EXPERIMENTAL INVESTIGATION OF THE T108 LOW PRESSURE TURBINE BLADE AT LOW RE NUMBER AND HIGH MACH NUMBER

Ayhan Nazmi İlikan, Turkey
Supervisors: T. Arts & J. Michálek

In modern turbo engines, the low pressure (LP) turbine has a crucial impact on the costs. Furthermore, the LP turbine weight is about 30% of the total engine weight. Recent developments promote use of high lift blades in LP turbines allowing a reduction of about 20 % in the number of blades, and consequently a reduction of the weight, manufacturing and operational costs and the specific fuel consumption. However, these blades are exposed to higher loads characterized by a higher velocity peak followed by a significant deceleration along the rear suction surface. These strong adverse pressure gradients cause boundary layer separation and subsequent very high losses.

This project follows a similar path to the one previously explored at the von Karman Institute by Houtermans, Paolucci, Monaldi and Michálek on high speed, low Reynolds number flows in low pressure (LP) turbines. In the present project, the new LP airfoil “T108” is investigated. It presents a very high lift and is front loaded. The project is linked to the EU contract TATMo (Turbulence and Transition Modeling for Special Turbomachinery Applications). The specific objective is to experimentally investigate the separation and the transition mechanisms on the suction side of the airfoil and to determine, and possibly understand, the evolution of the separation bubble and of the transition in terms of main flow parameters. This data is also to be used for validation of new transition models.

The measurements are performed in the VKI S1/C facility at high Ma and low Re number. A fixed linear cascade with six blades is used. Two instrumented blades are prepared. The suction side of the first one is equipped with 40 pressure taps to quantify the isentropic velocity distribution; the other blade is covered with hot-film sensors to obtain quasi-wall shear stress distributions. In addition, a pneumatic five hole probe is traversed in the pitch-wise direction to measure the local exit total pressure and blade-to-blade outlet flow angle. The measurements are performed both for steady and unsteady (periodic) inlet flow. The latter is obtained by installing a high speed rotating bar mechanism to simulate wakes generated upstream of the cascade.
The CFX software is used to provide a numerical prediction of the steady state test case. It is compared to the measurements. Apart from the measurements and the simulations, oil flow visualisation is also performed on the suction side of one of the blades.

The measurement results obtained from the hot-films and the pressure taps are used together to determine the positions of separation, pressure recovery, reattachment and transition onset. Correlations related to these parameters are then established and it is concluded that for most of the cases, the correlations agree well with the data in the literature. The comparisons of performance of T106 profile which was investigated before in VKI and T108 profile, show that T108 performs better than T106; and for T108, the separation bubble is suppressed completely in case of upstream wakes. The results from CFX software are compared to the results from the measurements and show consistent behaviour with the measurements.

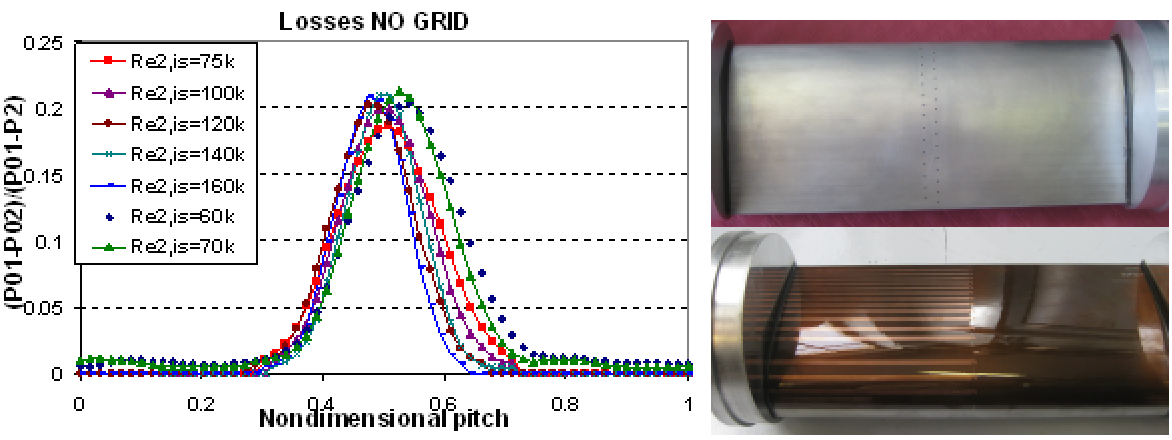

***Figure 1:** Left: Total pressure losses in pitch-wise direction for different Reynolds numbers*
***Right:** Blades instrumented with pressure taps and hot-film sensors*