AERO-THERMAL PERFORMANCE INVESTIGATION OF FIXED AND ROTATING RIB-ROUGHENED COOLING PASSAGES

In modern gas turbine engines, the continuous increase of power for an expected lifetime has resulted in a continuous increase of cycle pressure ratio and turbine inlet temperature. The latter implies that advanced materials and cooling techniques must be adopted for a safe operation of the HP gas turbine vanes and blades. Apart from the progress made in the metallurgical domain, a continuous cooling (convection, impingement and film) of the blades of the turbine first stages allows operating at temperatures which are far above the material's melting point, without affecting the component integrity and geometry. A complete and correct un-derstanding of the convection and conduction mechanisms associated to the applied cooling techniques is therefore of major importance.

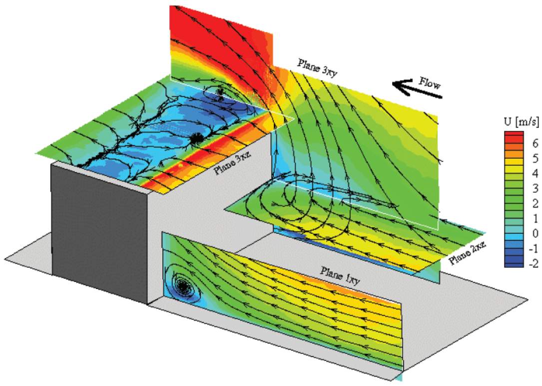

Figure 1: 3D flow topology upstream of a rib

Detailed aero-thermal investigations of the turbulent flow inside rib-roughened turbine blade cooling channels of various geometries have been con-ducted at the VKI. Inside these passages, the forced convection cooling process is significantly enhanced by the presence of ribs (turbulence promoters) installed on one or more walls of the channels. The effects of the rib size and orientation on the flow behavior and therefore on the heat transfer and pressure distribution along the channel walls, are closely related to the safe operation of HP gas turbine blades.

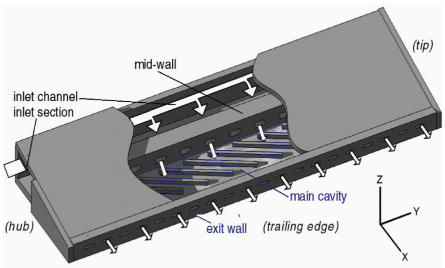

Figure 2: Complex trailing edge cooling model

The experiments are carried out on scaled up models of turbine nozzle or blade cooling channels, working in geometrical and flow similarity conditions. In many configurations, ribs are installed on one or several walls. Fig. 1 shows the time averaged flowfield devel-oping upstream of such a rib, obtained by Digital Particle Image Velocimetry.

More complex configurations are considered as well in order to combine several modes of cooling such as convection and impinge-ment, as presented in Fig. 2

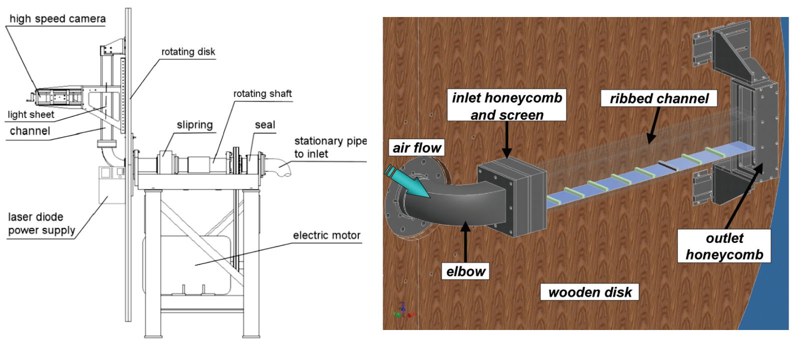

Figure 3: Rotating cooling channel model

Coriolis and buoyancy forces will play an important role when considering the performance of rotor blades. The rotating facility used for this purpose allows correct simulation of Reynolds and rotation numbers for measurements on leading or trailing ribbed surfaces (Fig. 3). The measurement chains are installed in the relative frame of reference, al-lowing the same resolution and accuracy as in a steady configuration. As an example, time resolved PIV is applied, making use of a continuous laser and a high speed camera.

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