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Effect of Perforation Shape on The Efficiency of Heat Sink Fin- A Review

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Abstract: In today's scenario world is facing extreme problems with electrical devices. As the increasing demand of electrical appliances has resulted in low cost manufacturing. Low cost manufacturing has resulted in various problems to the man kind. Various researches are prevailing in the field of electrical engineering appliances to provide the world with new and modern technology. Electrical and mechanical goes in series with each other. In this study main focus is devoted on Heat sink fin which acts as a cooling device for various applications. Most of the researches are going on to improve this device for the performance enhancement of the devices in which high amount of cooling is required. In this paper a brief review of the studies conducted to increase the efficiency of heat sink fin is presented

Keywords: Heat sink, Perforation, Temperature

1. Introduction

Heat sink helps us to overcome the problems cause by heat generation like overheating of system, because of this increases in the chances of system failure. So, there should be efficient heat sinks for overcome these problems in industrial application. Free convection or natural convection is one of the best cooling techniques from these devices played an important role in conserving their certain operation. In many industries for enhancing the process of free convection and heat transfer, extended surfaces that are known as fins are used in many. The performance of the heat exchanging devices can be increased by extended surfaces. There are many practical application of extended surfaces found in industries for cooling the combustion chamber, heat exchanger , electronic devices etc. but on using the fins as extended surfaces, increases the weight, size as well as cost of production. Lots of research and experiments has been done for increasing the efficiency of the fins as extended surface to optimize the fins geometry. For increasing the efficiency and heat transfer coefficient, different studies have been recognized shape by cutting some material from fins to make cavities, or channels through the fin body, holes, slots, grooves One of the popular heat transfer technique has got interrupted surfaces of different configurations. The focus of promoting surface turbulence the main intention of this is to increase the heat transfer coefficient besides the surface area. The non-flat surfaces have natural convection coefficients that are more than half to those of flat surfaces. And other researchers also reported a similar trend for serrated surfaces, interrupted, and perforated. The straight fins concave parabolic profile provides the maximum heat dissipation for a given profile area. But for lots of applications, at the place of straight concave parabolic fins, the rectangular fins are used to reduce a cost of manufacturing and production cost

2. Literature Review

Kavita H. Dhanawade et.al.[1] did an experimental study to investigate the heat transfer enhancement over horizontal flat surface with rectangular fin arrays with lateral square and circular perforation by forced convection. The cross sectional area of the rectangular duct was 200 mm x 80 mm. The data used in performance analysis were obtained experimentally for fin arrays of material aluminum, by varying geometry and size of perforation as well as by varying Reynolds number from 21 104 to 8.7 104 . It is observed that the Reynolds number and size perforation have a larger impact on Nusselt number for the both type of perforations

M. Khoshvaght-Aliabadi, F. Hormozi, A. Zamzamian[2] experimentally assessed of the copper–water nanofluid flow through different plate-fin channels is the main purpose of this study. Seven plate-fin channels, including plain, perforated, offset strip, louvered, wavy, vortex generator, and pin, were fabricated and tested. The copper–water nanofluids were produced by a one-step method, namely electro-exploded wire technique, with five nanoparticles weight fractions (i.e., 0%, 0.1%, 0.2%, 0.3%, and 0.4%). The required properties of the nanofluids were systematically measured, and empirical correlations were proposed. To obtain accurate results, a highly precise test loop with the ability to produce a constant wall temperature was designed and fabricated. The results depicted that both the convective heat transfer coefficient and the pressure drop values of all the channels enhance with increasing the nanoparticles weight fraction. The appropriate thermal–hydraulic performance and maximum reduction of surface area were found for the vortex generator channel. Finally, correlations were proposed to predict the Nusselt number and Fanning friction factor of the base fluid and nanofluids flows in the studied plate-fin channels.

V. Leela Vinodhan, K.S. Rajan[3] carried out Computational experiments on flow and heat transfer in four new microchannel heat sink (MCHS) configurations to compare their performance with the conventional MCHS. The new microchannel heat sinks simulated consist of four compartments with separate coolant inlet and outlet plenum for each compartment. The presence of several regions of developing flow in new designs result in higher Nusselt number and heat transfer rates. The substrate temperature gradients in new configurations are lower than that in conventional MCHS due to better distribution of coolant and recirculation. At the same pumping power, thermal resistances in the new designs are lower than the thermal resistances in conventional MCHS. The design may be further optimized by varying channel dimensions.

