Stereo PIV Measurement of Flow Structures underneath an Axial-Slot Casing Treatment on a One and a Half Stage Transonic Compressor

C. Brandstetter¹, M. Kegelj¹, F. Wartzek², F. Heinichen³, H.-P. Schiffer¹

1: Institute of Gas Turbines and Aerospace Propulsion, Technische Universität Darmstadt, Darmstadt, Germany
2: Rolls-Royce Deutschland, Dahlewitz, Germany

* Corresponding author: brandstetter@glr.tu-darmstadt.de

Keywords: Stereo PIV, Turbomachinery, High Speed Compressor, Casing Treatment

In this publication, a very effective Casing Treatment (CT) design with half heart-shaped axial slots is investigated using Stereo Particle Image Velocimetry. The Casing Treatment was applied to a transonic one and a half stage compressor test rig with variable inlet guide vanes. The setup is representative for a state of the art high speed compressor front stage. The CT design intent was solely aerodynamic, requiring a complex optical setup (Fig. 1 and Fig. 2) to generate optical access. Three component velocity data were recorded on a tangential plane at 92% relative channel height under and between Casing Treatment slots, as well as in the blade passage downstream of the slots. A complex field reconstruction technique was applied to generate data in the rotor relative frame. Results clearly depict the shock system and the secondary flow structures for different operating points on the design speed-line (Fig. 3). The measurements are compared to results of previous measurements of the smooth wall configuration, showing significant changes of the tip leakage vortex structure, which has a big influence on aerodynamic stability. Measured shock locations at different operating points show good agreement compared to unsteady wall pressure measurements performed in previous investigations. The reduction of shock detachment through the CT is confirmed quantitatively. This value is critical for blockage development and aerodynamic stability and may now be compared to numerical simulations. The filling and ejection process of the CT is resolved at different rotor relative positions. Therewith, the real working principle of the CT is resolved through insight into the critical rotor area.