INTERACTION OF AN INNOVATIVE LP STATOR VANE WITH A TRANSONIC HP TURBINE STAGE

Sergio Lavagnoli, Italy
Supervisors: G. Paniagua & T. Yasa

The quest for higher performances and durability for modern aero-engines requires the understanding of the complex flow field experienced by the gas turbine stages. Ultra-high bypass ratio aero-engines with increased fan diameters demand a reduction of rotational speed to maintain an acceptable tip velocity. Hence, the LP turbine radius must be increased in order to keep an acceptable level of efficiency. Furthermore, to reduce the axial length of the whole machine, a swan-neck diffuser is adopted to link the HP turbine to the LP guide vane. In the frame of new engine architectures, an innovative stator for the LP turbine is proposed with a multi-splitter configuration. It contains small aero-vanes and large structural aerodynamic airfoils which are used to support the engine shaft and house service devices.

The current experimental research focuses on the investigation of the global performance, aerodynamics and heat transfer details of this novel HP-LP turbine layout. This analysis is of utmost interest to design very compact s-shaped transition ducts. The measurement campaign will be carried out in the large VKI compression tube facility which allows testing turbine stages under engine representative conditions. The turbine will be tested under two pressure ratios to investigate different flow field regimes to isolate the main sources of blade row interactions. Since the number of airfoils in the first and second stator is similar but not equal, it will be possible to distinguish and isolate the effects produced by each vane row on the rotor.

A new five-hole probe rake has been designed in order to improve the testing during the measurement campaign. Dynamic calibration of pneumatic pipes with different diameters has been performed. A novel approach for thermocouple measurements has been proposed, based on a three-wire probe. The idea is to determine on-line the time constants of the wires to allow a wider frequency response. Mass flow measurement data reduction procedure has been improved. Additionally, the feasibility of the installation of a flow meter for high accurate mass flow rate measurement has been assessed. Guidelines for the choice of the metering device have been given and a preliminary design is proposed.
Numerical resources have been used. CFD simulations provided by ONERA helped to understand the complex flow field features and to suggest improvements for the experimental methodology accordingly.

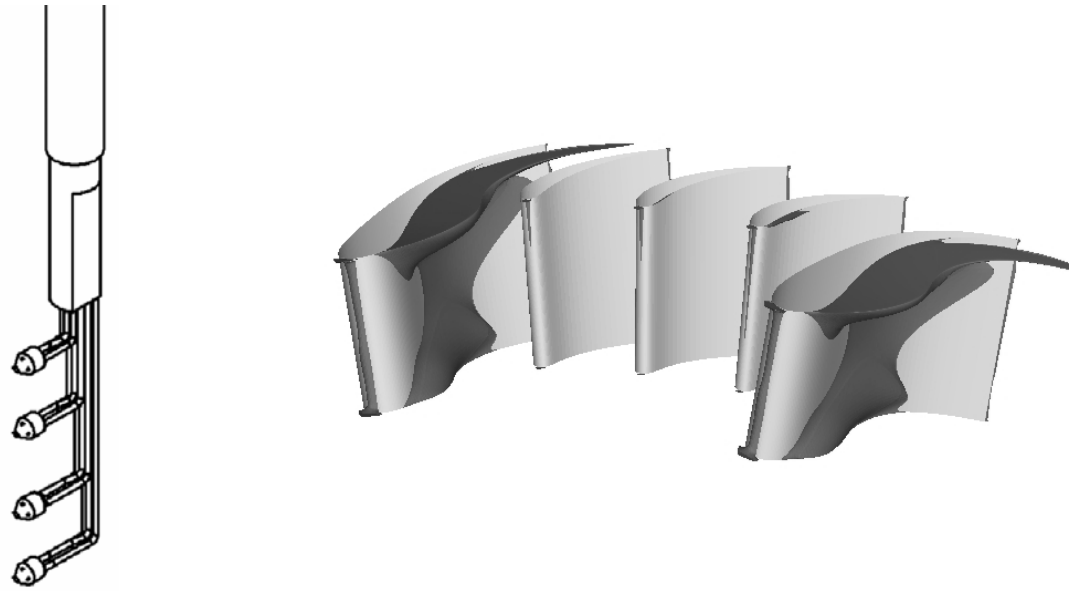

Figure 1: Novel 5-hole probe rake design (left) and CFD isocontours for the LP vane (right)