MULTIDISCIPLINARY STUDY OF A FAST RESPONSE COOLED PROBE FOR UNSTEADY TOTAL PRESSURE MEASUREMENTS IN HP TURBINE STAGES

Leonardo Nettis, Italy
Supervisors: J.-F. Brouckaert, T. Quintino, M. Mersinligil, T. Verstraete

Nowadays there exists a considerable need, both in the industry and research environments, for unsteady pressure measurements in locations where the temperature exceeds by far the operating range of current commercial off-the-shelf (COTS) sensors. The European HEATTOP project focuses on these issues.

This research study constitutes a part of the VKI contribution to the European Union FP6 project HEATTOP, Accurate High Temperature Engine Aero-Thermal Measurements for Gas-Turbine Life Optimization, Performance and Condition Monitoring. In this project, the von Karman Institute is responsible for the work package named Advanced Gas Path Measurement in which this diploma course project is involved. The main aim consists in developing a fast response pressure probe suitable for unsteady total pressure measurements in the flow at the exit of a HP turbine. A time resolved measurement of the pressure in the aforesaid position would be essential to improve condition monitoring and active control strategies for gas turbine engines, both stationary and in-flight. In particular, the probe should survive to the following extreme conditions: 1400K of temperature, 40bars of total pressure and a mean Mach number of 0.5. An additional issue arises due to the high frequency content of the flow in such a location. Therefore we need a considerably high frequency response as well.

The purpose of the current work is to perform a complete Conjugate Heat Transfer (CHT) analysis of the cooled probe immersed in the hot flow. In order to achieve this result the in-house Multi-physics platform COOLFluiD is employed. First a validation of the code for the case of a 2D cylinder in cross flow has been carried out, providing satisfactory results. Both the compressible and the incompressible solver of COOLFluiD have been tested at the same non dimensional parameters. The result comes out to be similar in terms of flow structure and temperature field (see Figure 1).
Subsequently the 3D study of the flow inside the probe and of the external one is performed. The latter is shown in Figure 2. In this way the coupled simulations between the two flows and the solid body of the probe, currently in progress, can be initialized with the computed flow solution.

Finally a new stop condition based on the convergence of the heat fluxes has been implemented in the code to ensure continuity of both fluxes and temperature at the coupled interface.

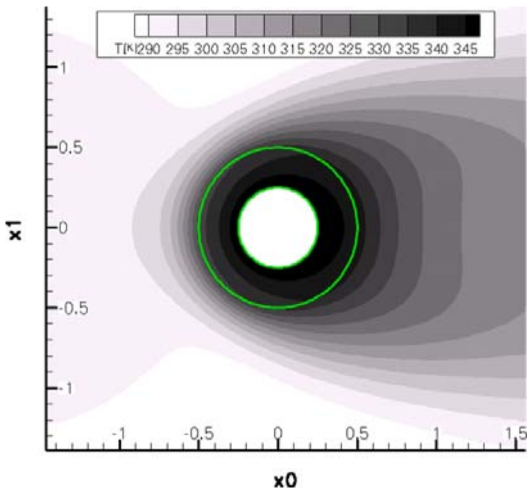

Figure 1: Coupled temperature field, compressible solver

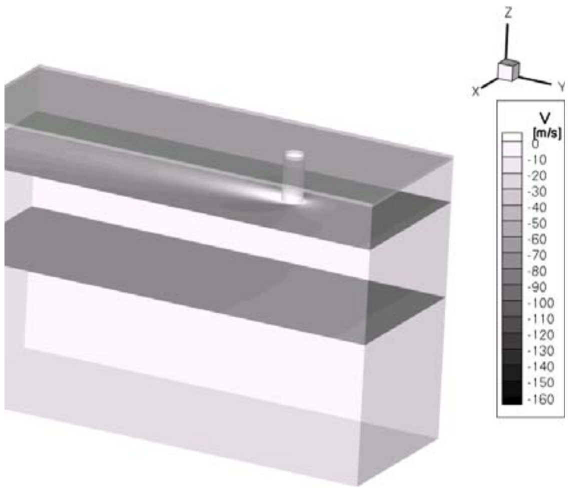

Figure 2: 3D probe, external flow