AEROTHERMAL ASPECTS OF TIP FLOWS

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The flow through the tip gap of a gas turbine rotor blade is a source of high aerodynamic losses and high heat transfer rates. The objective of this project is to investigate the tip leakage flow for 2 different tip geometries: a flat tip and a squealer tip. Experiments are performed in the von Karman Institute Isentropic Light Piston Compression Tube facility, CT-2, at two Reynolds number conditions (450,000 and 900,000) and two exit Mach number conditions (0.9 and 1.1) for a tip gap height of 1.34% of blade height. This represents the first high-speed tip flow data for the flat tip and squealer tip geometries. Static pressure measurements are made at the inlet and exit of the cascade, and the inlet endwall boundary layer profiles are obtained to provide proper boundary conditions for CFD calculations. Static pressure measurements are made on the blade tip, blade surface, and on the corresponding endwall. Aerodynamic losses are computed using total pressures measured downstream of the cascade by a traverse of a 3-hole pressure probe which has been dynamically calibrated.

Flow visualization performed with an oil and titanium dioxide mixture provides valuable information of the flow on the tip and near-tip surfaces. While the main flow through the tip gap of the flat tip blade (Figure 1) travels from pressure to suction side, there is also a region just downstream of the leading edge region where the flow along the tip actually travels in the streamwise direction. For the squealer tip blade (Figure 2), flow visualization results are in line with a recirculating flow within the squealer tip cavity where the flow on the cavity floor is moving from suction side to pressure side.

Static pressure measurements made on the endwall over the blade tip show that the squealer tip provides a significant decrease in velocity through the tip gap with respect to the flat tip blade. The flat tip blade shows a region of high velocity extending downstream of the leading edge region. For the flat tip, an increase in Reynolds number causes as much as a 30% increase in tip velocity levels, but the squealer tip is relatively insensitive to changes in Reynolds number. The only region of the endwall where the squealer tip does not result in lower overall velocities compared to the flat tip is near the leading edge. Flow visualization results show evidence of flow impingement existing near the leading edge of the squealer cavity.

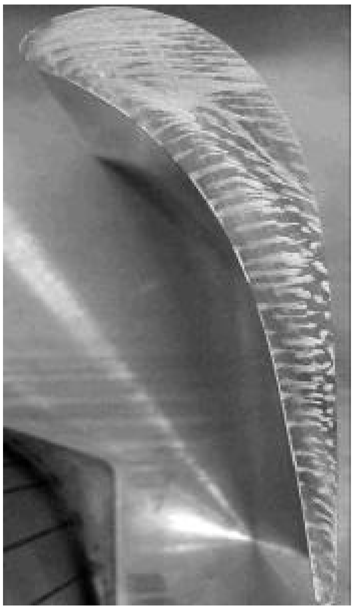

Figure 1: Flow visualization of flat tip blade

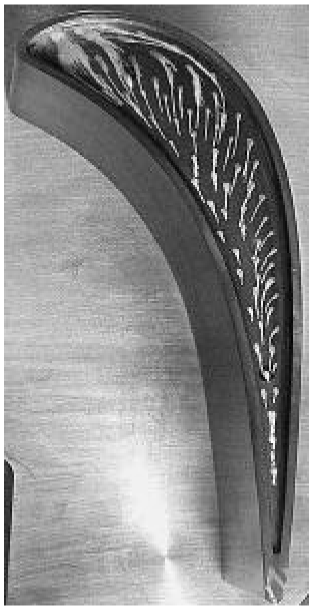

Figure 2: Flow visualization of squealer tip blade