SECONDARY FLOWS AND PERFORMANCE OF AN OUTLET GUIDE VANE CASCADE AT TWO DIFFERENT TURBULENCE INTENSITIES

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This paper presents a detailed experimental investigation of the evolution of secondary flows and losses in a low pressure turbine/outlet guide vane (LPT/OGV) cascade. These vanes are found downstream of the low pressure turbine in turbojet engines, and are responsible for turning the inlet swirling flow from the low pressure turbine into an axial outflow, whilst minimising pressure losses. This is of prime importance with both cost and weight being reduced in modern turbojets resulting in a reduced amount of stages in the LPT which in turn increases the loading on the OGV's.

This experimental study was carried out in a linear cascade at Chalmers University. The experiments are performed for the inlet conditions with engine-like properties in terms of Reynolds number, boundary-layer thickness and inlet flow angles with the goal to provide high quality benchmark cases for the flow field around aggressive designs LPT/OGV's to be used for validation of numerical codes. The flow quality is assessed by measuring inlet uniformity, boundary-layer heights, periodicity of the static pressure distribution around the OGV's and uniformity of the outlet flow [1]. Results presented here are obtained with 5-hole pneumatic probes [2] and cross hot-wire probes [3]. This allows for the determination of the mean vortical structures, their development and their interactions. The turbulence level seems to play a role on both the mixing within, and between the structures. The measurements also show that the losses along the blade span are dependent on the development of these structures.

Figure 1 presents the experimental results at two different turbulence intensities at 30° inlet flow angle, which is the on-design point. The boundary layer on the sidewall, accumulated boundary layer vorticity (corner vortex) and the blade shed vorticity are clearly visible. Their intensity is shown to be strongly dependent on the inlet flow angle. Figure 2 presents similar results at same Reynolds number and 40 degrees inlet flow angle. In addition, our results also show the interaction of these structures and how they evolve as they move downstream. The effect of increased turbulence seen to play an important role in the diffusion of the vortical structures as well as their interactions. These findings are then related to the main flow characteristics, including velocity, pitch angle, losses, turbulence intensity and Reynolds stresses. Subsequently this result in an understanding of the significance of the secondary flows and how they affect the efficiency of turning the flow in numerical calculations [4].

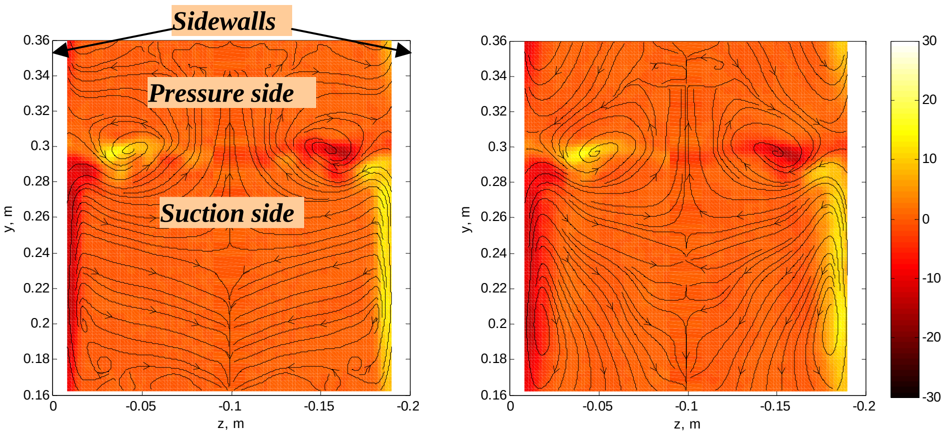

Figure 1. Streamwise vorticity distribution with superimposed streamlines downstream of the cascade at *x* = 0.5*C* and inlet flow angle 30° (design case). Left: at 0.5% turbulence intensity, right: at 5% turbulence intensity.

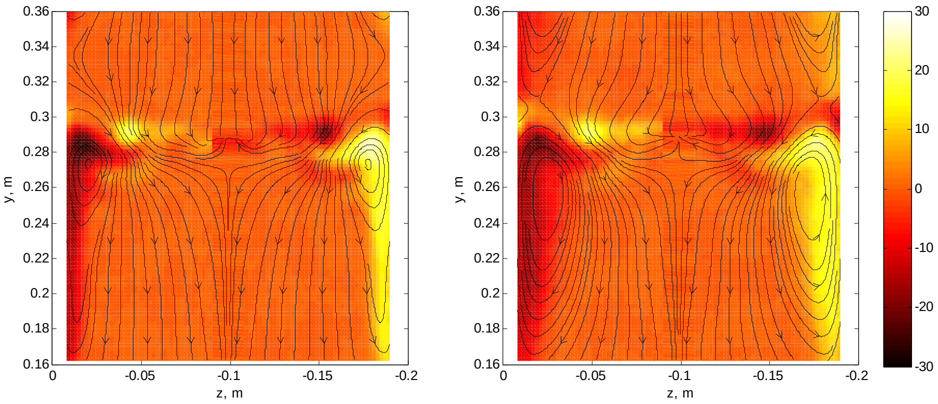

Figure 2. Streamwise vorticity with superimposed streamlines downstream of the cascade at *x* = 0.5*C* and inlet flow angle 40° (off-design case). Left: 0.5% turbulence intensity, right: 5% turbulence intensity.

REFERENCES

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