A Numerical Investigation on Effect of Shape-Size-Number of Drills on Heat Transfer Characteristics of a Circular Pin Fin

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1. ABSTRACT

An increased circuit density with digitalization and miniaturization demands a compact design for the heatsink, a thermal management system, with enhanced heat dissipation capabilities. One should be cognizant of the fact that the performance of an active air-cooled pin fin heatsink is a strong function of fin geometry. By taking the above fact into account, the present work focused to study the heat transfer characteristics of a drilled pin fin with different shapes, sizes, and number of drills. An exhaustive parametric study is taken up to elucidate the effect of the location of a drill, size of drill, no. of drills, convection heat transfer coefficient, heat flux, and fin conductivity on local fin temperature distribution, peak fin temperature, and thermal resistance of the fin. Results are analyzed for the optimum location, shape, size, and pitch of the drill on the fin for its low thermal resistance, and are documented.

2. INTRODUCTION

A heat sink is more effective with a fin possessing larger surface area and higher convection heat transfer coefficient for the given volume. By adhering to the above fact, a through literature survey has been performed by collecting enough number of works, numerical and experimental, pertains to performance of heat sink with variation in shape, size and number of fins. To name a few, Tehmina Ambreen et al. [1] observed, in their numerical investigation, that a circular pin fin micro heat sink performs better than a square and rectangular finned heat sinks. Mohammed Khalaf Ulaiwi Al-Karagoly et al. [2] experimentally proved that the increased length and width of groves brings down the thermal resistance of the fin. Ali Mohammad Ranjbar et al. [3] addressed, numerically, the effect of fin geometry on the performance of porous pin-fin heat sink and concluded that the decreasing-aligned pin fin configuration with the highest Darcy number provides the best performance. Deepa Gupta et al. [4], in their investigation on square shaped pin fin, proves that, irrespective of the size and number of perforations, the perforated pin fin heat sink exhibits better thermal performance in comparison to that of solid pin fin heat sink.

3. PROBLEM DEFINITION AND METHOD OF SOLUTION

The problem geometry comprises a circular fin of length L and diameter D subjected to convection from its tip and lateral surface, with a constant heat flux at its base. Circular, triangular, and elliptical drills of the same cross-sectional area with varying location, size, and pitch (no. of holes) are assumed for analysis. L/4, L/2, and 3L/4 are the drill locations considered for study. The size of the circular drill is varied between 0.3D and 0.6D, from which the size for elliptical and triangular shape drills are obtained for same cross-sectional area of the circular drill. The number of drills is varied from 1 to 6. Heat flux at the base of the fin is ranging between 102 W/m^2 and 10^5 W/m^2, whose lateral surface is exposed to a wide range of convection environments. A steady state thermal analysis has been performed in

Ansys-CFD. Prior to the parametric steady, a grid independence test has been carried out to optimize the size of element.

4. RESULTS & DISCUSSION

Results are obtained for local temperature distribution, peak fin temperature and thermal resistance for varying location, shape, size and pitch of drills. A drill in fin reduces the conduction with a supplement in convection. So, the size of drill matters the heat transfer capability of the fin and thus the maximum temperature observed by it. In order to analyse the same, Fig. 2 is plotted for variation in peak fin temperature with drill size of all shapes for a given fixed set of input parameters as shown. For a given shape of drill, the maximum fin temperature decreases gradually with increasing size of drill and reaches a minimum. With a subsequent enlarged drill, the loss in conduction overshadows the gain in convection, which results in increased temperature and is true for all shapes.

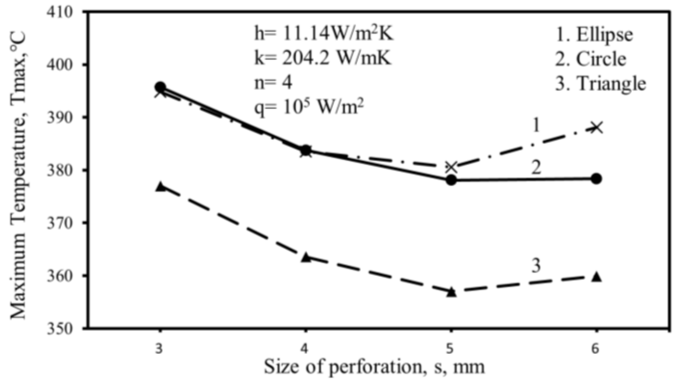

Fig.1 A change in maximum temperature of drilled fin with size of hole

5. RESULTS & HIGHLIGHTS OF IMPOINTANT POINTS

Irrespective of the shape and size, the location of drill is having a negligible effect on local and maximum fin temperatures. For any given shape of drill, the minimum value for maximum fin temperature is observed with 0.5D size of drill. Unlike to the size of drill, a monotonic drop in local and maximum fin temperatures are found with increased number of drills. For a given size and pitch of drills, the thermal resistance is low for triangularly drilled pin fin due to its more surface area for a fixed cross section of drill.

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