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A Review on Thermal enhancement in Heat Sink at different Heating conditions

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ABSTRACT

The thermal resistance and pressure drop are considered as multiple thermal performance characteristics. The effects of geometric parameters, fin height, fin diameter, fin material, base to surrounding temperature difference on heat transfer performance of fin arrays& fin separation value has been determined.Heat transfer rate increases with the increase in approach velocity, pin diameter & number of pins. The effect offin density on heat transfer performance is examined. This paper reviews the previous work on thermal performance analysis of heat sink in order to determine the enhancement in the heat transfer rate. Many engineering systems during their operation generate heat. If this generated heat is not dissipated rapidly to its surrounding atmosphere, this may cause rise in temperature of the system components.

Keyword: - Plate fin heat sink, Slotted fin heat sink, Temperature distribution, Thermal resistance.

1. INTRODUCTION

For optimum working condition of electronic system self-efficient heat sink is needed. There are various options available for cooling of electronic devices such as heat sink, heat pipe, thermoelectric coolers but heat sink is mostly used in the electronics cooling due to its heat transfer capacity & ease of use. Heat sinks are the most common thermal hardware used in electronics. They are employed in microelectronic devices as well as high power electrical components. They improve the thermal control of electronic components, assemblies and modules by enhancingtheir surface area through the use of pin fins extended surfaces are well known as fins and are commonly used to enhance heat transfer in many industries. Heat transfer rate is increased by using natural, forced or mixed convection. In the present scenario ofelectronic systems must be self-indulge to improve its reliability & from its premature failure. Thus efficient cooling of electronic devices becomes a challenging task in the thermal area. Innovation in technology has madea large leap towards compact. So equipment size variation has changed to miniature size. Applications utilizing pin fin heat sink for cooling of electronics have increased significantly during last few decades due to increase in heat flux densities and product miniaturization. In current scenario electronic circuits dissipates substantially heavier loads of heat than ever before. At the same time the premium associated with miniaturized applications has never been greater, and space allocated for cooling purposes is on decline. One of the most powerful cooling technologies that have been emerged in recent years is pin fin technology. The unique pin fin design generates significant cooling power & is highly suitable for hot devices & applications that have limited space for cooling. Pin fin heat sinks for surface mount devices are available in variety of configurations, sizes & materials. Pin fin heat sinks which

contain an array of vertically oriented round pins made of copper or aluminium, deliver significantly greater performance than standard heat sinks with flat fins. The aerodynamic nature of the round pins & their unidirectional configuration enable pin fin heat sinks to transfer heat very efficiently from the heat generating device to the ambient environment. As a result, this superior heat sink style is used in a wide range of application & industries wherever difficult cooling challenges takes place.

2. EXPERIMENTAL & NUMERICAL INVESTIGATIONS

Chang-Woo Han and Seung-Boong Jeong [1] "Evaluation of the thermal performance with different fin shapes of the air-cooled heat sink for power electronic applications" The proper selection of the heat sink, which is attached at the insulated-gate bipolar transistor (IGBT) module to dissipate heat by electric losses of the IGBT/diode chips, is important to satisfy the design criterion of the IGBT module. Prior to the performance evaluation of the air-cooled heat sink using the numerical method, the suitability of the simulation model was validated through the experimental result of the developed product. The simulation model predicted the hotspot temperature on the heat sink within a margin of error of 5.6 percent. From the verified numerical method, the thermal performance of the heat sink was evaluated according to the shape of the fins. The heat sink with the perforated fins had an excellent thermal performance because the rate of increment of the dissipation area was greater than the rate of decrement of the convection coefficient. The selected heat sink with the perforated fins was attached at the IGBT module and the junction temperature of the IGBT module was predicted. The predicted junction temperature was 131.4°C and the result satisfied the design criterion of 140.0°C. The selectedheat sink with the perforated fins was attached at the IGBT module, and the junction temperature of the IGBT module was predicted. The predicted junction temperature of the IGBT module was 131.4°C, and the result satisfied the design criterion of the IGBT module.

Christopher L. Chapman et al [2] "Thermal performance of an Elliptical pin fin heat sink "In the Study of this paper comparative thermal tests has been carried out using aluminum heat sinks made with extruded fin, cross-cut rectangular pins, and elliptical shaped pins in low air flow environments. The elliptical pin heat sink was designed to minimize the pressure loss across the heat sink by reducing the vortex effects and to enhance the thermal performance by maintaining the large exposed surface area available for heat transfer. The performance of the elliptical pin heat sink was compared with those of extruded straight and crosscut fin heat sinks, all designed for an ASIC chip. The results of the straight fin were also compared with those obtained by using Sauna TM, a commercially available heat sink modeling program developed based on empirical expressions. In addition to the thermal measurements, the effect of air flow bypass characteristics in open duct configuration was investigated. As expected, the straight fin experienced the lowest amount of flow bypass over the heat sink. For this particular application, where the heat source is localized in the centre of the heat sink base plate, the overall thermal resistance of the straight fin was lower than the other two designs mainly due to the combined effect of enhanced lateral conduction along the fins and the lower flow bypass characteristics. The elliptical pin heat sink tested represents only one set of design parameters relating pin spacing and shape based upon minor and major axes. There may exist other designs which produce better results in overall thermal performance. A study looking at reduced spacing, pin alignment, pin staggering, and an array of ellipse axis ratios would be advantageous to the heat sink industry.

