OPTICAL AND HOT-FILM MEASUREMENTS OF THE BOUNDARY LAYER TRANSITION ON A NACA AIRFOIL

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ABSTRACT

In this study, possibilities are explored of identifying position of a boundary layer transition using hot film measurements complemented by classical optical methods i.e. interferometry and schlieren method. The subject of the measurement is a NACA 0010-64 airfoil with varying leading edge surface quality corresponding to smooth surface and rough surface with Ra ~ 50 and Ra ~ 100. Measurements are performed at several subsonic regimes and a transonic regime.

Despite several shortcomings of the experimental setup, the method proved to be useful in providing information on the boundary layer transition. Measurements show that in the case of smooth leading edge, the onset of the boundary layer transition shifts upstream with increasing inlet Mach number and the major portion of the boundary layer is transitional. This is in accordance with other published results on the boundary layer transition on this kind of airfoils [1]. In all cases with rough leading edge, the complete transition takes place on the rough portion of the surface already.

INTRODUCTION

Development of a boundary layer on blade surfaces and its transition from laminar to turbulent is an important aspect of the design of turbomachinery bladings. It is important mainly in transonic and supersonic regimes of operation when a boundary layer interacts with a shock wave. In such cases, the turbulent boundary layer is preferable at the point of interaction as it can withstand larger pressure gradients than the laminar boundary layer. This plays role namely in the case of rotor blade tip sections of transonic compressors and the last rotor tip sections of large steam turbines. The latter operate at supersonic regimes and interaction of the inlet shock wave with the pressure side boundary layer takes place in the relatively short and narrow interblade channel, thus having significant impact on the main flow. [2]

Additionally, real shape and surface quality of a real blade profile may be significantly different from the nominal design due to manufacture or erosion. Therefore, possible changes in the shape and surface roughness should also be taken into account during the design. Yet, this may be a problem for CFD solvers which are nowadays vastly used in the design process. Transitional turbulence models do not always satisfactorily predict the boundary layer transition when an increased surface roughness is present. Thus, the existing transitional turbulence models need to be enhanced and their performance validated on a particular geometry of interest and at particular flow conditions. Therefore, introductory measurements of the boundary layer transition were done on an isolated airfoil NACA 0010-64 with the intention to measure the boundary layer transition on supersonic tip sections of large output steam turbines in the future. Experience with the measurement and its results are described in the paper.

REFERENCES

[1] Bertelrud, A. (1998). Transition on a Three-Element High Lift Configuration at High Reynolds Numbers, AIAA paper 98-0703

[2] Luxa M., Příhoda J., Šimurda D., Straka P., Synáč J. (2016). Investigation of the Compressible Flow through the Tip-Section Turbine Blade Cascade with Supersonic Inlet. Journal of Thermal Science., Vol. 25, Issue. 2, pp. 138-144.