Umesh V. Awasarmol and Ashok T. Pise [4] studied the heat transfer characteristic of perforated fin array in natural convection by varying the diameter of perforation from 4-12 mm and angles of inclination form 0-900. They observed that fins with 12 mm diameter of perforation shows greater heat transfer at an angle of 450. They first reported systematic study of the thermal performance of perforated fin array for different perforation diameter and angle of inclination, in natural convection environment. The temperature along the perforated fin length is consistently smaller than that on of an equivalent non-perforated fin. The perforated fin can enhance heat transfer. The magnitude of heat transfer enhancement depends upon angle of orientation, diameter of perforations and heater input. The perforation of fins enhances the heat dissipation rates and at the

Vishvas S. Choure [5] studied heat transfer enhancement from perforated pin fin in staggered arrangement. The number of Perforation varied from one to five and diameter of perforation from 3 to 5 respectively. They have observed that pressure drop across the heat sink decreases with increasing number of perforation and diameter of perforation. The Nusselt number increases with increase in number of perforation and diameter of perforation. They concluded that Pressure drop across the heat sink is smaller with increasing number of perforation and perforation diameter. In all cases, perforated pin fin array performs better than the solid pins. Hence, perforated pin fins require less pumping power than the solid pins for the same thermal performance. Also Nusselt number increases with increasing number of perforation and perforation diameter. Further increasing the perforation diameter will lead to a reduction in thermal dissipation. This is due to the decrease in vertical heat conduction along the perforated pin fins, as well as the perforations induces reshaping of wakes behind the pins. Thus, while designing a perforated pin fin array, the balance between the perforation number and diameter should be carefully taken into consideration.

M. S. Sundaram and M. Venkatesan [6] studied heat transfer of Perforated Fin in Forced Convection. They performed numerical analysis by varying different parameters such as diameter of perforation (2mm , 5mm, and 8mm), location of perforation (10mm, 20mm and 30mm)and number of perforations (1, 2 and 3). The heated pin fin was exposed to air at different velocities of 1.5, 3 and 5 (m/s). They observed that the temperature contour of perforated fin has lower base plate temperature than to a solid pin fin. The perforated pin fins with diameter 5 mm has maximum heat transfer and with further increase in diameter (d=8mm), there was a reduction in cross section area of pin fin heat sink

M. Khoshvaght-Aliabadi, S. Zangouei, F. Hormozi[7] considered A type of plate-fin channel with rectangular wings as a transverse vortex-generator channel The heat transfer and fluid flow characteristics of the vortex-generator channel were systematically analyzed by 3D-CFD simulations. As the first part of project, a precise and reliable experimental setup was designed and fabricated to generate a constant temperature boundary condition. Inlet eoutlet bulk and surface temperatures along with flow rate data were acquired by using pt-100 and K series calibrated thermocouples and an ultrasonic flow meter, respectively. Hence, boundary conditions for the CFD simulations were well defined, and data for the validation of a reference model were generated. Comparing the experimental data with the predicted results by CFD simulation implies that the applied CFD approach can properly predict the thermal-hydraulic specifications of the vortexgenerator channel. In the second part of the project, the influences of seven effective geometrical parameters (i.e. wings height, wings width, channel length, longitudinal wings pitch, transverse wings pitch, wings attach angle, and wings attack angle) for three conventional coolants flow (i.e. water, oil, and ethylene glycol) at the laminar flow regime were evaluated. As the third part of the project, general correlations were derived for Nusselt number of the coolants flow inside the plate-fin heat exchangers with vortex-generator channels.

