HEAT/MASS TRANSFER CHARACTERISTICS ON TURBINE SHROUD WITH BLADE TIP CLEARANCE

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ABSTRACT

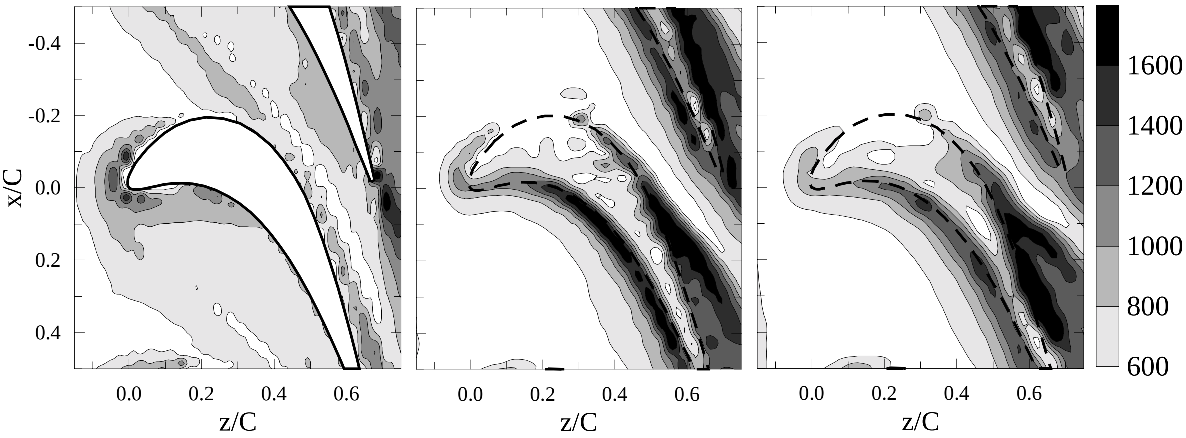
The clearance between the tip of the rotating component (compressor or turbine blade) and the shroud is unavoidable in gas turbine engines. The leakage flow across the gap is caused by the pressure difference between the pressure side and suction sides of blade. The leakage flow can have significant effects both on the stage aerodynamic performance and also on the structural durability of the blade[1].

In the case of turbine blades, hot spots may occur in the blade tip and shroud regions. Therefore, the cooling schemes, as film cooling, are applied to improve the durability of the components. Thus, understanding of heat transfer characteristics at the blade tip and shroud is required for effective cooling of components required to improve durability.

However, very limited experimental data have been reported in either stationary or rotating cascade environments[2]. The present study is conducted to investigate the local heat/mass transfer characteristics on the turbine shroud with blade tip clearance for the stationary linear cascade.

Many researchers have reported that the relative motion has little influence on the overall heat transfer characteristics, except on some local effects[1-2]. Therefore, the relative motion between the blade and shroud is neglected in this study. A naphthalene sublimation method is employed to determine the detailed local heat/mass transfer coefficients on the surface of the shroud. To help understand heat transfer characteristics more precisely, flow visualization and measurements are performed inside the clearance gap and downstream of blade for observation of the flow characteristics involved.

Figure 1 shows the contour plots of heat/mass transfer coefficients on the shroud for various gap distances. The results with no gap are shown in Fig. 1(a). The heat/mass transfer characteristics with no gap distance have been reviewed by many researchers[3-8]. As one can expect, the heat/mass transfer enhancement due to horse-shoe vortex is observed at the leading edge of blade. As flow goes, passage vortex is generated, and the region with high heat/mass transfer is formed along the suction side of the blade. Additional peak values caused by the generation of wake at the trailing edge are observed. With gaps between the blade tip and shroud (Figs. 1(b) and 1(c)), the flow enters the gap at the pressure side due to the pressure difference. Therefore, the heat/mass transfer characteristics on the shroud are changed significantly. At first, high heat/mass transfer occurs along the profile of blade at the pressure side due to the entrance effect and acceleration of the gap flow.



(a) With no clearance gap (b) Gap = 1.5 mm (c) Gap = 3.0 mm

Fig. 1 The contour plots of Sherwood number on the shroud with various clearance gap

Then, the heat/mass transfer coefficients on the shroud increase along the suction side of the blade because tip leakage vortices are generated and interact with the main flow. The results show that the heat/mass transfer characteristics are changed largely with the gap distance between the tip of turbine blade and the shroud.

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