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

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This work deals with the aerodynamic performance of a high pressure turbine unshrouded rotor blade tip, which was equipped with four different squealer geometries, namely a full squealer, partial suction squealer, partial double sided squealer geometry and a so-called "at worn condition" geometry based on the full squealer tip geometry following the effects of the "blade life". As a part of a European project "AITEB-2" (Aerothermal Investigation on Turbine Endwalls and Blades) within an EU Framework 6, this research follows the previous works done at VKI on this topic. The measurements were carried out using the von Karman Institute Isentropic Light Piston Compression Tube Facility CT2 on a linear stationary blade row made of five blades. The blade model was a prismatic prolongation of the tip cross section of the TATEF high pressure turbine rotor blade. The experiments were done at four different flow conditions (combinations of downstream isentropic Mach number of 0.8 and 1.1 and Reynolds number of 300,000 and 900,000, corresponding to engine real state conditions).

Cooling as a substantial and essential equipment of any high pressure turbine blade in the first blade row was applied on the tip in two ways. One was the film cooling that took place along the pressure side of the blade tip and the other was represented by the dust holes, which normally avoid the coolant channels from being blocked by dust particles and which support the tip gap flow resistance. These were placed along the blade camber line of the tip. Each flow regime was investigated with respect to five different cooling levels including the test without cooling application for comparison.

The main pressure measurements were on the squealer bottom, on the inner side of the squealer rim, all around the blade tip and over the opposite end-wall. The losses and the downstream flow angle deviation were measured using a swan neck type three-hole probe. The results were compared within the different geometries. In parallel the measurements of the heat transfer were carried out using thin film gauges.

The flow visualisations were performed on the end-wall, on the blade pressure and suction side and on the blade tip surfaces. The visualisation itself was carried out by means of dots of mixture of a colourless oil and colour pigment. Five different colours were finally used (red, blue, yellow and green) including white (titanium dioxide). This way the traces of the paint on the surfaces got highly contrasted and the flow structures on the walls turned to be more apparent. Thanks to this, the flow in the vicinity of the walls was better understood and eventual anomalies could be discovered and linked to the pressure measurements.

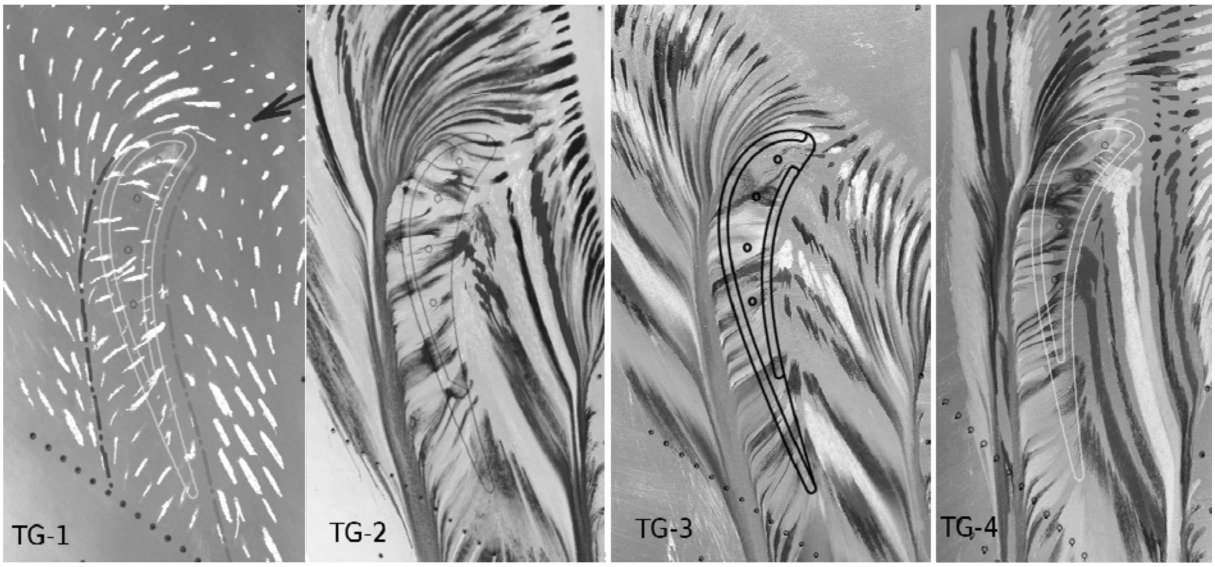

Figure 1: Flow visualisation at downstream high Re and low Ma number condition