BOUNDARY LAYER SEPARATION CONTROL ON A COMPRESSOR AIRFOIL

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In order to increase the efficiency of an engine, decreasing its weight can be considered. Reducing the number of blades in a stage is an answer for weight reduction. However, decreasing the number of blades will also decrease the solidity. Thus the blades will experience separation earlier.

After decreasing the weight of compressor by reduction of blade number, the new parameter for performance increase comes out to be control of boundary layer separation. This study is based on active control of boundary layer separation.

In order to control boundary layer separation, transition of the boundary layer is required. Introducing roughness close to leading edge of an airfoil is a passive control technique which will always be present in the flow. Active control provides transition only in case of separation.

Active control of boundary layer is based on suction or blowing of air on the blade surface. Momentum of boundary layer is enhanced by vortices and on the suction surface, separation delay or reattachment of the separated flow is possible. One of the most effective techniques is fluctuating air injection on the suction surface of blade, by taking the advantage of Coanda effect.

In order to inject air on the airfoil surface, small scaled devices are advantageous. In this study, Micro-Electro-Mechanical Systems (MEMS) which refer to micrometric-millimetric devices are intended to be utilized.

MEMS integrate electronics with mechanical components, usually combining sensors, actuators. They can actuate mechanically on the micro scale, individually or in arrays, to act on the macro scale. MEMS employed in this study are self oscillating micro-valves. They provide fluctuating air jet without additional energy supply. These micro-valves are composed of a micro channel covered with flexible membrane and not surprisingly they are manufactured in atmospheric conditions. However, cascade tests for this study will be conducted in vacuum conditions. This is the first time to operate micro-valves below atmospheric pressure. Hence, determining the behaviour of the devices both in atmospheric and vacuum conditions are in the scope of this study. Devices should resist to vacuum conditions for long time and the characteristic should be consistent both in atmospheric and below atmospheric pressures.

Geometry of an enclosure to install micro-valves into a compressor blade is also in the scope of this study. A casing is designed preliminary to airfoil tests. Dimension of the casing is possible to be installed into an airfoil. Hence, a similar cavity in the blade will be required to install micro-valves in and fix them on the suction surface, then close the pressure surface.

Next step of this study will be conducting experiments on cascade which will be below atmospheric pressure. Reattachment of the boundary layer and wake region behind the blade will be investigated under the effect of micro-valves.

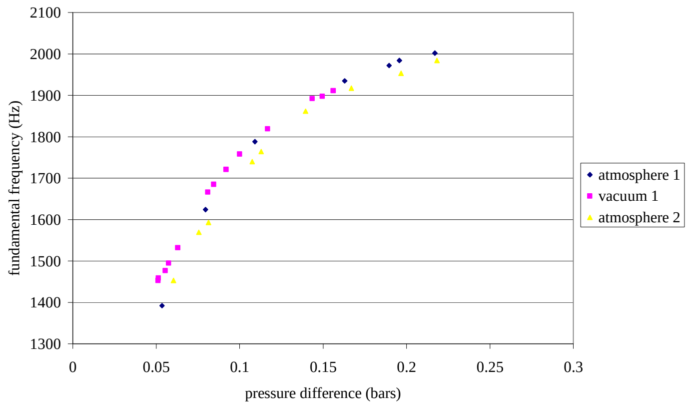

Figure 1: Fundamental frequency distributions for Micro-Valve

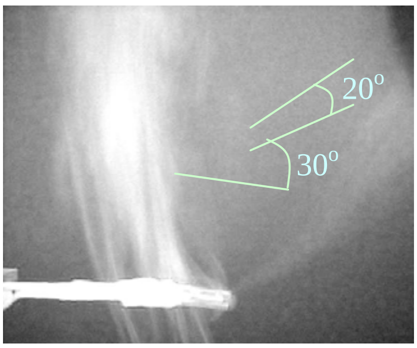

Figure 2: Deviation and aperture of the jet