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EFFECT OF ROTATION TO THE CYCLONE COOLING METHOD MASS TRANSFER MEASUREMENTS

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Due to the ever rising demand for high specific thrust and thermal efficiency, turbine inlet temperatures have reached values well above the melting temperature of currently available turbine blade materials. In order to guarantee sufficient component life at gas temperatures of 1600K to 1900K, sophisticated blade cooling systems have been developed during the previous two decades. In general these cooling systems are supplied with compressor air, which is first passing through an internal blade passage system and then it is ejected through numerous film cooling holes in the wall of the stator aerofoil. The film holes are designed such that the ejected air builds a cooling film downstream of the hole exit which shall protect the surface against the hot gas of the turbine annulus. The first stator of a **H**igh **P**ressure **T**urbine (HPT) is the component which requires the highest amount of cooling air because it is located right at the exit of the combustion chamber and therefore has to cope with the highest gas temperatures, especially with the non uniformity of the gas temperature distribution. A cooling mass flow of 6 – 10% relative to the turbine inlet mass flow is quite normal for the inlet stator aerofoil. Most of this air will be guided to the leading edge and trailing edge region of the stator. These are the areas with the highest heat load, mainly due to the peak heat transfer coefficients in these areas.

The cooling mass flow for blade cooling is lost for the cycle. So an increase of the internal heat transfer leads to the possibility to save coolant, which now can take part at the cycle. An improvement of the internal cooling method is desirable. In the past a lot of methods to increase the internal heat transfer were developed, so there are ribbed channels, pin fins or the impingement cooling for example. A new method for this is the so called cyclone cooling. Cyclone Cooling means that a swirl is impressed to the coolant.

To increase the heat transfer with swirling flow is well know. In relation with blade cooling Hay and West [1975] did experiments with a swirl chamber with a tangential inlet and an axial outlet. They varied the cross section of the inlet and the angel relative to the chamber axis. They found that the heat transfer could be eight times higher than the normal tube flow at the entry. Chang and Dhir [1995] investigated the flow field in a swirl chamber with tangential injection and found that the reason for the rise in heat transfer is the radial pressure gradient and the high turbulence. There are much more proceedings dealing with this topic, for example Glezer et al [1996] and Hedlund et al [2000] but there is only one known where swirling flow was investigated in a rotating system. This is Glezer et al [1998]. A round channel with tangential inlets over the complete height of the channel was mounted in a rotating rig and the change in heat transfer coefficient was measured with the help of an infrared detector. They figured out an influence of the coriolis force to the heat transfer augmentation by varying the position of the tangential feed holes. The investigations were made with only one geometry.

In this paper the effect of rotation on the mass transfer in a cooling channel with swirling internal flow will be presented. A comparison to the axial pipe flow under rotating conditions will be given like

shown in Fig. 1. The results will be given for several swirl numbers and over a spectrum of rotation numbers from 0 to 0.36 based on the hydraulic diameter of the pipe. The Reynolds number is varied between 10.000 and 40.000 which is typical for a turbine leading edge.
The used model is shown in Fig. 2. It is mounted in the rotor of the rotating rig, shown in Fig. 3.

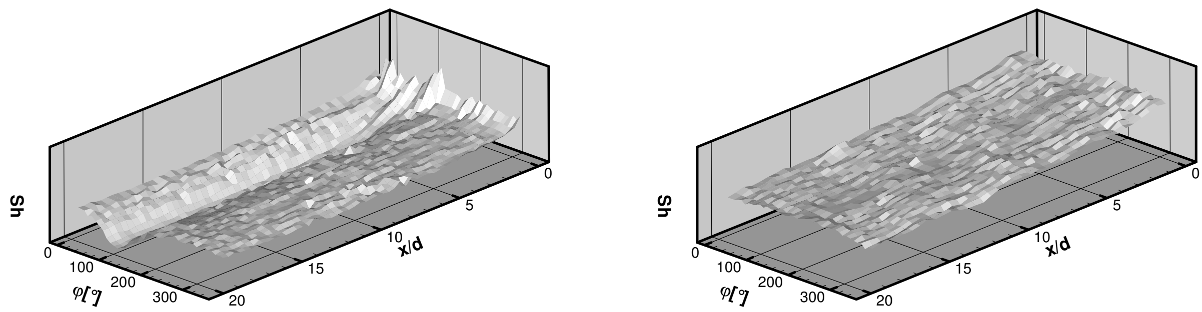

Fig. 1 Axial pipe flow vs. swirling flow under rotating conditions

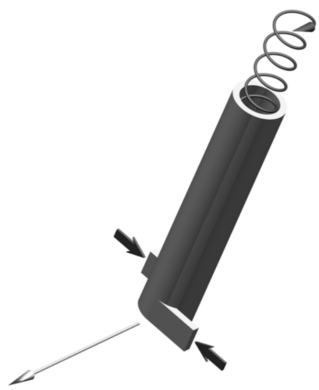

Fig. 2 Schematic model of the test section

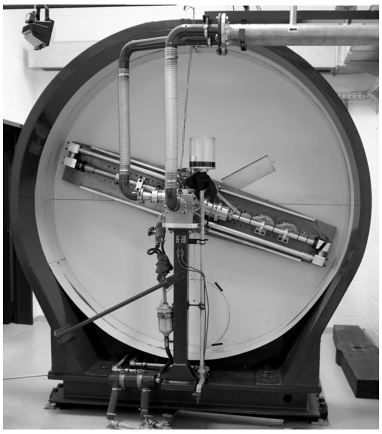

Fig. 3 rotating rig

In order to measure the mass transfer the naphthalene sublimation technique is used at the rotating rig. Background for using this technique is the analogy of heat and mass transfer.

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