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NUMERICAL SIMULATIONS FOR GAS TURBINE NOZZLE GUIDE VANE WITH FILM COOLING AND VORTEX GENERATORS JETS

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Streamwise vortices (SV) have been known already for a very long time to play an important role in flow control methods. Typical vortex generators (VG) are usually of the fixed type (vane type). Fixed type VG are preferred until now because of their reliability and maintenance free work. The vane type vortex generators (VG) with different shapes are very well known and they are the most often mounted in adequate regions of airfoils. The advantages of such approach is reliability and easiness of installation or service, but they have not been used in the turbomachinery because of the danger of the VG vane element detachment from the blade. Already in the 70's it was shown that vortex generators jets (VGJ) are of the same effectiveness as fixed VGs even in supersonic flows. In the 90's the research on VGJ was continued in subsonic flow regime (Compton and Johnston, 1992), (Johnston et al., 2002).

Application of VGJ in turbomachinery needs very careful consideration because of the flow structure complexity, especially if the cooling flows are applied. VGJ have been tested experimentally and numerically for low pressure turbine by (Volino et al., 2009) or (Ibrahim et al., 2009). An aerothermal impact of VGJ on a linear turbine blade cascade under the influence of film cooling at different Mach and Reynolds numbers are analysed by (Gomes and Niehuis, 2010).

The paper presents numerical investigations for highly loaded nozzle guide (Fig.1). The geometry was designed and investigated experimentally and numerically within a framework of AITEB-2 project. The measurements were conducted in the High-speed Cascade Wind Tunnel of the Institute of Jet Propulsion at the University of the German Federal Armed Forces Munich (Gomes and Niehuis, 2010).

The simulations were done for the cascade at different operating conditions with film cooling (FC) rows and vortex generators jets as the flow control device. Numerical simulations are performed with FINE/Turbo NUMECA solver. The mesh was generated in IGG/Numeca for the cascade configuration including FC and VGJ holes and plenum for cooling and flow control devices. Due to the mesh size limitation, the periodic slice including the necessary number of FC and VGJ holes is investigated . It means that the sidewalls effects are neglected and the periodic boundary conditions in spanwise direction are applied. The mesh cells number varies from 4.7M to 8.2M dependently of the FC and VGJ holes number. The simulations are done with Spalart-Allmaras turbulence model.

Isentropic Mach number at the midspan and loss coefficient for different flow conditions were compared with experimental data (Gomes and Niehuis, 2010). An example of the isentropic Mach number distribution for datum case (without FC and VGJ) is shown in Fig. 2.

Influence of the film cooling flow and vortex generator jets for different pitch (distance in spanwise direction) on the heat transfer coefficient is also presented (Fig.3).

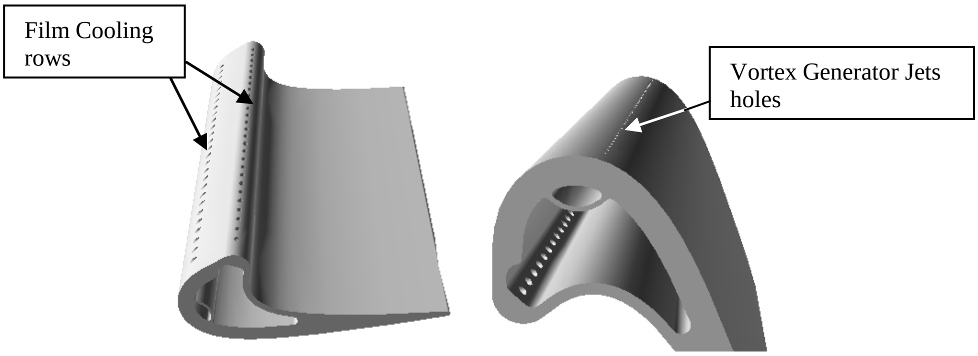

Fig.1 Nozzle guide vane profile with film cooling rows and VGJ

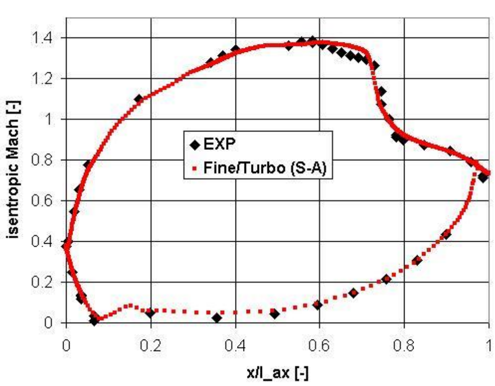

Fig. 2 Isentropic Mach number
FC off – VGJ off
Ma = 0.87 Re = 800k

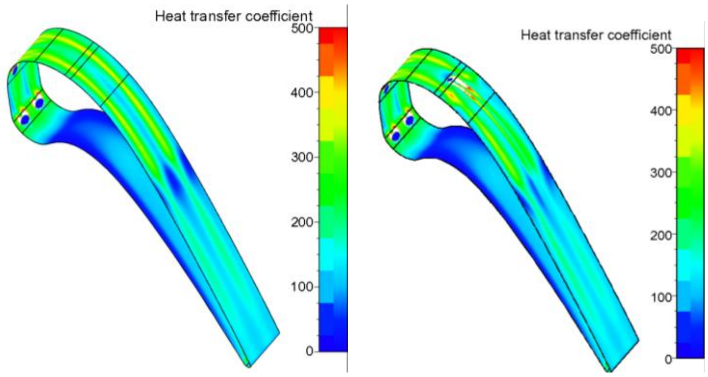

Fig. 3 Heat transfer coefficient
FC on – VGJ off (left) and FC on – VGJ on (right)

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