Experimental Study of Film Cooling Performance on Turbine Guide Vane with Optimized Hole Arrangements in a Transonic Annular Sector Cascade

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Long Abstract

Turbine guide vane is one of the hot components operating under the extreme condition of quite high pressure and temperature, in gas turbine engines since today's gas turbine engines are designed to have extremely high pressure ratio and turbine entry temperature. Therefore there are many concerns on the cooling of the guide vane and the researches on the cooling improvement have been carried out extensively. One of the possible way to improve the cooling performance is adopting optimized cooling hole arrangement on the guide vane surface, especially on the pressure side surface. In the present study, the film cooling performance on the turbine guide vane was estimated experimentally for optimized cooling hole arrangements.

Figure 1 shows the schematic diagram of the experimental facility and test cascade. The mainstream and the secondary air for cooling are supplied by 500hp and two 50hp compressors, respectively. To measure the film cooling effectiveness on the surface, the transient measurement method was used with two sets of IR camera systems. The tests were conducted at mainstream exit Reynolds number ranging from 7.6×10^5 to 2.7×10^6 and the coolant blowing ratio from 0.5 to 1.5. The mainstream temperature was maintained about 20°C above the room temperature for the transient method.

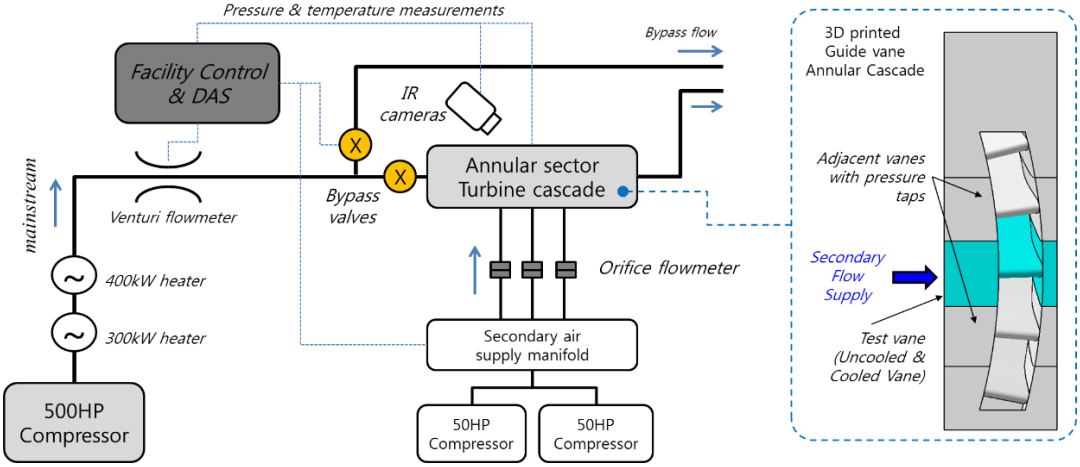
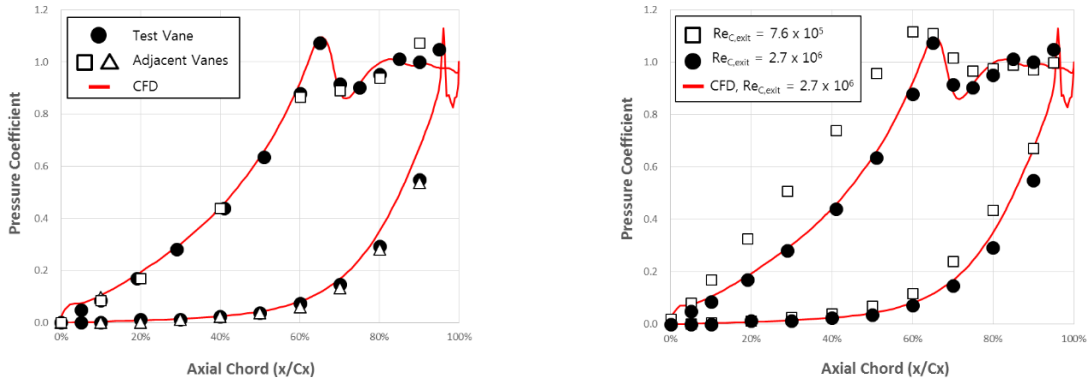
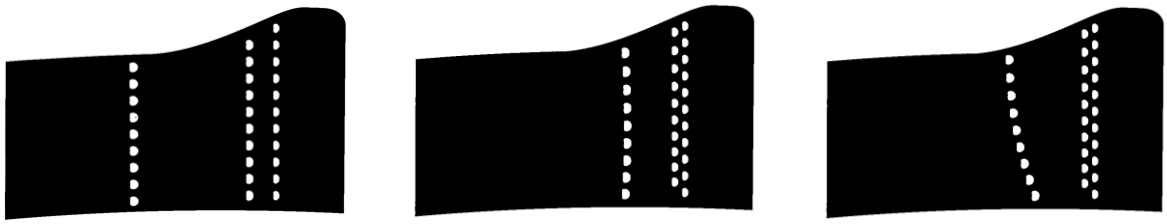


Figure 1. Schematic view of transonic turbine cascade facility and test cascade



(a) periodic flow check at design condition (b) effect of different Reynolds numbers

Figure 2. Pressure coefficient distributions at mid-span on the nozzle surface



(a) Case 1 (b) Case 2 (c) Case 3

Figure 3. Film cooling hole arrangements on the pressure side surface of the guide vane

The pressure coefficients, (Pt – Ps)/(Pt-Ps,exit) on the guide vane surface are presented in Fig. 2. Fig. 2(a) confirmed flow periodicity around the test nozzle in a transonic condition. The pressure distribution difference between subsonic and transonic conditions is clearly observed in Fig. 2(b). Figure 3 presents various film cooling hole arrangements investigated in this study. Case 1 is the baseline geometry of the film cooled guide vane. Case 2 and 3 are derived from the design optimization results of film cooling effectiveness given by Lee et al.[1]. In this study, detail measurements of film cooling effectiveness for various hole patterns were carried out and the experimental results of film cooling effectiveness were compared with numerical simulation results.

References

[1] S. Lee, D.H. Rhee, Y.S. Kang, D.Y. Seo, J. Kim, K. Yee, Optimization of Film Cooling Hole Array on Pressure Side of HPT Nozzle for Enhanced Cooling Performance," Proceedings of 2015 APCATS, Paper No. 140219, 2015.