EFFICIENCY OF A COOLED HP TURBINE TESTED IN A COMPRESSION TUBE FACILITY

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Single stage high pressure gas turbines are developed to minimize the engine size and weight. Such highly loaded turbines often result in supersonic flows, implying net efficiency reductions due to shock losses and strong secondary flows. The exact relationship between turbine performance and design parameters is not yet comprehended due to the complexity of the flow field and unsteady flow field interactions. Hence, experimental and numerical studies remain necessary to understand the flow behavior at different conditions to advance the state of the art of the prediction tools.

In the frame of this thesis a methodology to accurately determine the efficiency in a transient facility has been developed. The compression tube rig (test duration ~0.4 s) allows testing the turbine at the temperature ratios, *Re* and Mach numbers encountered in real engines. The accurate measurement of the acceleration as well as those of the inertia and the rotational speed provides the shaft power. The inertia of the whole rotating assembly was accurately determined by accelerating and decelerating the shaft with a known energy. The efficiency of two turbines was measured. The investigation comprised two different vanes (cooled and uncooled), several rotational speeds and pressure ratios. The resulting levels of repeatability varied between 0.27% and 1% (for a 95% confidence level), being the global uncertainty affected mainly by the dispersion in the exit total pressure traverses. Figure 1-left presents the efficiency results in a Smith Chart obtained in this campaign compared with all previous results reported in the literature.

The effect of vane shock formations and the tip clearance were analyzed based on the experimental data, numerical tools and the loss correlations. The changes of blade and vane performances are measured at mid-span for three different pressure ratios which influence the vane and rotor shock mechanisms. The vane shock patterns were analyzed in detail at both hub and tip endwalls (see Figure 1-right). Further analysis is currently performed using the results of the numerical simulations to yield a better understanding of the flow field. Moreover, the blade forced response was computed using the unsteady pressure measurements in the rotor.

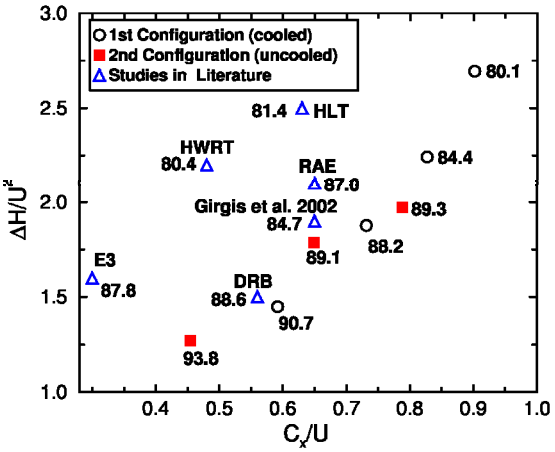

Figure 1: Turbine stage efficiency at various conditions

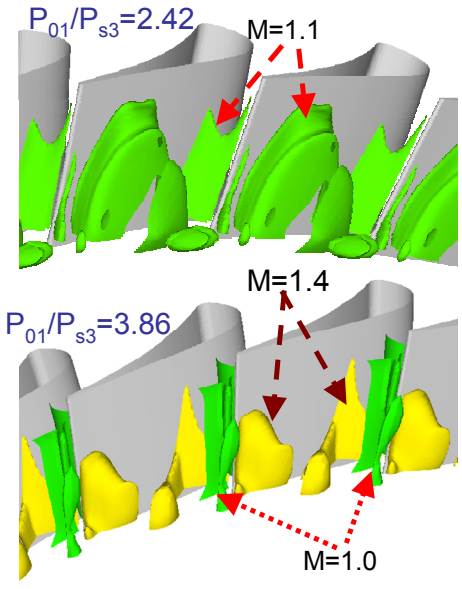

Figure 2: Mach iso-surfaces at vane exit at two different stage pressure ratios