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An Experimental Investigation of Mixed Convection from a Finned Wall in an Inclined Rectangular Duct

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Abstract- **In this paper an experimental investigation is carried out on in three-dimensional laminar mixed convection heat transfer from longitudinal fins in rectangular channel with inclination. The lower surface of the channel is subjected to a uniform heat flux, the other walls are insulated. A set of experimental tests for air flow with mixed convection heat transfer with longitudinal fins is applied in a horizontal and inclined rectangular duct. Inclined orientations with the range of Θ=0°,30°,60°,75° with the horizontal. The experiment was designed for determining the effect of inclination on local base temperature, heat transfer coefficient and average heat transfer coefficient at three Reynolds numbers (1000, 1800, and 2300) and the range of Grashof number 3×10^8-1×10^9. Dimension fin spacing was S/H=0.17 and fin height was H_f/H=0.6. The results obtained from experimental study show that the optimum inclination angle which yields the maximum heat transfer. The orientation of fins array also plays important role to heat transfer enhancement. The experimental results show that the average heat transfer coefficient increased with Reynolds number and Grashof number for all inclination angles. Results also show that the heat transfer coefficient increasing with increasing inclination angle. The optimal inclination angle for the best heat transfer is obtained when Θ=75°.**

Keywords: Mixed convection, Fins, Channel, Inclination

I INTRODUCTION

A heat sink is an object that absorbs and dissipates heat from another object using thermal contact. In the design and construction of various types of heat transfer equipment, simple shapes such as cylinder, bar, and plates are used to implement the flow of heat between a source and sink. They provide heat-absorbing or heat rejecting surfaces, and each is known as a prime surface. When a prime surface is extended by appendages intimately connected with it, such as the metal tapes and spines on tubes and plates, the addition surfaces is known as extended surfaces [1].

In the electronic thermal management, heat sinks are usually attached on the tops of the electronic packages to enhance heat dissipation and control junction temperatures of these packages. The overall objective of the heat sink design is significant enhancement of convective heat transfer with minimal increases in the streamwise pressure drop penalties. Rectangular fins are used extensively to increase the heat dissipation rates from systems, because such fins are simple and cheap, to manufacture.

The mechanisms of heat transfer to the fluid flowing through a channel by the heat dissipating surfaces can be obtained generally by forced convection, natural convection and by radiative heat transfer. The current study examines the effect mixed convection on fin array. Convective heat transfer in a channel with fin array has been studied by many researchers. ***Lakhal et al.(1997)[2]***, studied numerically the natural convection heat transfer in inclined rectangular enclosures with perfectly conducting fins attached to the heated wall. The parameters governing this problem are the Rayleigh $10^2 \le Ra \le 2\times10^5$, the aspect ratio of the enclosures $2.5 \le AR \le \infty$,the dimensionless lengths of the partitions $0 \le B \le 1$, the inclination angle $0 \le \Theta \le 60$ and the Prandtl number Pr=0.72. Their results indicate that at low Rayleigh numbers, the heat transfer regime is dominated by conduction. ***Huang et al.(2008)[3]***, carried out an experimental study on natural convection heat transfer from square pin fin heat sinks subject to the influence of orientation. A flat plate and seven square pin fin heat sinks with various arrangements are tested under a controlled environment. Test results indicated that the downward facing orientation yields the lowest heat transfer coefficient. However, the heat transfer coefficients for upward and sideward facing orientations are of comparable magnitude.

Experiments on natural convection heat transfer from longitudinal trapezoidal fins array heat sink subjected to the influence of orientation were carried out by ***Al-Azawi (2009)[4]***. A trapezoidal fins heat sink with various orientations tested under a controlled environment. He indicated that the sideward horizontal fin orientations yield the lowest heat transfer coefficient and the sideward vertical fin orientation gave the best performance on the natural cooling. From the experiments Nu is determined as a function of Ra at Pr=0.7 for each orientation with Ra ranging between (1400 and 3900).From the results Heat