# EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE BOUNDARY LAYER TRANSITION ON THE PRISMATIC TURBINE BLADE

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## ABSTRACT

The paper presents the detection of the laminar-turbulent boundary layer transition on the prismatic turbine blade. Experimental results are compared with the numerical simulation. Experiments are performed on the linear blade cascade in the closed-loop wind tunnel, which allows investigation of this phenomenon on different isentropic outlet Mach and Reynolds numbers. The infrared thermography and hot-film anemometry was used to detect the boundary layer transition. The experimental results were than compared with the results from the numerical simulations using different transition models performed by in-house numerical code which is equipped with the algebraic bypass transition and separation induced transition model.


## INTRODUCTION

Kinetic energy is dissipated due to the viscous forces that are connected with the presence of the turbine blades in the flow field. These losses are strongly dependent on the boundary layer (BL) character on the blade surface and also on the BL separation in subsonic flow. Intensive experimental and numerical researches are being carried out because of dependency between turbine efficiency and these losses. Many experimental methods and numerical models for the investigation of the BL transition can be used. In the experimental fluid mechanics hot film anemometry (Gomes at al. [1]) or infrared thermography (Saric and Zuccher [2]) can be mentioned. For numerical simulation transition models were developed and now are frequently modifying and supplementing, see e.g. Straka and Příhoda [3] or Susan and Huang [4].

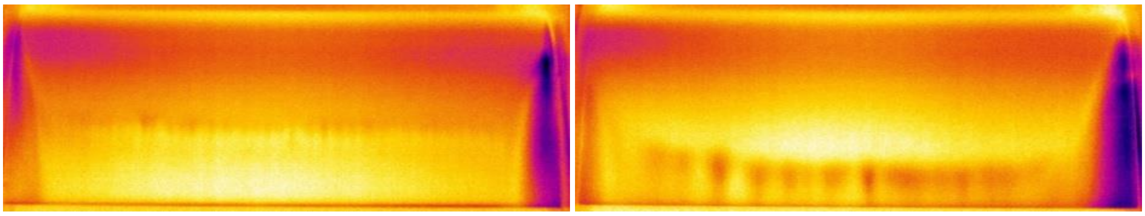
The BL transition was investigated for several flow regimes defined using isentropic Mach and Reynolds numbers. Hot film anemometry (HFA), infrared camera and numerical simulations were used for the investigation of this phenomenon.

Experiments were performed on a linear cascade model with the prismatic blade that was manufactured from low thermal conductivity material. Low thermal conductivity of the blade was the key for the best results, because heat transfer from the HFA to the blade was minimized and temperature differences between places with laminar and turbulent BL on the blade surface were not washed up.

For comparison with CFD prediction an in-house numerical code based on finite-volumes method, which is equipped with the algebraic bypass transition and separation induced transition model, is used.

## RESULTS AND DISCUSSION

Visualization of the BL transition is shown in Figure 1. Isentropic Mach number at the outlet of the blade was $M_{2is} = 0.6$. Isentropic Reynolds number were set $Re_{2is} = 7.5\times10^5$ (Figure 1a) and $Re_{2is} = 2.5\times10^5$ (Figure 1b). Significant shift in the position of BL transition can be observed (with decreasing $Re_{2is}$ BL transition moves downstream, closer to the trailing edge). Moreover corner vortices were detected as regions with lower temperature on both sides of the blade.



a) b)

**Figure 1.** Visualization of the BL transition for $M_{2is} = 0.6$ a) $Re_{2is} = 7.5\times10^5$, b) $Re_{2is} = 2.5\times10^5$.


## REFERENCES

[1] R.A. Gomes, S. Stotz, F. Blaim, R. Niehuis, Hot-film measurement on a low pressure turbine linear cascade with bypass transition, *Journal of Turbomachinery*, Vol. 137, 2015.

[2] S. Zuccher, W.S. Saric, Infrared thermography investigations in transitional supersonic boundary layers, *Experiments in Fluids*, Vol. 44, 1, 2008.

[3] P. Straka, J. Příhoda ,Application of the algebraic bypass-transition model for internal and external flows, *Conference proceedings, Experimental Fluid Mechanics*, TU Liberec, 2010

[4] Y.B. Suzen, P.G. Huang, Modeling of flow transition using intermittency transport equation, *Journal of Fluids Engineering*, Vol. 122, 2000.