Amer Al-Damook et.al.[8] designed and fabricated an experimental heat sink with multiple perforations for parameter studies of the effect of perforated pin fin design on heat transfer and pressure drops across the heat sinks undertaken. Experimental data is found to agree well with predictions from a CFD model for the conjugate heat transfer into the cooling air stream. The validated CFD model is used to carry out a parametric study of the influence of the number and positioning of circular perforations, which shows that the Nusselt number increases monotonically with the number of pin perforations, while the pressure drop and fan power required to overcome the pressure drop all reduce monotonically. Pins with five perforations are shown to have a 11% larger Nu than for corresponding solid pin cases. These benefits arise due to not only the increased surface area but also heat transfer enhancement near perforations through the formation of localized air jets. In contrast, the locations of the pin perforations are much less influential. When examined in the context of CPU cooling, a conjugate heat transfer analysis shows that improved heat transfer with pin perforations translates into significantly reduced processor case temperatures with the additional benefit of a reduction in the weight of the heat sink's pins. To achieve these benefits care must be taken to ensure that pin perforations are aligned with the dominant flow direction and manufactured with a good quality surface finish.

Vishal V. Dhole, V. S. Shinde and S. S. Kore[9] explained the effect of change in perforation geometry and number of perforations of cylindrical pin fin heat sink on heat transfer rate and pressure drop. Heat sinks were tested in rectangular wind tunnel having internal cross section 50×100. Pin fins were arranged in staged manner. Tests were conducted on different heat sinks at constant heat input of 60W and Reynolds Number 10000-30000. Conical perforations acts like convergent nozzles thus increases the velocity of air passing through them, increased velocity of air raises turbulence over heat sink. Effect of number of conical perforations is studied by changing number of conical perforations. It is found that increase in number of perforation reduces pressure drop and increases Nusselt number. Angle of conical perforations is also varied which plays important role in generating turbulence

Amer Al-Damook, J.L. Summers, N. Kapur, H. Thompson[10] investigated the benefits of using pinned heat sinks (PHSs) with multiple circular, square and elliptic perforations for electronic cooling applications using Computational Fluid Dynamics (CFD). A conjugate heat transfer analysis, using the RANS-based modified k-ω turbulence model, is used to determine the effect of perforation shape on the cooling and hydraulic performance of PHSs. The numerical solutions indicate that the optimum design will be a compromise between elliptical perforations, which minimize pressure drop and mechanical fan power consumption, and circular perforations, which provide the most effective heat transfer. Employing staggered arrangements of perforated pins in PHS is also shown to be highly beneficial and to enable the power consumption required to cool a heat sink to a target temperature to be reduced significantly.

Tzer-Ming Jeng, Sheng-Chung Tzeng, Ching-Wen Tseng, Wei-Ting Hsu [11] proposed a novel configuration of active LED graphite-composite heat sink and experimentally investigated the effects of vent channels and metal conductive base on the fluid flow and heat transfer characteristics of this active heat sink. The heat sink was made of the graphite powders, aluminum-alloy powders, and adhesive mixed in specific proportion by the vacuum-pressure injection technique. The cost and weight of this graphite composite material are much lower than those of aluminum alloy. The configuration of heat sink is a hollow circular cylinder with multiple radial fins. Different motor fans can be put in the chamber of heat sink, with various vent-channel positions and orientations (vertical vent channels, horizontal upper-row vent channels, and horizontal bottom-row vent channels) and numbers of channels (24, 36, 48, and 72) in the heat sink to enhance overall cooling performance by driving through airflow. The results indicate that the overall Nusselt number (Nu) of the graphite-composite heat sink with motor fan was 2.23–2.50 times that without motor fan. The numbers of vent channels in heat sink were positively related to the total flow rate of through air. Thus, the heat sink with the most vent channels had the maximum Nu in the motor-fan mode. When an additional annular aluminum-alloy conductive base was mounted in the graphite-composite heat sink with the most vent-channel configuration, the Nu was 35% higher than that without conductive base in motor-fan mode, proving the metal conductive base was effective. The optimal vent-channel configuration in this study was also used for the full aluminum-alloy heat sink, the corresponding Nu of the models without/with motor fan were compared with the full aluminum-alloy heat sink without vent channel, the heat transfer enhancements were about 13% and 127%, respectively

