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Numerical investigation of natural convection from a horizontal heat sink with an array of rectangular fins

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ABSTRACT

This research focuses on the numerical analysis of a rectangular fin array with a horizontal heat sink to examine its performance in natural convection heat transfer. The study uses air as the primary working medium. Steady-state 3D modeling is carried out using the finite volume method (FVM), allowing velocity and temperature distributions to be evaluated by solving equations relating to mass conservation, fluid dynamics, turbulence, and heat transfer. This research details temperature and velocity variations as well as fluid trajectories. It also explores how the intensification of heat flow, varying from 361 W/m^2 to 2527 W/m^2, influences the cooling efficiency of the fins. It is observed that the increase in heat flux reduces the formation of vortices and intensifies natural convection by rising the temperature gradient between the radiator and the surrounding. The temperature increases at all parts of the heat sink fin array as heat flux increases. Besides, it is noticed that the maximum temperature is generated at the mid-region of the base plate heat sink and gradually dissipates to the surroundings through the bodies of the fins. Moreover, the study indicates that the average convection heat transfer coefficient (h_{av}) and the average Nusselt number (Nu_s) increase by 86 % and 84 %, respectively, when the heat flux is increased from 361 W/m^2 to 2527 W/m^2. These observations are corroborated by a comparison with existing experimental data, showing an agreement of less than 9 %. The digital model is validated by comparing pre-existing data on radiators with horizontal rectangular louvers, revealing minimal deviations of less than 2 %.

1. Introduction

Many engineering systems generate heat as a side effect during operation, reducing the performance of their components. Since many of these systems are designed to function at a particular temperature. When these temperatures are exceeded, the system fails. Thus, many engineering systems have used various heat transfer mechanisms, such as natural convection and thermal radiation. Applications such as microelectronics, CPU components, solar cells, etc., use finned heat sinks to avoid the overheating problem [1]. In a study by Harahap et al. [2], the heat transfer coefficient between horizontal fin bases and vertical fins was examined. This study uti-

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