NEWAC subproject 2 “Intercooled Recuperative Core” - Editorial by Stefan Donnerhack

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When the Group of Personalities wrote and signed their "European Aeronautics – A vision for 2020" document about ten years ago, a number of engine specialists were rather sceptical about the ACARE initiative and the achievability of the targets set to meet the requirements for sustainable air traffic in future.

One novel concept to reach or even surpass the ACARE targets concerning the reduction of emissions is the concept of IRA, the Intercooled Recuperated Aero-Engine. More than ten years ago comprehensive studies to promote this radical new engine concept have been initiated at MTU Aero Engines. The particular benefits offered by an optimised IRA cycle are: HPC efficiency gain due to intercooling upstream of the HP compressor, increase in thermal efficiency due to better energy exploitation by means of recuperators in the hot exhaust flow, weight decrease of core components due to intercooling and, last but not least, a significant reduction potential for NO_x emissions from the combustor due to the low overall pressure ratio of a typical IRA cycle as compared with any other highly efficient engine cycle. As a result, IRA has been identified as one of the novel candidate concepts for a "green" aero-engine that might have the potential to meet the challenging ACARE targets. However, all these benefits cannot be achieved for free, but at the expense of additional engine architectural complexity, the weight increase from the intercooler and recuperator modules and, hence, of new ways and efforts for investigating and optimising this engine concept. We believe that MTU's profiled-tube recuperator (see figure 1), a new design approach for a compact, lightweight, highly efficient and highly durable heat exchanger is one of the key modules and enablers for the IRA concept.

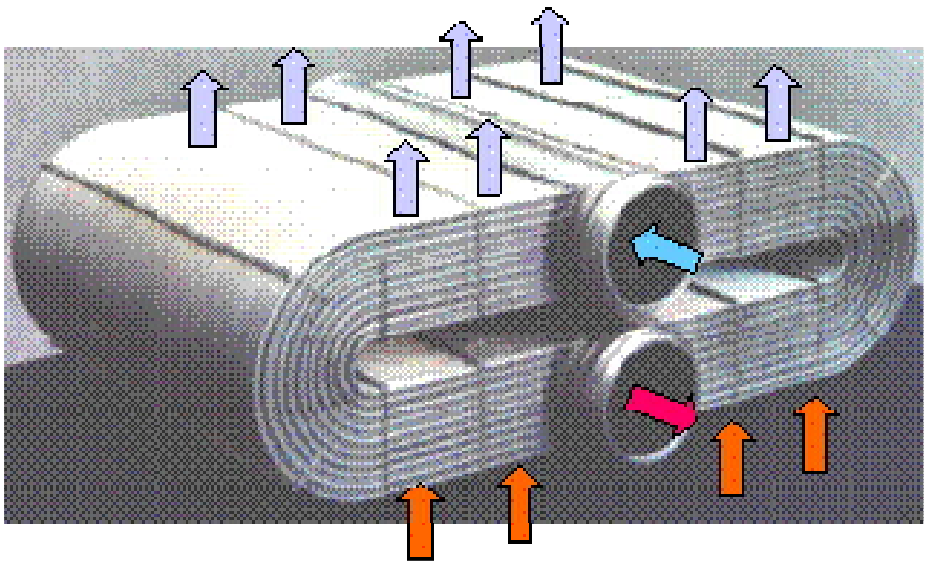

Fig.1: MTU's profiled-tube recuperator design for IRA

About a decade ago MTU entrusted me with work on and support for the step-by-step development of IRA modules, IRA integration and any other associated challenging tasks to ensure a continuous follow-up of the realisation of the IRA concept. Before, I had been involved in the previous European major research project EEFAE, under which the IRA cycle was established and selected IRA technologies were successfully investigated, designed and tested in the frame of the CLEAN technology platform. MTU Aero Engines then assigned me to the current NEWAC project, under which the IRA core was selected as one out of four core engine concepts to be investigated, to lead NEWAC SP2 "Intercooled Recuperative Core".

The IRA cycle proposed under the NEWAC project will benefit greatly from a further increased propulsive and thermal efficiency and offers the potential of an up to 20% reduction of fuel consumption and CO_2 emissions. The very low overall pressure ratio of a typical IRA cycle of well below 30 as compared with conventional highly efficient high OPR engine cycles will by itself support low NO_X combustion conditions since it permits the use of special ultra-low NO_X combustor technologies which are not suitable for engines with a high overall pressure ratio, e.g. lean premixed pre-evaporation (LPP) combustion. Figure 2 shows a 3D sketch of an intercooled recuperated aero engine integrated in conventional nacelle and underwing configuration.

