THE HERCULES R&D PROGRAMME

The R&D Programme HERCULES is the outcome of a joint vision by the two major European engine maker Groups MAN and WARTSILA.

In the year 2003, a common long-term R&D programme was put forward, planning for 10 years duration and 100 Million EUR research budget, to develop new technologies for marine engines, with general aims:

1. Increase engine efficiency, thus reduce fuel consumption and CO2 emissions,
2. Reduce gaseous & particulate emissions,
3. Increase engine reliability.

The evolution in the thematic content of the HERCULES programme is shown in Figure 1.

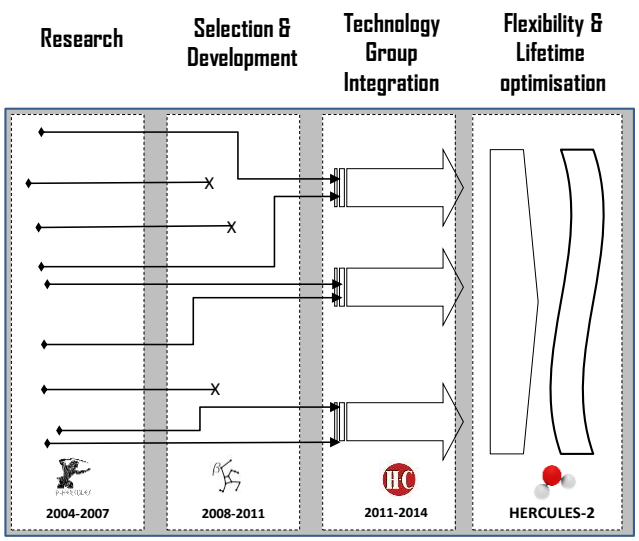

Fig.1 From HERCULES-A, B, C to HERCULES-2

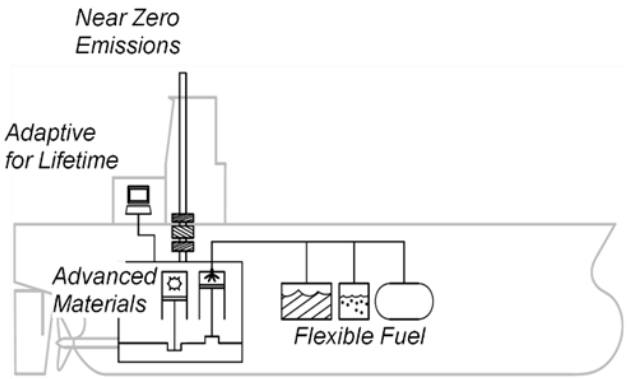

Fig.2 HERCULES-2 objectives

In the year 2004, the Integrated Project HERCULES-A (High Efficiency Engine R&D on Combustion with Ultra Low Emissions for Ships) commenced. The HERCULES-A, involved 42 industrial & university partners, with a budget of 33M€ partly funded by the European Union and the Swiss Government.

HERCULES-B was the Phase II of the Programme, from 2008 to 2011, with 32 participant organizations and 26 M€ budget. Based on the developed know-how of HERCULES-A, it was possible to further develop the most promising techniques.

The HERCULES-C project (2012-2015), with 22 participant organizations and 17 M€ budget, adopted an extensive integration of the multitude of new technologies.

The current project HERCULES-2 with 32 partners and 25 M€ budget is targeting at a future fuel-flexible large marine engine, optimally adaptive to its operating environment, as shown in Figure 2 (above).

THE HERCULES R&D PROGRAMME

The overall timeline of the 4 HERCULES projects is presented in Figure 3.

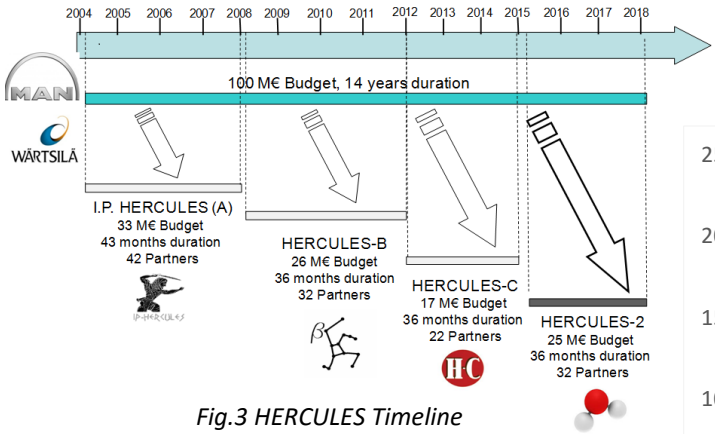

Fig.3 HERCULES Timeline

METRICS OF HERCULES

The progression from each HERCULES project to the next and the links in the R&D themes are shown in Figure 4.

