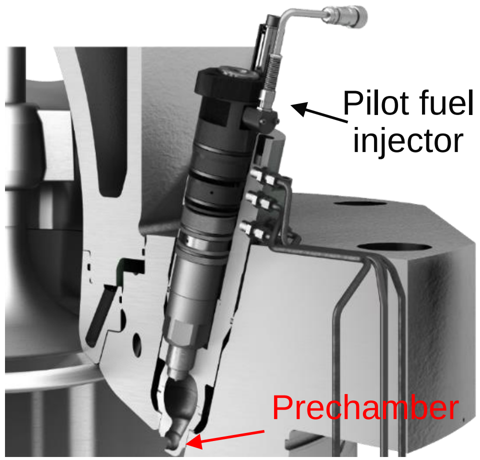




- Component testing on 4-stroke single cylinder test engine (~310mm bore size); different cycles were employed for totally 220min
- No signs of hot corrosive attack observed
- Surface cracks were observed indicating that alloy 2 in its current condition exhibits inadequate mechanical properties for the envisaged application

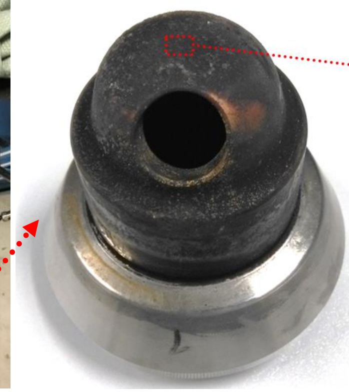
Final results & Achievements: Engine testing 2

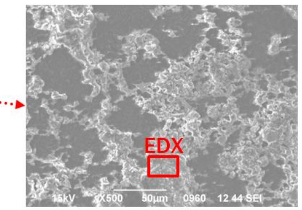
RTX-5 in Trieste

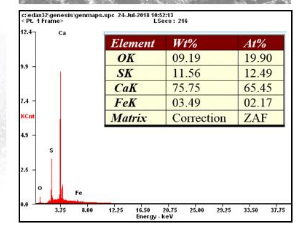


Pilot fuel injector

Prechamber after engine test







Element	Wt%	At%
OK	09.19	19.90
SK	11.56	12.49
CaK	75.75	65.45
FeK	03.49	02.17
Matrix	Correction	ZAF

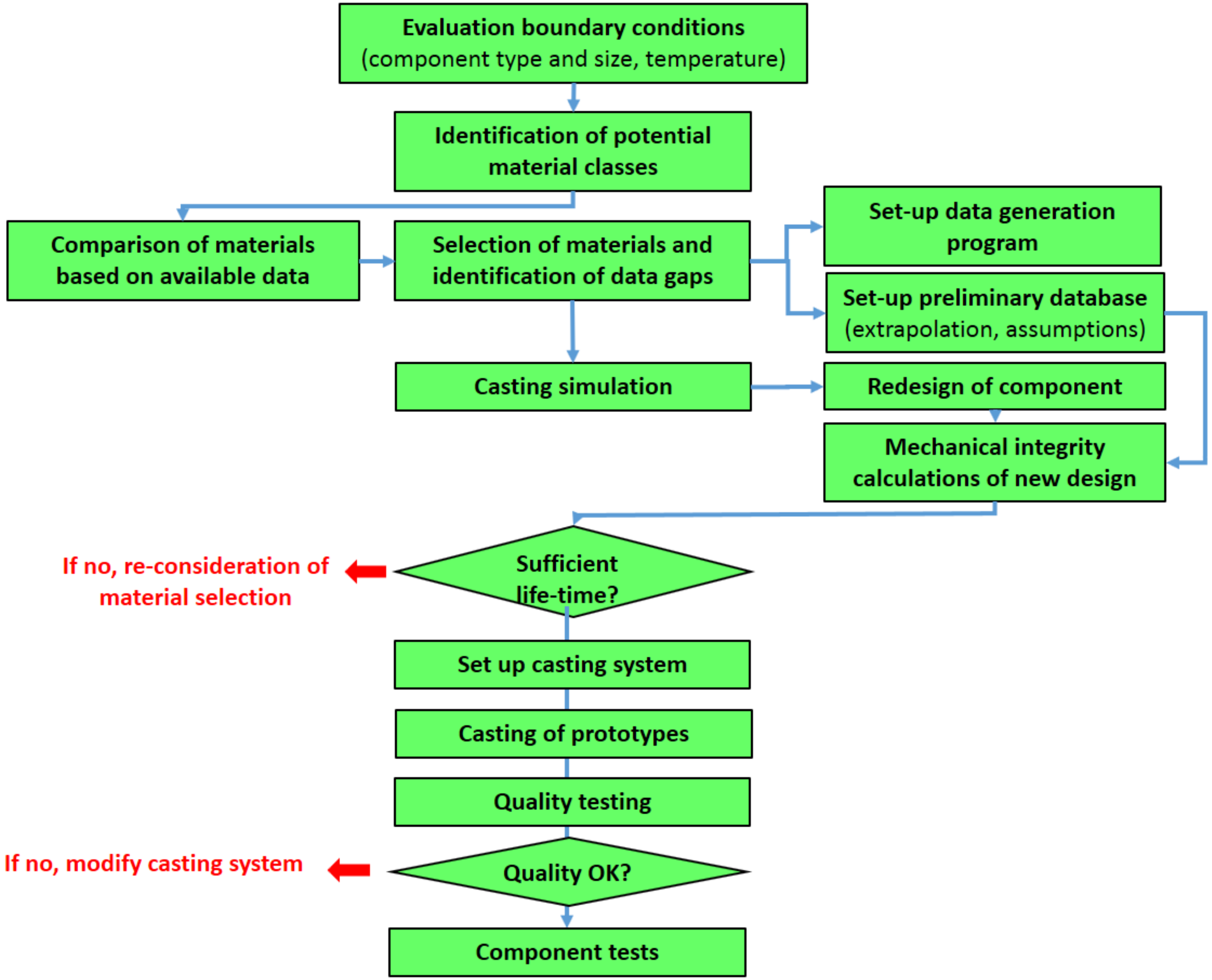
- Component testing on 2-stroke DF research engine (500mm bore size);
- Component was installed and running for totally 61hrs (20.9rhrs in gas mode and 40.1 rhrs in diesel mode)
- No signs of hot corrosive attack observed
- No signs of degradation of mechanical integrity observed

