DEVELOPMENT OF DOPPLER GLOBAL VELOCIMETRY
IN TURBOMACHINERY FLOW

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Since the innovative idea of Komine [1] of a field optical measurement technique, increasing interest is growing in the development and application of Doppler Global Velocimetry (DGV) as a tool for fluid dynamic laboratories. The application of non-intrusive measurement techniques in the study of the flow dynamics in turbomachinery is appealing for the possibility of applications both in steady and in rotating components. The advantage of DGV over the point wise Laser Doppler Velocimetry (LDV) lies in the capability of being a field technique, and it differs from Particle Image Velocimetry (PIV) because it can easily retrieve the three components of velocity and because of the faster image processing needed, which makes DGV an almost on-line technique. The knowledge of 3D flows in turbomachinery is vital in the understanding of secondary flows.

DGV is a system to measure velocity of particles crossing a laser sheet: the scattered Doppler shifted frequency of light is analyzed in order to retrieve the velocity of the tracer particles. An absorption line of the molecular iodine is used as a frequency to intensity converter: the light going through iodine vapor strongly depends on the light frequency, and light intensity measurements are easy to perform with photodiodes or cameras. The spectroscopic knowledge of the iodine absorption versus light frequency allows the detection of the Doppler shifted frequency and therefore the particle velocity. An existing Argon-ion laser has been modified to allow precise control of the laser frequency: a servo motor has been mounted on the intracavity etalon in order to increase the tilting angle resolution and accuracy. Hence calibrations of the iodine cells were possible at lower etalon tilting speeds. The possibility of fine controlling the etalon and of moving one of the cavity mirrors, leads to the calibration of the iodine cell in a continuous way. The comparison with the previous calibrations, which were only performed in a discrete way, is presented in figure 1. An active control of the cavity length has been added to the laser in use, in order to stabilize the natural frequency drift: the signal coming from a reference iodine cell is used as input to a PID circuit that displaces a cavity mirror.

The promising results obtained in the core of a jet with velocity ranging from 40 to 120 m/s encouraged the further step towards real turbomachinery flow measurements. In order to get advantage of the ability of the technique to retrieve the three components of velocity, secondary flows downstream of a turbine cascade will be measured. A new turbine cascade test section has been designed, manufactured and mounted on the C3 blow down wind tunnel of VKI. Special care has been taken to provide optical access to the laser beam and the receiving optics. A single camera with an appropriate optical set-up is used to record both the signal and the reference images. The sketch of the test section presented in figure 2 shows the cascade, the optical access for the receiving optics, the table on which the receiving optics will be arranged, and the table for the optics which will direct the laser beam into the test section.

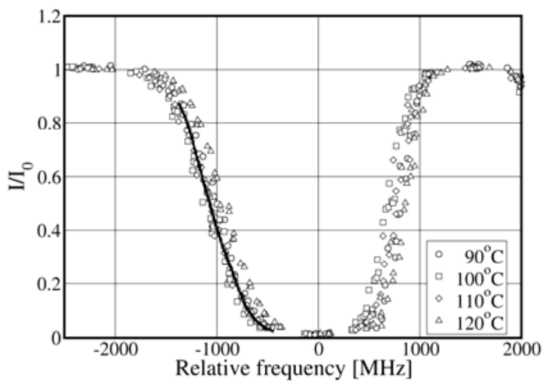

Figure 1. Iodine absorption line

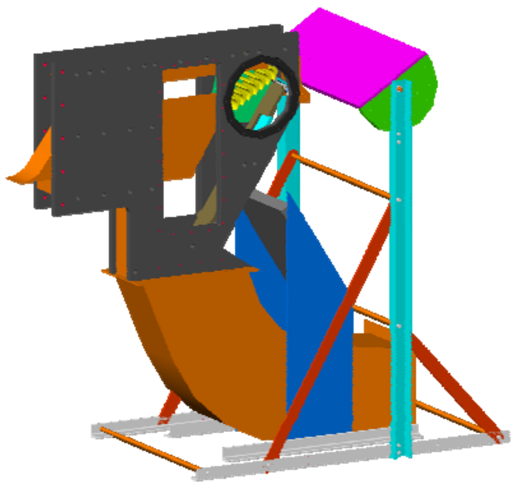

Figure 2. Sketch of the test section

[1] Komine H. 1990, System for measuring velocity field of fluid flow utilizing a laser-Doppler spectral image converter. US-Patent No. 4.919.536