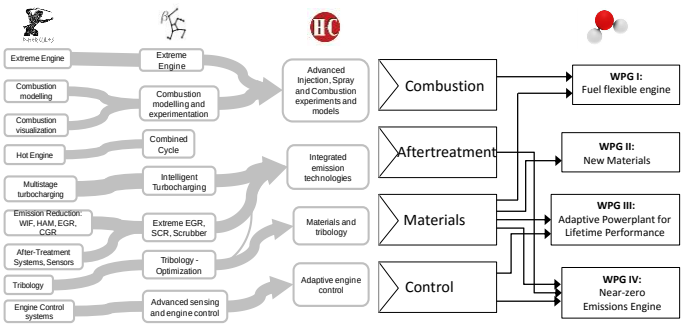

Fig.4 Links from H-A, H-B and H-C to H-2

The 3 completed projects HERCULES -A, -B, -C have cumulatively resulted in 38 patents applications, 91 scientific publications, a total of 49 prototypes, with some prototype systems tested onboard 8 ships of major operators Hapag-Lloyd, Maersk and Wallenius. A total of 18 active products resulting from the projects results are presently supported commercially.

The evolution in numbers of prototypes and products from HERCULES-A to HERCULES-C is shown in Figure 5.

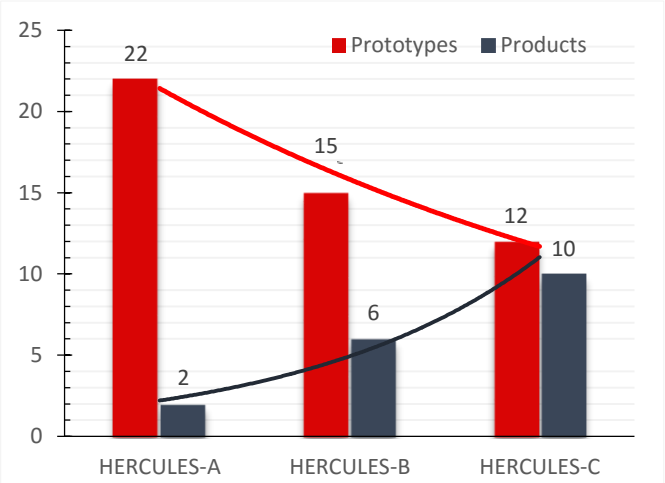

Fig.5 Prototypes and Products in service from HERCULES projects

PAST RESULTS

The last completed HERCULES-C project demonstrated in 2014 a 3% increase in engine efficiency and an 80% reduction in NOx emissions over the 2010 commercial Best Available Technology. A world record was also achieved: A prototype experimental large engine operating at 300 bar maximum cylinder pressure.

The resulting technologies from the HERCULES programme related to the future large marine engines, are listed below:

- Multi-stage Turbocharging (+Variable Valve Timing), allowing higher performance and improved fuel consumption

THE HERCULES R&D PROGRAMME

- Power Take In/Out and Flexible Turbocharger (+Variable Geometry), allowing improved economy over the operating range (Figure 7)

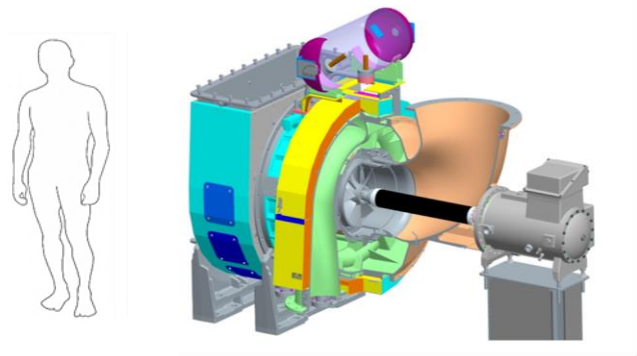

Fig.7 PTI/PTO System

- Increased maximum cylinder pressure, BMEP, leading to reduced fuel consumption
- Cylinder auto-tuning & Injection optimization for improved performance, economy, reliability and emissions
- Water-In-Fuel, Water injection, for reduced NOx emissions (Figure 8)

