Investigation of Effect of Turbulence Intensity on Cross Injection Film Cooling at the Endwall of a Vane

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ABSTRACT

This research concerns with a film cooling technique applicable to the protection of the endwalls of a vane. The way film cooling works is to provide a layer of coolant air which effectively separates the vane and the endwalls from the hot-gas environment so that the wall material can be protected. To better simulate the situation in real engines, turbulence intensity is considered in the present study. In the experiments, cross injection coolant flow with offset centerlines was utilized to form better film cooling effectiveness. The test model is a two-half vane. A computational fluid dynamics (CFD) package was used to simulate the pressure distributions of a linear cascade and a two-half vane counterpart. The opening size of the side gaps in the two-half vane model is determined based on the comparison of the simulation results. The levels of turbulence intensity used in the experiments are T.I. = 1.8%, 7%, and 12%. Other parameters considered in the film cooling experiments include three inlet Reynolds numbers, three blowing ratios (0.5, 1.0, and 2.0), and a forward-facing or a backward-facing endwall step. Thermocromic liquid crystal thermography with steady-state experiments were used for the measurement of the film cooling effectiveness.

Results show that increasing turbulent intensity decreases film cooling effectiveness. The reason for that is the interaction of unsteady, high-turbulence main stream with the injection coolant which disrupts the film coverage, causing the film cooling effectiveness to decrease.

Keywords : cross injection、film cooling effectiveness、liquid crystal thermography、turbulent intensity、endwall

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