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Correspondence to:
Pabitra Kumar Mandal
pabitra.mandal@bcrec.ac.in

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Experimental and numerical investigation of square heat sink having staggered and inline pin fin arrays placed at different orientation

Pabitra Kumar Mandal[1,2], Sayantan Sengupta[1], Subhas Chandra Rana[1] and Dipankar Bhanja[3]

[1]Department of Mechanical Engineering, National Institute of Technology, Durgapur, 713209 (W.B.), India, [2]Department of Mechanical Engineering, Dr. B.C. Roy Engineering College, Durgapur, 713206 (W.B.), India, [3]Department of Mechanical Engineering, National Institute of Technology Silchar, 788010 (Assam), India

Abstract The present problem is devoted to establish the effect of orientation on thermo-hydraulic performance of a horizontal heat sink with vertical pin-fin-array under forced convective environment. The fins are embedded on the base-plate of the heat sink in inline and staggered manner. When air passes over the fin-arrays it convects the heat conducted from the solid base-plate to the fins' surface. Both the experimental and numerical studies have been performed under the same geometric configurations of the test plate and an acceptable agreement in results is obtained. To examine the influence of the orientation angle (β) on system performance, the heat sink is rotated anticlockwise in a regular interval from 0° to 360° about a vertical axis passing through the centre of the sink. The study has been performed over a large number of incoming Reynolds numbers (Re = 8500 to 38500) to investigate the possibility to achieve an optimal angle of orientation when Nusselt number (Nu) is maximum. Test results show that thermal dissipation attains maximum value at $\beta = 40°$ for the inline array and that for $\beta = 120°$ in case of staggered array. For low Reynolds number values (*Re* = 8500), the system performance is found better at an angle 35° and 120° for inline and staggered arrangement respectively. However, with *Re* = 38500, the maximum system performance is achieved at an angle 10° and 240° for inline and staggered arrangement respectively.

1. Introduction

Fins are used in a large number of applications like radiators in cars, heat exchangers in power plants, turbine blades, transformers, hydrogen fuel cells, computer CPU heat sink etc. They are also used in heat exchangers for exhaust waste heat recovery in diesel engines [1-3]. In the last few years, due to shrinking size of the electronic equipments, the volumetric heat generation rates in these electronic devices are continuously rising and so, the need for more effective cooling technology has become even more crucial. Thermal management has become one of the key issues for designing modern, small scale and compact electronic devices. Engineers are continuously hunting for cooling solutions suitable for such small spaces while maintaining a restricted budget. Though over the years, different cooling techniques have been developed but heat sinks with fins remain as one of the most effective, simplest and cheapest solution for the thermal management of the electronic components. In the last few decades, the design of pin-fin heat sinks has improved considerably to satisfy the needs of modern electronics cooling systems.

Many investigations were done on the heat transfer and pressure drop of channels with pin fins. Pandey et al. [4] performed a numerical study to improve the thermal performance of a cold plate heat sink with parallel channel as well as with pin fin. They have suggested that pin-fin