Conclusions

- Investment casting of Alloy 2 showed the potential of fabrication near net shape components (considerably reduction of machining time compared to current material used, which is machined from complete bars)
- Alloy 2 exhibits sufficient hot corrosion resistance (considering the time tested on the rigs) and can be used at higher temperatures as reference material
- For 4-stroke applications an increased ductility is required – according to literature there exits strategies (alloy optimisation) to improve ductility
- For 2-stroke application mechanical properties sufficient – further rig testing with more running hours required

Overall: promising material for use in marine engines could be identified and proven – material and/or processing optimization and further testing required

Status of Sub-project 3.2: Novel materials for turbine casing

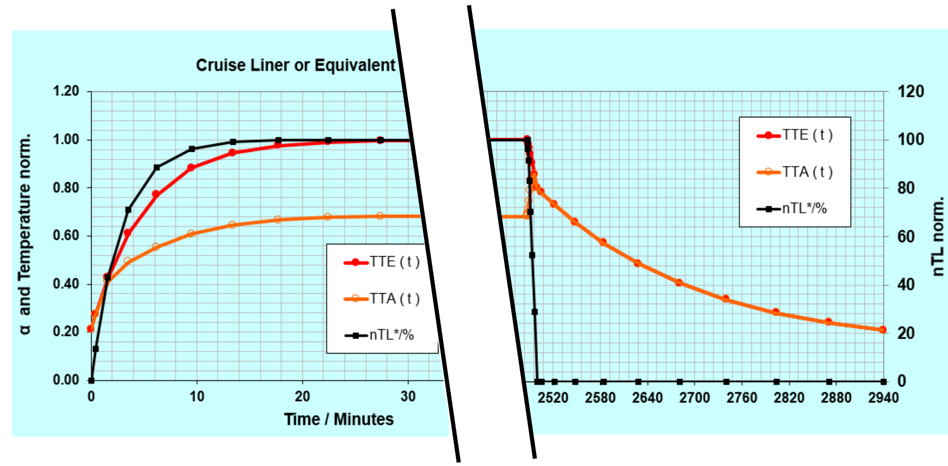


Setting boundary condition and selecting material/processing routes

Definition of load-profile - typical for cruise ship or equivalent application

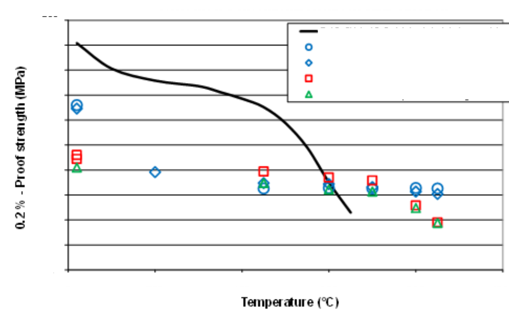
Maximal gas temperature at turbine inlet: TTE = 800°C

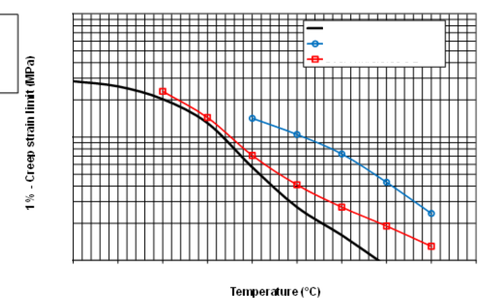
The profile consists of a start up, full load for 40 hours and a shut down



