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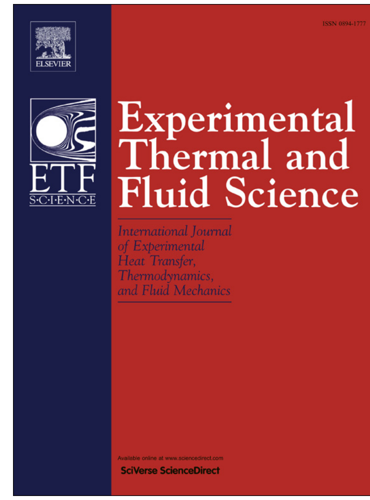

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Slot Jet Impingement Cooling of a Concave Surface in an Annulus

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Abstract

Experimental and numerical studies have been carried out for slot air jet impingement cooling of a concave heated surface in an annulus. The inner cylinder which is a part of the slot nozzle is chosen to be insulated. The slot nozzle impinges downward to the concave surface of the outer cylinder which is positioned as Ɵ = 0°. The outer cylinder is machined from aluminum bar stock into a 200 mm long cylinder with an outside diameter of 90 mm and inside diameter of 70 mm. This cylinder is partially opened at the top with width of W = 30 mm and is kept at constant temperature (T_s = 62 °C) during the tests. The annulus temperature field is visualized experimentally using Mach–Zehnder interferometry. The experiments are performed to determine the local and average Nusselt numbers for the jet Reynolds numbers in the range of $100 \leq Re_j \leq 1{,}000$ and two different ratios of nozzle-to-surface spacing (Z/B = 4.2 and Z/B = 12.5). Apart from the experiment, an open-source CFD software is used for the 2D heat transfer analysis. The results indicate that, the local Nusselt number is relatively high for the region close to the stagnation point (Ɵ = 0°). In addition, it is observed that the local heat transfer coefficients are significantly dependent on the jet Reynolds number and are less sensitive to the nozzle-to-surface spacing. Moreover, obtained results show that the local Nusselt number decreases in the circumferential direction of the concave surface with increase of angle from the stagnation point due to the thermal boundary layer growth. Based on the experimental results, a correlation for the average Nusselt number as a function of Re_j and Z/B is derived.

Keywords: Heat transfer, Concave surface, Jet impingement cooling, Annulus, Nusselt number

1. Introduction

Due to the various practical applications, jet impingement cooling has been the subject of many experimental and numerical investigations and has been employed in a wide variety of industrial demands such as glass production, metal annealing, paper drying and cooling of electronic devices. In particular, jet impingement cooling inside an annulus has been widely used in high temperature gas turbines and blade cooling of turbo machines. Jet impingement is characterized mainly by three zones of the flow field namely the mixing zone, the impingement

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