Numerical Investigation of Effectiveness of the Film Cooling Technique with Cross Injection at the Endwall of a Straig o

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ABSTRACT

This research employs numerical computation to investigate the performance of cross injection cooling technique as applied to the endwall of a straight or a curved duct. Three Reynolds numbers of the main flow are used in the computation, they are 62500,125000 and 250000. The free-stream temperature is fixed at and the coolant temperature is kept at . Each pair of coolant injections have orientation angles and an inclination angle . The separation distance of each pair of holes in the cross stream direction is 0D (Configuration 1), 1.5D (Configuration 2), 3D (Configuration 3), and 4.5D (Configuration 4), and the double-row holes are 4D apart in the mainstream direction. The blowing ratio is set to be 0.5, 1, 2, 3, 4, and 5. Finally, holes of different shapes for each pair are also investigated in the computation. Results show that Configuration 1 has the best film cooling effectiveness in both straight and curved ducts, followed by Configuration 4 and then Configuration 3. Configuration 2 is the worst one. At low blowing ratios, cross injection does not contribute much to the formation of vortices. At high blowing ratios, clockwise (CW) vortices have better cooling effect on the endwall than counterclockwise (CC) vortices. However, the liftoff phenomenon of the injected coolant is already visible. The CC vortices cool more endwall area near the suction (convex) wall, while most of coolant of CW vortices may also cool part of the pressure (concave) wall. When the secondary flow structure is destroyed by the cross stream pressure gradients in the far downstream region, the straight duct flow has better cooling effect than the curved duct flow. The above trends also hold when the coolant holes have different shapes.

Keywords : offset impinging cooling jets ; endwall ; film cooling effectiveness

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