EXPERIMENTAL INVESTIGATION OF FLOW CHARACTERISTICS INSIDE AN AXISYMMETRIC CAVITY OF A SHROUDED SINGLE-STAGE COMPRESSOR USING A FIVE-HOLE PROBE

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ABSTRACT

The present study constitutes an experimental study of the 3-dimensional flowfield inside the axisymmetric cavity of a shrouded single-stage compressor. The aim of this work is the experimental investigation of the flow characteristics created at the inlet and outlet of the cavity as well as its impact on the main flow that passes through the blades.

INTRODUCTION

The test rig contains an open, low speed wind tunnel, which serves as a mass flow generator, an axisymmetric cavity with a profile of sudden enlargement at the inlet and sudden contraction at the outlet and the compressor stage. The wind tunnel consists of a bellmouth intake nozzle, flow conditioning elements, variable geometry exit nozzle and fan stacks that generate mass flow. The mass flow can be controlled by either changing the power supply of the fans or the position of the exit nozzle.

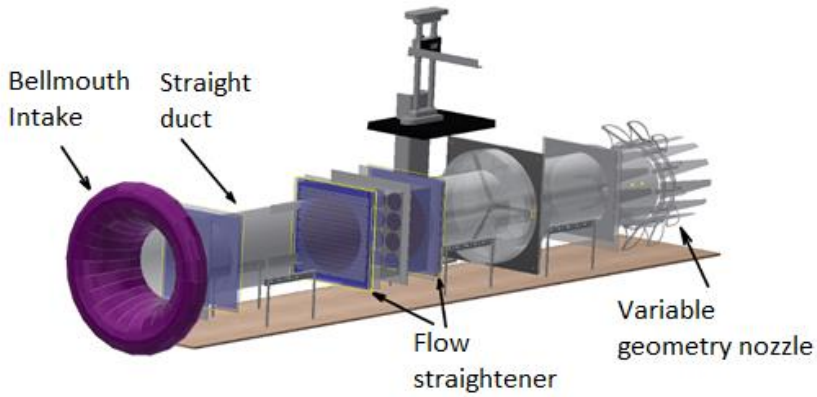

Figure 1. Experimental setup used for measurements

The measurements inside the flow-field were conducted with a 5-hole Cobra-shaped probe which its miniscule dimensions make it suitable for highly 3-dimensional flows measurements. The probe was calibrated and demonstrated good overall behavior concerning its accuracy. So, it is considered reliable within a ±30° range for both angular planes. Reduced uncertainty of measurements can be achieved if the probe is used within a ±20° range, which is highly suggested. The measurement procedure consists of three different cases. In the first case, the blades are stationary and the measurements are conducted in a plane perpendicular to the main flow direction (r-θ plane). Aim of that set of measurements is to extract the pressure and velocity fields along the compressor stage as well as inside the cavity. The second case contains the measurements taken in a plane parallel to the main flow and perpendicular to the compressor (r-x plane). Supplementary measurements were taken in this case to create the flow's vorticity fields. The third case represents the rotating stage experiment. Measurements were taken downward the stage. This led to the extraction of pressure and velocity profiles along the radius of the stage and inside the cavity.

RESULTS AND DISCUSSION

Results showed that a 3-dimensional flow between the opposite sides of the blades was spotted where part of the fluid moves from the pressure side to the cavity and another part moves from the cavity to the suction side. Furthermore, a structure of vortices was found downward the shroud in the form of a counter-rotating vorticity dipole. That dipole moves downward to the cavity affecting both the toroidal vortex of the corner and the main flow exiting the compression stage.

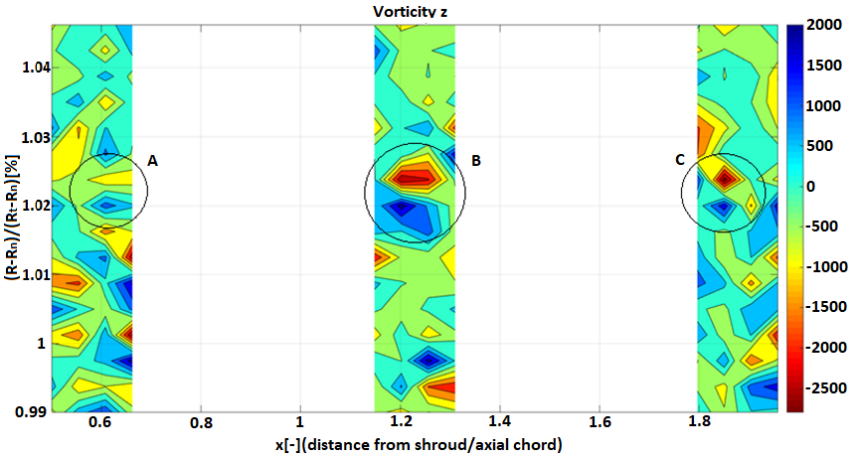

Figure 2. Iso-lines of tangential vorticity

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