AERODYNAMIC INVESTIGATION OF HUB DISK LEAKAGE AND PLATFORM COOLING IN A TRANSONIC TURBINE

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To achieve high specific power and cycle efficiency, the gas temperature at the High Pressure Turbine inlet of a modern jet engine is above the melting point of the metal. Active cooling is therefore necessary to preserve the mechanical integrity of the blades and ensure a reasonable engine life time. Two cooling techniques are studied here. On one hand, hub disk leakage prevents hot gas ingestion at the interface between the stator and the rotor. On the other hand, platform film cooling protects the engine by creating a thin layer of cold air at the surface the metal. The objective of this particular study is to assess the influence of those two techniques on the global flow field of a transonic high pressure turbine. In addition, a novel data reduction tool is developed to estimate the signals spectra by a data adaptive maximum entropy method.

The tests have been carried out in the VKI isentropic compression tube turbine facility, which allows full-scale tests at representative Reynolds and Mach numbers as well as pressure and temperature ratios. Five test conditions were devised to study of the effect of hub disk leakage, two different platform coolant blowing ratios, and the rotational speed. The turbine flowfield is investigated with numerous probes, instrumented blades, and fast response pressure transducers on the hub, the outer casing, and inside the hub disk cavity. Two blades are instrumented to measure the static pressure on the platform, and on the suction side at 15% of the span. A third blade is instrumented on the leading edge with high frequency response Pitot probes at 15%, 50%, and 85% of the span.

The blockage effect of the coolant injected at the hub disk is perceived in the whole channel, and leads to a general decrease of the Mach number up to the tip. The measurements at the hub and inside the cavity reveal a pitchwise distribution of ejection and ingestion zones regardless of the net ingress, which is dictated by the vane shock system (see Figure 1). The blowing ratio influences the vane shock patterns which in turn affect the size of the ingestion regions. An increase of the coolant rate is shown to decrease the shock strength and move the shock impingement on the rotor crown to an earlier phase. On the rotor platform, the decrease in Mach number leads to a lower incidence and an extension of the high pressure zone both in front and behind the blade leading edge. The greater resolution of the Maximum Entropy Spectral Analysis is used to analyse the frequency content of short data samples with a better frequency resolution than the FFT. Downstream of the cooling holes and for high hub disk leakage rates, the governing phenomenon is found to be occurring at twice the vane blades passing frequency, possibly due to an interaction between the platform cooling and the coolant convected from the hub disk region.

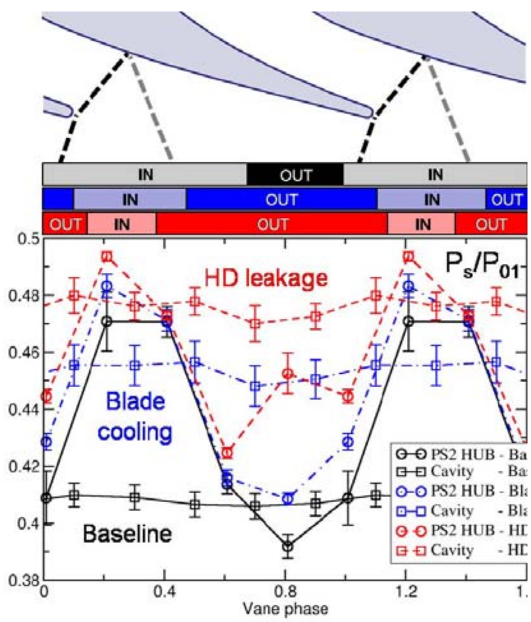

Figure 1: Coolant ejection and ingestion zones downstream of the stator