AERODYNAMICS OF LOW PRESSURE TURBINES

Today's evolution in gas turbine engines is to decrease the production and maintenance costs through a reduction of the total engine weight. One of the adopted solutions consists in reducing the number of blades keeping constant, or even increasing, the total amount of work per blade row. A high lift, high load design philosophy must therefore be applied. As a consequence, the suction side boundary layer undergoes severe adverse pressure gradients along the rear part of the airfoil. Considering the low Reynolds number environment prevailing in low pressure turbines, this could eventually lead to a heavy separation which will seriously hinder the blade aerodynamic performance. A careful control of laminar to turbulent transition is therefore of major importance. Moreover, global free-stream turbulence intensity and periodic incoming wakes will also play a big role on LP airfoils performance, and need therefore to be correctly simulated.

The continuous high speed facility S1 of the von Karman Institute is therefore equipped with a test section for aerodynamic performance determination of low pressure turbine blades mounted in a linear cascade environment (Fig. 1). This continuous, cold-flow, high speed cascade tunnel operates at Reynolds and Mach numbers similar to those encountered in the low pressure section of a modern gas turbine (Re : 20 … 300 103 …, M : 0.3 … 1.0). Static and total pressure, flow direction and free-stream turbulence characteristics are measure¬ed upstream of the cascade, time-averaged and time resolved wall static pressure and semi-quantitative skin friction measurements are performed along the airfoil, performance measurements are conducted downstream of the blade row by pneumatic or fast response probes. Provision is also made for periodic upstream wake/boundary layer interaction by means of a rotating disk equipped with small (up to 0.8 mm) diameter radial bars (Fig. 2) in order to restitute a correct flow coefficient. The test section dimensions are 225 x 500 mm (span x height), hosting airfoils with a chord ranging from 20 to 95 mm).

Several airfoils were studied in this facility, varying freestream Reynolds and Mach number, freestream turbulence intensity and reduced frequency of the incoming wakes. A significant part of these investi-gations were undertaken under EU-funded programs.

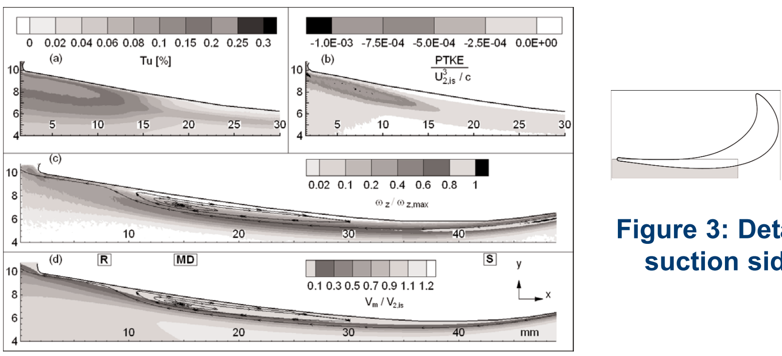

Figure 3: Detailed PIV measurements in the suction side separation bubble vicinity

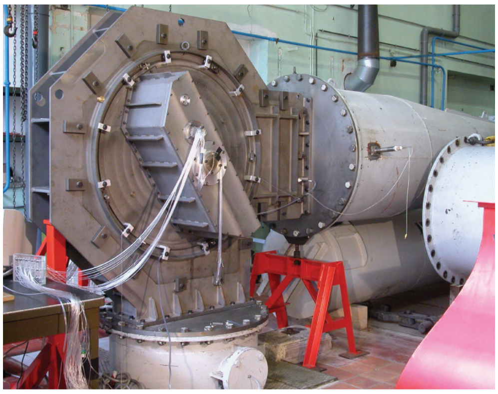

Figure 1: New cascade model in the S1 facility

Figure 2: Periodic wake generator

Parallel investigations are performed in the low speed C1 cascade facility, dis-carding the Mach number similarity, but allowing detailed flowfield measurements by means of PIV (Fig. 3). Providing a correct "low-speed" redesign of the airfoil, all the other similarity parameters are con-served.

The complementary character of these high and low speed investigations allows understanding the physics related to the aerodynamics of LP turbines.

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