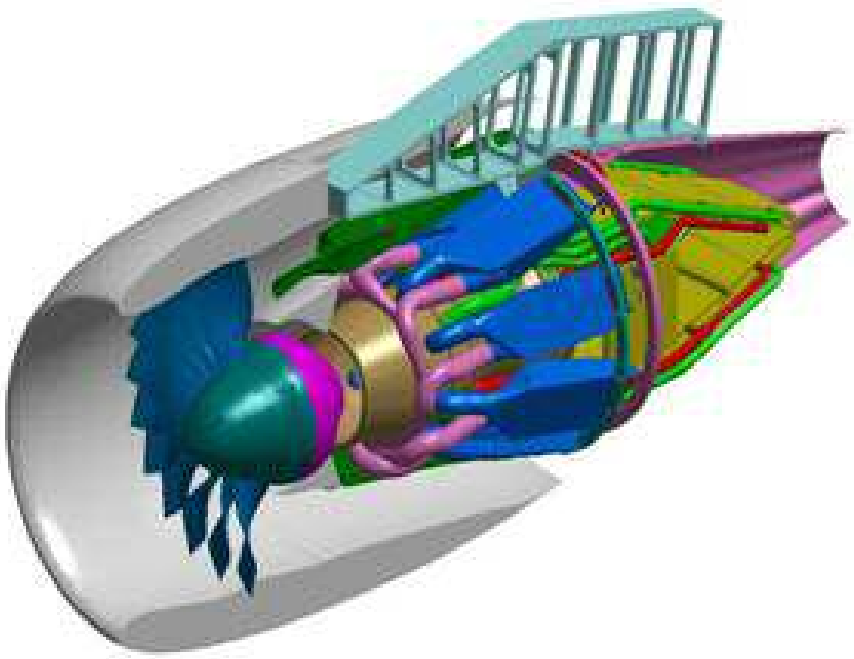

Fig. 2: IRA integrated in conventional nacelle and underwing configuration.

In NEWAC SP2, we are focusing on selected technology fields of interest for IRA component and installation improvements:

- An installation concept study to cope with the particular attachment and mounting constraints of the heavy recuperators in the rear hot nozzle section.

- A systematic comparative study on the applicability of different HP compressor configurations with due consideration being given to the IRA core / exit interface and ducting constraints.
- The development of an advanced radial HP compressor that features significantly increased performance and efficiency and, at the same time, a reasonable surge margin to satisfactorily fit IRA requirements. This activity comprises the design, hardware manufacture and rig testing. A complemetary study on stability enhancement measures by means of internal recirculation technologies rounds up the scope of SP2 compressor investigations.
- The optimisation of the rear hot nozzle section and recuperator arrangement geometries to provide uniform flow conditions through the recuperator matrixes and, hence, lowest possible pressure losses. For the analytical part of the study a new approach for flow simulation through the recuperator matrix, based on a porosity model, has been developed and already validated experimentally.

Under NEWAC, a lean-premixed pre-evaporation (LPP) combustor concept for IRA is being investigated. LPP is well suited to the low overall pressure ratio level of the IRA core. The LPP has good potential for lowest NO_x emissions. These development activities will be pursued in the NEWAC combustor development subproject SP6. Figure 3 summarizes the IRA activities under NEWAC.

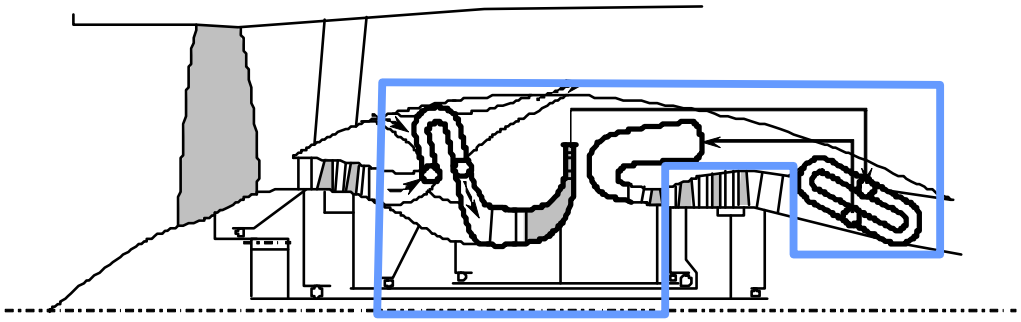

Fig.3: Components investigated under NEWAC: radial HPC, recuperator and related ductings, LPP combustor

The NEWAC SP2 activities on IRA core component improvements are aimed at an additional 2% SFC reduction and a 1% overall weight reduction versus the results already achieved under the EEFAE-CLEAN project.

The partners involved in the IRA improvement activities include OEMs (Airbus Industry, MTU, Turbomeca), SMEs (PBS, PCA) and universities and research institutions (DLR, Thessaloniki University).

One further objective of the NEWAC project is to explore and investigate new and even more advanced core engine configurations for the time after 2020. SP2 has addressed these additional objectives by initiating studies, led by Volvo Aero, on future innovative cores. 4 different configurations have been selected for more detailed investigations:

- variable geometry core cycle

- pulse detonation concept for innovative combustion
- contra-rotating core configuration
- innovative heat management system

These studies, which are based on analytical and first order assessment methods, i.e. studies at a lower TRL, are mainly performed by universities (Chalmers University and Graz Technical University) and MTU. The universities' work is led by the two OEM companies Volvo and MTU to make sure the results achieved are of significance for the overall propulsion system and also flight mission.

Since SP2 covers a wide range of challenging mid-term and long-term aspects and technologies for future advanced propulsion systems, it offers an interesting working field for ambitious European engineers. The entire SP2 team has already achieved significant progress towards the targets in all tasks and work packages during the last three years. We are now confident that we will be able to complete the SP2 activities successfully as planned – for the benefit of the IRA concept.