Mohammad Reza Shaeri [12] investigated Cooling performances of perforated-finned heat sinks (PFHS) in the laminar forced convection heat transfer mode, through detailed experiments. Perforations like windows with square cross sections are placed on the lateral surfaces of the fins. Cooling performances are evaluated due to changes in both porosities and perforation sizes. Thermal characteristics are reported based on pumping power, in order to provide more practical insight about performances of PFHSs in real applications. It is found that at a constant perforation size, there is an optimum porosity that results in the largest heat transfer coefficient. For a fixed porosity, increasing the number of perforations (reducing the perforation size) results in an enhancement of heat transfer rate due to repeated interruption of the thermal boundary layer. The opposite trend is observed for PFHSs with larger perforation sizes. This indicates that there is an optimum perforation size and distance between perforations in order to achieve the maximum heat transfer coefficients at a constant porosity. Also, a PFHS results in smaller temperature non-uniformity across the heat sink base, as well as a more rapid reduction in temperature non-uniformity on the heat sink base by increasing pumping power. In addition, the advantage of a PFHS to reduce the overall weight of the cooling system is incorporated into thermal characteristics of the heat sinks, and demonstrated by the mass specific heat transfer coefficient.

3. Conclusion

From the above literature survey it can be concluded that perforation in fin increases its efficiency. In the present study one step is tried further by studying the effect of various perforation shapes on the efficiency of the fin. From the present literature study a conclusion can be drawn that some study using different perforation shapes can result in better performance of heat sink.

Refrences

1. Kavita H. Dhanawade, Vivek K. Sunnapwar and Hanamant S. Dhanawade "Thermal Analysis of Square and Circular Perforated Fin Arrays by Forced Convection" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
2. M. Khoshvaght-Aliabadi, F. Hormozi , A. Zamzamian "Experimental analysis of thermal–hydraulic performance of copper–water nanofluid flow in different plate-fin channels" Experimental Thermal and Fluid Science 52 (2014) 248–258

3. V. LeelaVinodhan, K.S. Rajan "Computational analysis of new microchannel heat sink configurations" Energy Conversion and Management 86 (2014) 595–604
4. Umesh V. Awasarmol , Ashok T. Pise, "An Experimental Investigation of Natural Convection Heat Transfer Enhancement from Perforated Rectangular Fins Array at Different Inclinations" Experimental Thermal and Fluid Science, 2015, pp.1-23.
5. Vishvas S. Choure, Mahesh R. Jagadale, Vijay W. Bhatkar ,"Heat Transfer Enhancement using Perforated Pin Fins", International Journal For Technological Research In Engineering ,volume 3, issue 2, October 2015, pp. 2347 – 4718.
6. M. S. Sundaram and M. Venkatesan, "Heat Transfer Study of Perforated Fin under Forced Convection", International Journal of Engineering, volume 28, number 10, October 2015, pp. 1500-1506.
7. M. Khoshvaght-Aliabadi, S. Zangouei, F. Hormozi "Performance of a plate-fin heat exchanger with vortex-generator channels: 3D-CFD simulation and experimental validation" International Journal of Thermal Sciences 88 (2015) 180e192
8. Amer Al-Damook, N. Kapur, J.L.Summers, H.M.Thompson, "An experimental and computational investigation of thermal air flows through perforated pin heat sinks" Applied Thermal Engineering 89 (2015) 365e376
9. Vishal V. Dhole, V. S. Shinde and S. S. Kore "Thermal and hydraulic performance analysis of cylindrical pin fin heat sink with conical perforations" International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
10. Amer Al-Damook, N. Kapur, J.L. Summers, H.M. Thompson "Effect of Different Perforations Shapes on the Thermal-hydraulic Performance of Perforated Pinned Heat Sinks", Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN: 2458-9403 Vol. 3 Issue 4, April - 2016
11. Tzer-Ming Jeng, Sheng-Chung Tzeng, Ching-Wen Tseng, Wei-Ting Hsu "The effects of vent channels and metal conductive base on thermal characteristics of the active graphite-composite cylindrical heat sink" International Communications in Heat and Mass Transfer 73 (2016) 7–15
12. Mohammad Reza Shaeri, Bradley Richard and Richard Bonner "Cooling Performances Of Perforated-Finned Heat Sinks" Proceedings of the ASME 2016 Heat Transfer Summer Conference HT2016 July 10-14, 2016, Washington, DC, USA