Material selection based on literature/ABB internal data and definition of missing material data

Decision to manufacture prototypes via casting using a heat resistant austenitic cast steel





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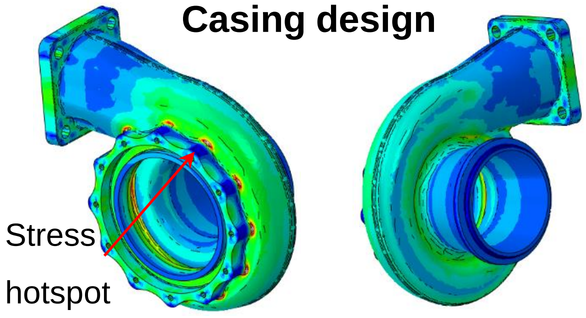
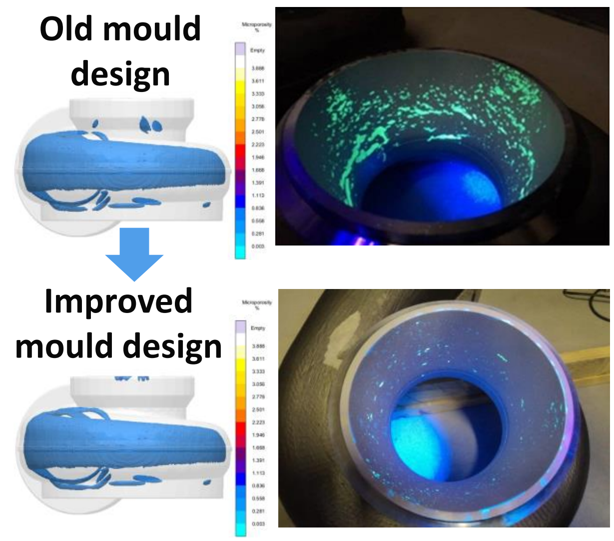
Results & Achievements: Successful Prototype Manufacturing

Parametrisation of CAD-model used for lifetime assessment of casing design



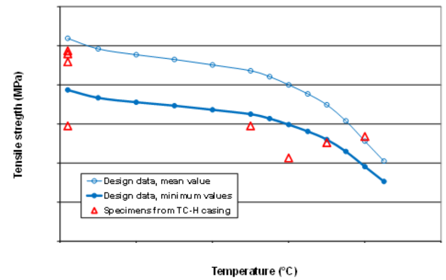
After optimisation of mould design casting of prototypes with acceptable material quality possible

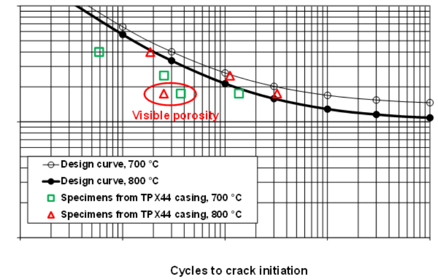


WP3: Intermetallics and advanced materials for marine engines

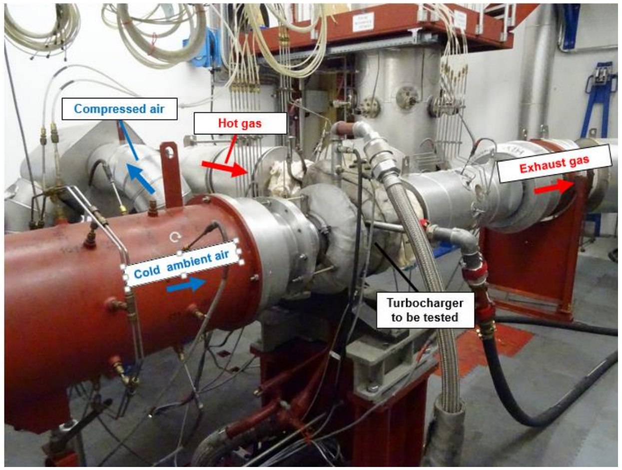
Results & Achievements: Material data generation and Turbocharger rig testing

- Extensive material data generation (LCF, TMF, tensile testing up 800°C) from samples taken from the as-cast turbocharger prototypes made of the austenitic cast steel





- Cyclic temperature test (50 cycles between 90-730°C) performed, which is required for new turbochargers
- The turbocharger new material passed the thermal cycle test without indications of increased leakage or wear.



Conclusions

- Turbine casing made of the newly applied austenitic cast steel is basically possible
- Lifetime analysis showed that the so-called “tongue” needs to be improved for a serial component
- Material data generated during Hercules 2 highly beneficial for ABB Turbo Systems
- Prototype made of the new austenitic cast steel fulfilled the qualification test, next step field testing