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Empirical correlations for mixed convection heat transfer through a fin array based on various orientations

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ABSTRACT

The transfer of heat by the fins is influenced by the change of the direction of the fins. This paper investigates study the effect of the direction of longitudinal fins on a three-dimensional convection heat transfer in a rectangular channel and also study the effect of the lateral and longitudinal inclination of the rectangular channel. The Grashof range from 5×10^{8} to 10^{9}, Reynolds from 1000 to 2300 and Prandtl 0.71. The bottom surface of the channel is exposed to constant heat flux, while other walls are isolated. Two cases are investigated. In case one, measurements were conducted for a lateral inclination of the channel, with a range of $\alpha = 0°, 30°, 60°$, and $90°$. Case two studied the longitudinal inclination of the channel, with the lateral inclination angle fixed at $\alpha = 90°$ and the longitudinal inclination angle $\Theta = 0°, 30°, 60°$, and $70°$. The dimensionless of fin height was Hf/H = 0.6, and the fin spacing was S/H = 0.17. The experimental results show that the coefficient of the heat transfer for lateral inclination ($\alpha = 0°$) was greater than that for a sideways orientation ($\alpha = 90°$). Additionally, the average coefficient of heat transfer for both the lateral and longitudinal inclination case is increased with the longitudinal inclination angle. The empirical equations are obtained based on the experimental results. These equations correlated the Nusselt number as a dependent variable of the orientations angles, Reynolds number, and the Grashof number, these equations are consistent with experimental results.

1. Introduction

Most engineering applications consume energy and associated with produce heat [1,2]. This heat production is usually an undesirable side effect that decreases the system performance, each engineering system is designed almost to operate within a specified range of temperatures [3]. Failure of a system occurs when these limits are surpassed by overheating [4]. Therefore, many engineering systems try to avoid this overheating problem as much as possible by using different methods for dissipating heat away from the system to surrounding areas [5]. The energy of heat is released in several ways; systems that operate give energy in the form of heat, chemical reactions release latent energy such as heat, electrons that flow through materials that generate heat, pressure gases generate heat, and radiation matter creates heat [6].

In the design and construction of different types of energy (heat) transfer systems, different devices, such as cylinders, rods, and plates, are used to achieve heat flow between the source and the sink. These structures provide surfaces for absorption or rejection of heat and are defined as main surfaces [7].

To increasing heat transfer from surfaces are usually used fins when it is not possible to increase the rate of heat transfer, either by increasing the coefficient of heat transfer on the surface or by increasing the difference of temperature between the surface and the fluid [8]. In the system of electronic thermal management, heat sinks are usually attached to the tops of the electronic package to enhance heat dissipation and control the junction temperatures of these packages [9]. The main desired goal of the design of heat sink is a substantial enhancement of the heat transfer by convection with minimal increases in the pressure drop of streamwise. The rectangular fins are widely used to increase the rate of heat dissipation of the systems because they are simple and inexpensive to manufacture. The transfer of convective heat within a channel containing fins was studied by many researchers [10–14].

The convection heat transfer in rectangular enclosures is studied numerically by Lakhal et al. [10] with perfectly attached fins to the hot wall. The effective parameters for this problem are the enclosures aspect ratio is $2.5 \le AR \le \infty$, the Rayleigh number is $10^{2} \le Ra \le 2 \times 10^{5}$, the dimensionless partitions lengths are $0 \le B \le 1$, the angle

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