ENERGETICS

MUR DM 118 - Development of Enabling Technologies for Rotating Detonation Engines for a Greener Propulsion

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Politecnico di TORINO [P.iva/CF:00518460019]

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Context of the research activity	The research address technical issues associated to the development of a Rotating Detonation Engine. The unsteady coupling between a Rotating Detonation Combustor and a High-Pressure Turbine will be analysed by means of Computational Fluid Dynamics. The final goal of the activity is to jointly design new cooled ducts and vanes able to weaken flow unsteadiness and maintain unaltered the efficiency gain associated to the pressure gain cycle. Progetto finanziato nell'ambito del PNRR – DM 118/2023 - CUP E14D23001620006

Objectives	The recent trends in aero-engine design push towards the usage of greener solutions for the abatement of CO2 and NOx emissions. The use of Sustainable Aviation Fuels partially fulfills such need, but a radical change in the thermodynamic cycle of gas turbines is also necessary, moving from the Brayton to the Zeldovic-Neumann-Doring (ZND) cycle. In fact, Pressure Gain Combustion (PGC) can provide an increase by 17% in the cycle efficiency for small and medium range flights and perfectly fits the necessity to use hydrogen as a fuel. Still, enabling technologies to make such solutions feasible in a realistic environment are well behind the Technology Readiness Level (TRL) in the European framework, as proved by the Marie Curie action “INSPIRE” funded by the European Commission. On the contrary, Rotating Detonation Engines (RDE) have already been tested at engine scale in the United States. Based on the results obtained at Politecnico di Torino in the framework of the INSPIRE project, it is now possible to raise the TRL of the research to design components that can effectively couple a Rotating Detonation Combustor (RDC) with the turbine module. In the present project, the design of a high-pressure turbine stage able to cope with the relatively high Mach number flow coming from an RDC will be performed. Boundary conditions for the redesign of the transition duct from the RDC to the turbine are available from the INSPIRE project thanks to the current collaboration with

Objectives	the University of Purdue (US) and TU-Berlin (DE). Turbine aerodynamics will be optimized to increase the stage efficiency to the typical values of subsonic gas turbines, not to impair the increased cycle efficiency associated to the ZND cycle. Active Flow Control (AFC) devices such as pulsating cooling is fundamental to reduce the losses associated to the development of secondary flows, but the optimal mass-flow must be individuated, given that the flow is also necessary to cool down the end-walls. A cooling system for the High-Pressure Vane (HPV) will also be designed to mimic a realistic configuration and study the impact of a time-dependent boundary condition on the adiabatic effectiveness map. Unsteady simulations of the re-designed stage will allow for calculating the actual high-pressure turbine stage efficiency, thus moving towards a higher TRL for the specific topic. All the presented activities rely on the track record of the research group in the design optimization and numerical simulation of turbomachinery flows, including the development of in-house tools for the analysis of compressible flows. Most of the activity will be performed by means of Computational Fluid Dynamics, but some components may be experimentally tested at the University of Purdue based on the already existing agreement established during the INSPIRE project. In that scenario, a secondment in that location is expected.

Skills and competencies for the development of the activity	Basic knowledge of technical characteristics of gas turbines, with special interest in turbine aerodynamics and film cooling. Basic knowledge of Computational Fluid Dynamics (with commercial tools, preferably ANSYS Fluent or CFX, preferably but not necessarily in heat transfer analysis). Basic knowledge of the English language to proceed with the reading of scientific literature.