ENERGETICS

Ammin/DENERG - Advanced numerical modelling of turbine components and robust design of enabling technologies for green energy and aviation

Funded By	Dipartimento DENERG Politecnico di TORINO [P.iva/CF:00518460019]
Supervisor	SALVADORI SIMONE - simone.salvadori@polito.it
Contact	MISUL DANIELA ANNA - daniela.misul@polito.it
Context of the research activity	The gas turbine market is experiencing important changes with reference to secondary air systems, alternative fuels, and the thermodynamic cycle. Research efforts aim at defining new design procedures that fit the needs of gas turbine producers. The goal is to create a workbench to include a high-fidelity solver in a design process that takes advantage of the capabilities of uncertainty quantification and machine learning to optimize the aero-thermal behavior of gas turbine components.
Objectives	The project will rely on an extensive literature review about the implementation of high-fidelity methods for the study of turbine components; on the study of existing methods for the numerical simulation of unsteady flows in turbomachinery; on the development of numerical methods for design optimization including uncertainty quantification effects. Research efforts are currently aimed at defining new design procedures that fit the needs of the leading gas turbine producers. Various workflows have been designed to achieve multi-objective optimizations of aeroengine components. For that reason, the development of high-fidelity in-house tools (i.e., including large-eddy simulation or stress-blended eddy simulation) for the study of turbomachinery flows is of great importance thanks to the possibility to concentrate on programming specific solutions for the analysis of component interaction (i.e., reactive flows and high-pressure turbine stages, low-pressure turbine performance at cruise), of secondary air systems, and of thermal load (i.e., conjugate heat transfer). In the current research project, high-fidelity methods will be implemented for the analysis of complex geometries in engine scale conditions and develop a virtual turbine model. Moreover, innovative components will be designed while taking into consideration unsteady component interaction. The main goal of the activity is to create a workbench to efficiently design enabling technologies to cope with the extreme conditions expected in the next generation aeroengines. Uncertainty quantification will be introduced to

	complete the transition towards robust design methods. Each step of the research will be validated using available experimental data from academic test cases. More in detail, high-fidelity methods will be implemented and tested in our in-house solver. The validated version of the solver will be used to test the performance of the already available existing pressure-gain combustion configurations from the "Turbomachinery for Energy and Propulsion" research group. Further on, the impact of different materials will be considered by means of conjugate heat transfer analyses performed on the most promising solution with internal cooling systems. The impact of turbulence will be quantified, thus releasing a design practice able to reduce turbine inefficiency in pressure-gain cycles. Also, the unsteady performance of a low-pressure turbine cascade experimentally analyzed at the von Karman Institute for Fluid Dynamics will be studied using the freely available data from the SPLEEN open database. In the final part of the activity, a workbench will be developed in Python to include the solver in an existing optimization routine, aimed at designing enabling technologies for the next generation aeroengines. Manufacturing uncertainties will eventually be implemented in the model to improve the overall performance of the final solution.

Skills and competencies for the development of the activity	The candidate should have basic knowledge of technical characteristics of gas turbines, including design trends for green aviation and power generation. Also, a basic knowledge of Computational Fluid Dynamics is welcome. Previous experience in the optimization field, in uncertainty quantification, and in Python programming is positively evaluated.