# LOW REYNOLDS NUMBER FLOW
# WITH HEAT TRANSFER IN ROTATING CHANNELS

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The flow in micro gasturbines impellers and cooling channels of large turbine blade is characterized by low Reynolds number, Coriolis forces and a considerable heat transfer. Performance analysis and optimization of those devises are possible only if the Navier- Stokes solvers correctly account for those phenomena. The RC-1 facility has been specially built to provide accurate high resolution data for software evaluations.

The facility consist of a rotating divergent channel of .7 m length mounted on a rotating disk to reproduce an impeller passage while respecting the main scaling parameters: Reynolds number from $3{\cdot}10^3$ to $3{\cdot}10^4$, Rotational number between 0. and 0.3 and Buoyancy number up to 0.73 (at 1 m/s fluid velocity and 80°C wall temperature) can be achieved. Covering the transparent walls with a layer of Indium Tin Oxide allows heating of the walls up to 80.$^o$C while conserving the transparency of the walls. Replacing the divergent channel with a parallel walled channel allows the simulation of a cooling channel.

Detailed flow measurements are possible by means of Particle Image Velocimetry in which the light sheet is produced by means of a continuous laser diode and images are taken with a high- speed camera, both rotating with the channel. The main advantage of this system is a direct and hence more accurate measurement of the relative velocity and the time accurate measurement of the flow variations. For the first time an insight to flow structures in a rotating flow was obtained (Fig 1). Isotropic vortices can be identified rotating at a relatively large distance from the wall. The vorticity distribution in the boundary layer near the pressure side concentrates on a hairpin vortex. "Dependent circular bootstrapping" was used to obtain statistical quantities with related errors. This technique, known in the econometric community, was applied for the first to correlated time- resolved PIV data. Measurements show that the suction side boundary layer thickens almost linearly with rotational number. Positive Richardson numbers on the suction side indicate a stabilization of the flow. The peak turbulence intensity shifts away from the wall with increasing rotation with only small changes of its peak value. The pressure side boundary layer thickness rapidly decreases for small rotation numbers but remains almost unchanged for larger values. The turbulence intensity on the pressure side concentrates closer to the wall with increasing Ro giving rise to an increase of its maximum value at the wall. The measured velocity distribution in the inviscid part has a smaller gradient than predicted by the potential flow theory.

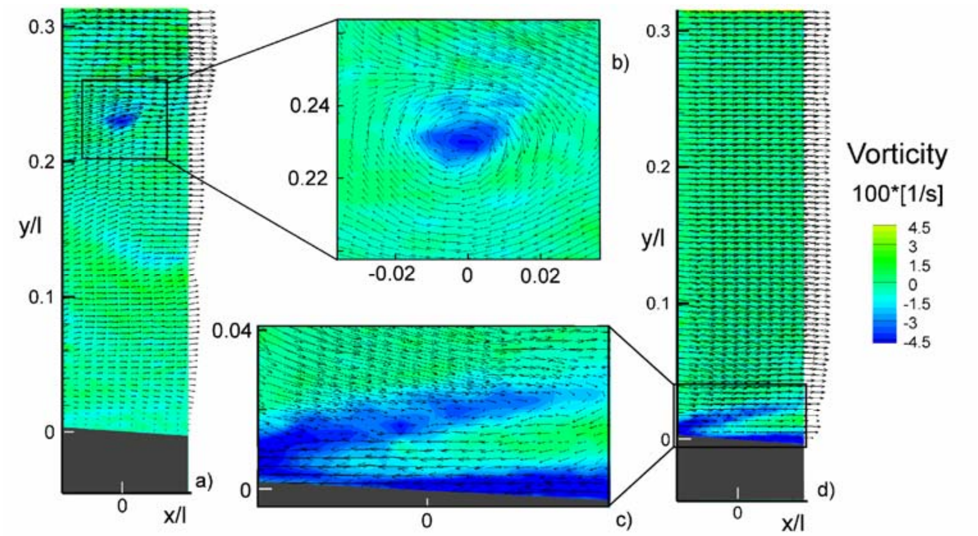


***Figure 1. Instantaneous velocity vectors near suction (a) and pressure (b) side for Ro= 0.52 and detail of the vortical structures after subtraction of the vortex core velocity (b) and (c).***