Effects of an Entrance Step on the Performance of Film-Cooling Holes with Compound Angles at the Endwall of aGas Turbine

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ABSTRACT

In the existing literature for such a problem, all researchers used smooth walls for hot gas passage. Thus, boundary layer developed along the endwalls before reaching the leading edge of the first stage guide vanes. After that, the flow of hot gas is affected by the pressure distribution in the passage between adjacent vanes and forms complex tree-dimensional flow field. In reality, however, the structure of transition nozzle connecting the combustor chamber and the first stage vanes could be very complicated. The matching of the exit of the transition nozzle and the annular endwalls of the vanes may have relative displacement due to thermal expansion of different materials, causing an entrance step for the hot gas entering the vane passages. The size of the entrance step, which may vary with the load of a gas turbine, will influence the three-dimensional flow downstream. This research will adopt the way of steady state heat transfer experiment with liquid crystal thermography. At the same time, it will use three compound-angle film cooling holes and set Reynolds number. Then, the blow ratio is adjusted to M= 0.5 and 2.0. Placing the no entrance step as the standard, the experiment uses forward entrance step and backward entrance step to represent the displacement of a transition nozzle due to the thermal expansion. The result shows that when the condition of forward-facing entrance step exists, it will reduce the film cooling effectiveness. On the opposite, when the condition of backward-facing entrance step exists, it will increase the film cooling effectiveness. However, there is totally different phenomenon of film cooling between suction side and pressure side of endwall. When the condition of backward-facing entrance step exists, increasing the blowing ratio will increase the film cooling effectiveness. Yet, when the condition of smooth entrance step and forward-facing entrance step exists, increasing the blowing ratio will reduce the film cooling effectiveness. The condition of compound angle can improve the increasing of film cooling effectiveness greatly, especially the forward-facing compound angle.

Keywords : entrance step ; endwall ; film cooling effectiveness ; steady state heat transfer experiment with liquid crystal thermography

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