BLADE ROW INTERFERENCE AND CLOCKING EFFECT IN A ONE AND HALF STAGE TURBINE

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Modern aero engines require higher power to weight ratio and smaller specific fuel consumption. Each component of the gas turbine plays a role and a significant overall gain can be achieved only from improvements on the different components. This work focuses on the high-pressure turbine and in particular on the interaction between the first stage and the following stage. Because it is located downstream of the combustion chamber, the high-pressure turbine operates in a harsh environment with turbine inlet temperatures between 1800-2000 K i.e. far above the melting point of the alloys used for the blades. For this reason, the high-pressure turbine parts are intensively cooled and in some cases, the stator of the next stage is also cooled.

The proposed research is mostly experimental and consists in investigating the aerodynamic and heat transfer in a one and half stage turbine. The turbine is tested under engine representative Reynolds number (10^6), Mach number, gas to wall temperature ratio and gas to coolant temperature ratio. Pressure and heat flux measurements were performed in order to obtain both steady and unsteady components of the flow field. Previous investigations focused on the interaction between the rotor and the stator of the high-pressure stage. The current work highlights the interaction between the high-pressure stage and the second stator. For this purpose, airfoils of the second stator are instrumented with pressure taps, fast response pressure transducers and thin-film gauges at 15, 50 and 85% span as well as the hub and tip endwalls. Additionally, several types of probes monitor the second stator inlet and exit flow field (total pressure, flow angle and temperature).

First, the effect of rotor blade passing events on the flow field of the second stator was quantified and explained. The second stator ingests a number of non-uniformities coming from the preceding stage like wakes, secondary flows, and pitchwise static pressure gradient since the rotor exit Mach number is M=0.9. One of the key results consists in the strong similarities between the pressure fluctuations and the unsteady heat transfer measured on the second stator (Billiard, et al. 2005).

The second part of the investigation concerns the stator-stator interaction. Indeed, downstream of the first turbine stage, there exist non-uniformities linked to the first stator. For this reason, the relative position of the second stator with respect to the first stator influences the second stator flow field. Both time-averaged and time-resolved flow field were investigated for 4 clocking configurations. It appears that clocking has a strong influence in term of heat transfer rate, with a lower heat transfer rate for *Clocking 1* (Figure 1).

Finally, CFD computations will help to understand the physical phenomena. A quasi-3D unsteady Navier & Stokes solver developed at the University of Florence by Adami, Belardini and Martelli has been validated against experimental data in stage alone configuration. First results in one and half stage configuration are encouraging. They will be used to investigate in details the time-resolved flow field of the turbine and help the understanding of the interactions and clocking effects.

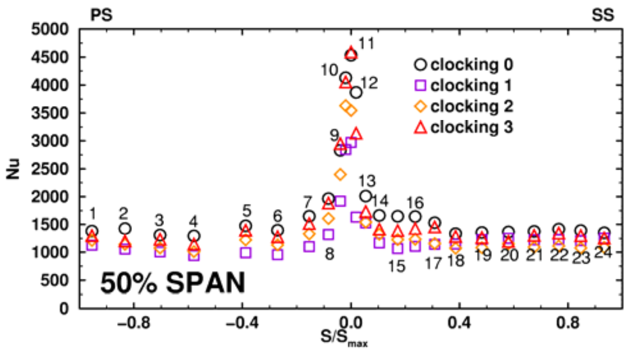

Figure 1: Nusselt distribution at 50% span of the second stator

Billiard, N.; Paniagua, G.; Dénos, R., 2005: Effect of clocking on the heat transfer distribution of a second stator tested in a one and a half stage HP turbine, ASME paper GT2005-68462, Turbo Expo 2005, Reno, NV, USA