AERODYNAMIC PERFORMANCE OF TWO VERY HIGH LIFT LOW PRESSURE TURBINE AIRFOILS (T106C – T2) AT LOW REYNOLDS AND HIGH MACH NUMBERS

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A detailed experimental analysis of the effects of Reynolds number on the aerodynamic performance of two very high lift, mid-loaded low pressure turbine blades (T106C and T2) is presented in this paper. The study was held on a large scale linear cascade in the VKI S1/C high-speed wind tunnel operating at fixed high exit Mach number (0.65) with a range of low Reynolds numbers (80,000-200,000). This facility allows an accurate reproduction of the operating conditions encountered in low pressure turbines of modern aero-engines. Aerodynamic upstream and downstream boundary conditions are accurately quantified in order to provide the necessary input for code validation. The two airfoils are characterized by a high pitch-to-chord ratio, implying a significant diffusion, and therefore risk of separation, along the rear suction side.

Besides the investigation conducted for steady, uniform inlet conditions, the simulation of incoming periodic passing wakes was performed by an upstream high-speed rotating bars system providing an engine-similar inlet velocity triangle (or flow coefficient). Depending on the operating Reynolds number, the rear suction side flow is characterized by a more or less important separation bubble. The bursting phenomenon of the bubble is clearly demonstrated. The control of the separation is tentatively addressed by means of passive local roughness. Its effect on loss performance is also demonstrated.

The overall aerodynamic loading of both airfoils was evaluated based on measurements at blade mid-span by static pressure taps (pneumatic and fast response transducers) and hot-film sensors (pseudo shear stresses). The effect of the separation bubble on the isentropic Mach number distribution is demonstrated. Space-time diagrams show the periodic effect on the boundary layer of the incoming periodic wakes. The pitch-wise traversing of a pneumatic 5-hole probe downstream of the cascade allows evaluating kinetic energy losses and flow deviation.

Besides the knowledge gained on unsteady transition and separation phenomena in low pressure turbines operated at engine similar operating conditions, the large variety of boundary conditions also provides a unique database for code validation dealing with separated flow transition at high Mach number and low Reynolds number in turbomachinery.

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