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Experimental Study on Heat Transfer from a Perforated Fin Array with Cross Perforations

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Abstract

Experimental study is performed to analyze heat transfer characteristics as well as thermal performance of a new type of perforated fin with cross openings. For measurements, an array of these fins over a flat surface is made from aluminum and two cross circular holes are drilled in each fin. The tests are conducted in a wind tunnel which produces uniform air motion upstream of the test case. Temperature measurements are carried out by means of calibrated thermocouples system and surface temperature measurement is determined by a thermograph imager. Results of thermal structure and heat transfer are plotted for Reynolds numbers 2×10^4-4.6×10^4 based on the fin length.

Keywords: Convection heat transfer, perforated fins, cross perforation, temperature measurement

Introduction

One of the primary purposes in the design of modern thermal systems is the accomplishment of more compact and efficient heat exchangers. Decreasing energy loss due to ineffective use and also enhancement of energy transfer in the form of heat has become an increasingly substantial duty for the design engineers of thermal systems. The heat dissipation rate of electronic systems rises as the component's size and compactness goes up. For some electronic devices, it is crucial to obtain the maximum temperature of the systems within a secure level. For remedy, various cooling technologies i.e. cooling with heat pipe, cold plates, impinging jets are introduced. Furthermore, various types of coolants e.g. liquids or gases are utilized to enhance heat transfer performance. Among different coolants, air cooling is very well-known for its availability and easy thermal management. In fact, it is so economical to evaluate thermal performance of such systems and decreasing their weight and enhance their efficiency. In this regard, various numerical and experimental studies have been performed. Diani et al. [1] investigated to find the effects of geometric parameters on thermal performances of such heat sinks. They also obtained optimized fin configurations for a specific cooling application. Sara et al. [2] compared thermal and hydraulic performances of perforated rectangular blocks with a solid block. They observed lower performances for both solid and perforated blocks at higher Reynolds number flows. El- Sayed et al. [3] determined the optimized fin array position to maximize heat transfer enhancement at high Reynolds number flows. In this regard, fluid flow parameters are measured for the variety of flow orientations. Thermal performance of different types of extended surfaces are evaluated numerically and/or experimentally by several authors, Kadle et al. [4], Lau et al. [5], Wirtz et al. [6], Suabsakul [7], Sata et al. [8] and Molki et al. [9]. Jonsson et al. [10-11] improved empirical correlation to anticipate Nusselt number and pressure drop along different types of fin geometry. Sahin et al. [12] concluded that either increasing the inlet air velocity or increasing the surface area, heat transfer performance of extended surfaces can be burgeoned. Sarkar et al. [13] enhanced thermal performance of a channel using perforated star shape fins for various range of perforations. They proposed empirical relations for convective heat transfer coefficient at various Reynolds numbers. Mahmood et al. [14] attained the effect of temperature ratio and flow structures for a dimpled channel at different Reynolds numbers ranging from 600 to 11,000 with inlet temperature ratio of 0.78 to 0.94. Sparrow et al. [15,16] probed the effects of bypass flow over the tip of pin fin heat sinks. They also performed an experimental study to determine Nusselt number for a perforated surface which was faced upstream. Two major parameters e.g. the Reynolds number and pitch-diameter ratio are utilized in their study. Dorignac et al. [17] developed a Nusselt number correlation for perforated plates according to the experimental observations. Wu et al. [18] developed a model to anticipate the thermal performance of plate fin heat sinks. They proposed correlations to predict the value of friction factor and Nusselt number for different flow regimes for various Reynolds numbers less than 5000. Yu et al. [19] conducted combine experimental and numerical studies for thermal performances of plate fin and plate-pin fin heat sinks. They reported 30% higher thermal resistance for a plate fin in comparison with a plate-pin fin. Yaghoubi and Velayati [20] developed new correlations for the Nusselt number and fin efficiency in turbulent flow over an array of cubes. Shaeri and co-workers [21-24] had a series of numerical simulations for various perforated fins in both laminar and turbulent flows. Several perforated fins with various lateral and longitudinal perforations are considered and heat transfer