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Experimental investigation of cooling of heated circular disc using inclined circular jet☆

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ABSTRACT

An experimental study is performed to examine the heat transfer characteristics of impinging circular jet onto a heated circular disc. The disc is heated under constant heat flux and it has an inclination angle with impinging jet in the range of $90° \leq \varphi \leq 150°$. The air is supplied using a radial fan. The fluid flows through a designed tunnel. Experiments were performed under different Reynolds number, 2800, 9000, and 36,000, and different values of inclination angle of the disk and jet-to-plate distance to jet diameter ratio H/D_h as 5, 10, and 15. The results of experiments showed that the most effective parameter is the inclination angle between jet and heater. Both locations of stagnation point and heat transfer are affected from this parameter.

1. Introduction

Impinging jets are widely used in engineering applications such as drying of food, paper, or textile products; cooling of electronic equipment or turbine blades; thermal development of photographic films; and printing of plastics. Like these examples, many applications require highly localized cooling or heating procedures.

Jet impingement onto surfaces can be classified mainly in three categories. In the first category, jets are impinged onto surface normally, which is the widest application. The physics of jet impingement on various surface configurations have been reviewed by Martin [1]. Gardon and Akfirat [2] have investigated the dependence of heat transfer on parameters such as Reynolds number, jet to target plate distance and turbulence for the range of Reynolds numbers, and dimensionless jet to plate distances. A wide review has been performed on heat transfer data for single circular jet impingement by Jambunathan et al. [3]. In this context, Huang [4] investigated the heat-transfer coefficients for air flow through jets impinging normal to a heated surface. Dagtekin and Oztop [5] numerically investigated the jet impingement problem using two slot jets with different Reynolds number. They observed that maximum heat transfer occurs for high Reynolds numbered nozzle. Koseoglu and Baskaya [6] investigated the effects of jet inlet geometry and aspect ratio on local and average heat transfer characteristics of totally nine confined impinging jets. They used thermochromic liquid crystals (TLC) for experimental analysis and numerically by using a 3D low Reynolds number k–ε model.

The second category is impingement of jets to curved surfaces. For example, Tawfek [7] experimentally investigated the effect of jet inclination of the local heat transfer under an obliquely impinging round air jet striking on isothermal circular cylinder. They measured the circumferential heat transfer distribution as well as the axial Nusselt number for different Reynolds number and inclination angles. He compared the surface average heat transfer rate with the normal impingement. Gori and Bossi [8,9] studied the jet cooling problem of a circular cylinder. They tried to find the optimal slot height. They indicated that mean Nusselt number has a maximum value depending on Reynolds number, ratio of distance between the slot and the cylinder diameter, and ratio of cylinder diameter to slot height. They experimentally investigated heat transfer and optimal slot height in the jet cooling of a circular cylinder for Reynolds numbers ranging from 4000 to 20,000. Eren et al. [10] studied the nonlinear flow and heat transfer dynamics of impinging jets onto slightly curved surfaces. Amiri et al. [11] made an experimental and numerical study to investigate the heat transfer characteristics of a horizontal circular cylinder exposed to a slot jet impingement of air. A square-edged nozzle is mounted parallel with the cylinder axis and jet flow impinges on the bottom of the cylinder. The flow and thermal fields are seen to be stable and symmetric around the cylinder over the range of parameters studied. Gau and Chung [12] made a study on surface curvature effect on slot air jet impingement cooling flow and heat transfer process.

The last category of the jet impingement is the impingement of the jet with an inclination angle onto inclined surface. Akansu et al. [13]

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