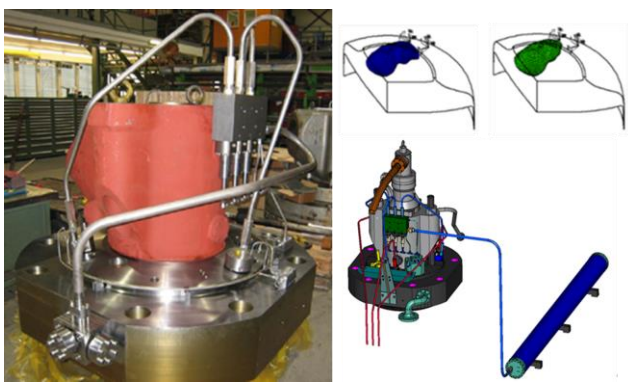

Fig. 8 Direct Water Injection (DWI) System

- Waste Heat Recovery from Hot Engine with Thermal Barrier Coatings, for improved economy (Figure 9)

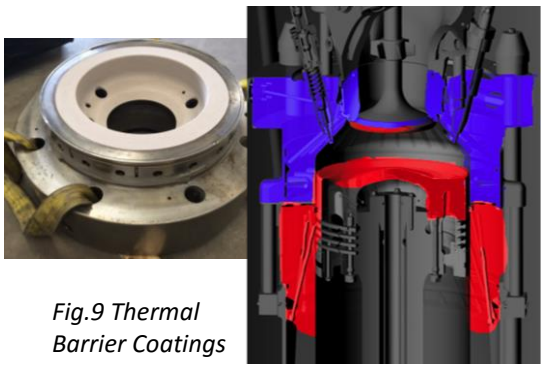

Fig.9 Thermal Barrier Coatings

- Exhaust Gas Recirculation, for reduced NOx emissions, with scrubbers and high pressure boiler for heat recovery (Figure 10)

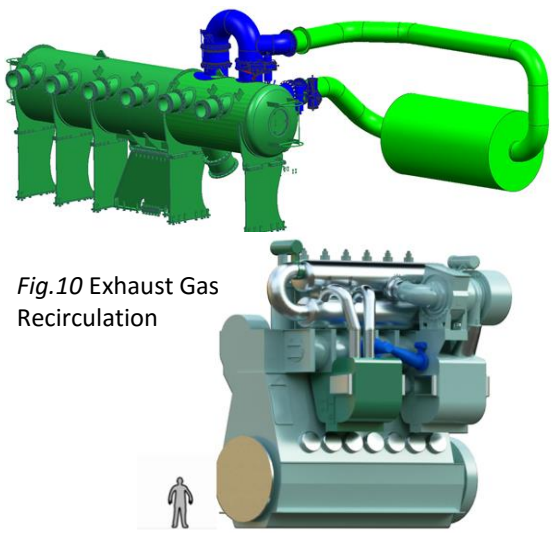

Fig.10 Exhaust Gas Recirculation

- Selective Catalytic Reduction-SCR for exhaust NOx aftertreatment
- Tribology and Lubrication improvements and advanced materials, for improved economy and reliability

THE HERCULES R&D PROGRAMME

CONCLUSIONS

The longevity of alliances has often been used as a proxy for their performance. In that respect the HERCULES alliance, dating from 2004 till today, has been convincingly successful.

The metrics of the completed projects indicate that the work has been quite productive. Several results of the R&D have already matured into commercial products, available in the market

The HERCULES Programme involved a large number of organizations and co-workers with more than 300 engineers and scientists from 82 partners being involved in the various phases of the programme.

ACKNOWLEDGMENTS

The HERCULES partners gratefully acknowledge the financial contribution of the European Union and the Swiss Federal Government through EC- FP6 Contract TIP3-CT-2003-506676 with EC Project Officer Mr. Michael Kyriakopoulos, through the EC-FP7 Grant Agreement SCP7-GA-2008-217878, with EC Project Officer Mr. Joost De Bock , through the EC-FP7 Grant Agreement SCP1-GA-2011-284354 with EC Project Officers Mr. Gabriel Mialocq and Mr. Joost De Bock and through the EC-H2020 Grant Agreement 634135 with EC Project Officers Mr. Gabriel Mialocq and Ms. Renata Kadric.

SIXTH FRAMEWORK PROGRAMME

SEVENTH FRAMEWORK PROGRAMME

HORIZON 2020