AERODYNAMIC INVESTIGATION OF THE LEAKAGE FLOW FOR A BLADE WITH A SQUEALER TIP AT HIGH-SPEED CONDITIONS

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Modern high pressure turbines operate under high temperature conditions. Cooling of the blades is therefore an absolute necessity. The gap existing above a turbine rotor blade is responsible for an undesirable effect, called tip leakage flow. It is a source of high aerodynamic losses and high heat transfer rates. A better understanding of the tip flow behaviour is needed to provide a more efficient cooling design in this region.

Substantial research has been performed in the past at VKI, but work still needs to be carried out in investigating this phenomenon, especially with respect to the cooling flow. The objective of this project was to investigate the tip leakage flow for a blade with a squealer tip and film cooling applied on the pressure side in a non-rotating, linear cascade arrangement. The experiments were performed in the von Karman Institute Isentropic Light Piston Compression Tube facility, CT-2. The tip gap flow was investigated by two different approaches: qualitatively with flow visualization and quantitatively with static and total pressure measurements. These tests were performed for different flow exit conditions, namely at outlet Reynolds' numbers of 300 000 and 900 000, and at outlet Mach number of about 0.8.

The flow visualizations were performed by means of dots of oil mixed with titanium dioxide on the outer surfaces of the blade and the endwall, on the blade rim and inside the squealer. It enabled the observation of the different flow patterns such as separation, reattachment etc. Static pressure was measured along the outer surface of the blade, on the blade rim and inside the squealer while a downstream pitch-wise traverse with a three-hole probe determined the exit flow loss. Parallel measurements of the heat transfer are made in a companion project.

The main flow structure in the cavity was deduced from the pressure measurements and from the flow visualisation (see the figure below)*. Positive influence of the cooling application on the tip gap flow and on the aerodynamic losses was found. It was shown that increasing the coolant mass flow increases the tip gap flow resistance; the flow through the clearance slows down therefore the tip gap mass flow and in analogy the heat transfer decreases. It was also shown that injecting high momentum coolant into the tip gap flow decreases the aerodynamic loss.

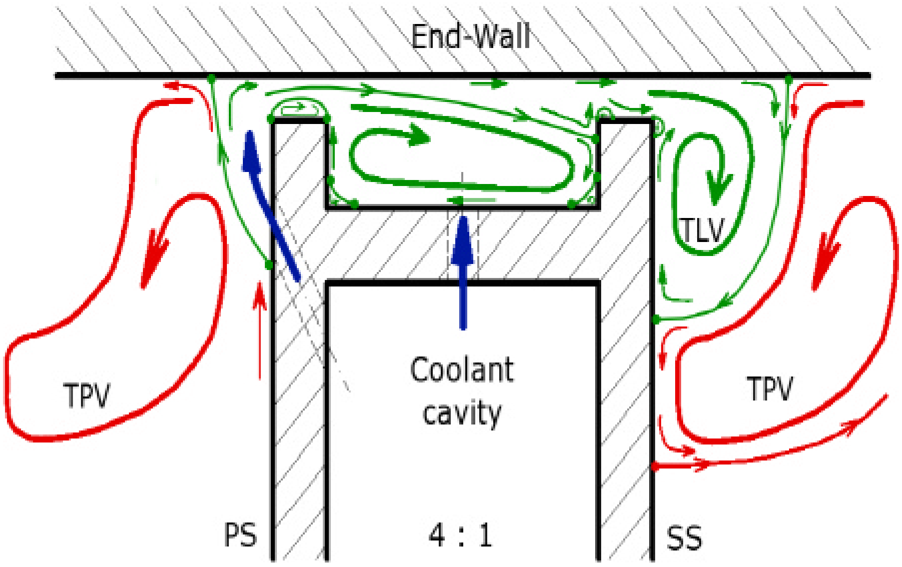

Figure 1: Deduced flow structure around the blade tip.

* This figure corresponds to a cross-section perpendicular to the camber line of the blade profile placed between two dust holes. Legend: PS-blade pressure side, SS-blade suction side, TPV-tip passage vortex, TLV-tip leakage vortex.