Sukhvinder Kang, Maurice Holahan [3] "The Thermal resistance of pin fin heat sinks in transverse flow" This paper presents a physics based analytical model to predict the thermal behavior of pin fin heat sinks intransverse forced flow. The key feature of the model is the recognition that unlike plate fins, stream wiseconduction does not occur in pin fin heat sinks. Thus, the heat transfer from each fin depends on its local airtemperature or adiabatic temperature and the local adiabatic heat transfer coefficient. Both experimental dataand simplified CFD simulations are used to develop the two building blocks of the model, the thermal wakefunction and the adiabatic heat transfer coefficient. These building blocks are then used to include the effect ofthe thermal wake from upstream fins on the adiabatic temperature of downstream fins in determining the fin-by-fin heat transfer within the pin fin array. This approach captures the essential physics of the flow and heattransport within the fin array and yields an accurate model for predicting the thermal resistance of pin fin heatsinks. Model predictions are compared with existing experimental data and CFD simulations. The model isexpected to provide a sound basis for a consistent performance comparison with plate fin heat sinks. The modelprovides a framework for putting existing literature correlations and information developed from detailed fine-grid CFD simulations to work in the design of pin fin heat sinks. At a minimum, the model can be expected to predict heat sink performance similar to a detailed CFD model with a fraction of the data entry andcomputational effort. Better yet, the incorporation of empirical information allows the present model to capturecomplex physical effects which would require huge detailed CFD models to simulate from scratch each time.Last but not least, the model provides detailed but easily interpreted results regarding heat transport andtemperatures within the heat sink structure. It is anticipated that the model will become a valuable tool to enable consistent performance comparisons and selection between various types of pin fin and plate fin heat sinks.

Jatinder Singh, Harpreet Singh [4] "Heat Transfer Analysis of an Array of Different Fin Configuration under Forced Convection" The main part of the study concerns about the comparison of temperature and pressure difference between flat plate without fins and inline circular fins and staggered circular fins at the heat sink test section. In the design of a heat sink test section, the plate thickness, the hole diameter, the hole centre pitch and the plate pitch are some of the important geometric parameters. Diameter (10mm o/d, 7mm i/d) and height (100mm) of the all fins and centre pitch span and stream wise (50mm) is selected throughout the dissertation. In whole process mass flow rate is kept at constant and power input is varied. Initially, temperature at inlet, outlet and at flat plate without fins are measured. Then same process is repeated for inline and staggered fins. The heat sink is heated by a plate heater and temperatures and pressure drop are measured at the various positions. All thermocouples are connected to a digital recorder to record the temperature once the steady stateis achieved. The power input to the heater is controlled by a variac. A digital wattmeter is used for recording the power of the heater. An enhancement of heat transfer was observed in the given case as compared to the heat sink having a conventional duct. However following conclusions can be taken from experiments carried out

- It has been observed that as the Reynolds number increases the Nusselt number also increase in all type ofarrangements.
- Fins having staggered arrangements much higher heat transfer coefficient followed by inline circular finarrangement and without fin arrangement.
- As the Reynolds number increases the effectiveness drop slightly in staggered fin and inline finarrangement.
- The effectiveness remains constant in without fin arrangement and its equal to unity.
- The Reynolds number does not adverse effect on friction factor. But generally the friction factor instaggered fin arrangement has slightly higher compared to inline and without fin arrangements.

O. M. Mesalhy [5] et al "Thermal performance of plate fin heat sink cooled by air slot impinging jet with different cross sectional area" Flow and heat transfer characteristics of a plate fin heat sink cooled by a rectangular impinging jet with different cross-sectional area were studied experimentally and numerically. The study concentrated on investigating the effect of jet width, fin numbers, and fin heights on thermal performance. Entropy generation minimization method was used to define the optimum design and operating conditions. It is found that, the jet width that minimizes entropy generation changes with heat sink height and fin numbers. This paper investigated thermal resistance and pressure drop of a plate fin heat sink cooled by fixed mass flow rate confined impinging jet with different width. The investigation was carried out for different fin numbers and fin heights as well as for a turbulent jet flow condition. Both experimental and computational techniques had been employed. In the computational part, the full 3-D turbulent flow over the heat sink was solved using the commercial CFD code FLUENT. The results showed good agreement between the computed and measured thermal resistance.

Piyush Laad, BhushanAkhare [6] et al "Thermal analysis of heat sink with fins of different configuration using Ansys Workbench 14.0" The effect of the pin-fin shapes on the overall performance of the heat sink with inline and staggered arrangement is studied in this paper. Six different shapes of fins rectangle, trapezoidal, rectangular interrupted, square, circular inline and staggered are subjected to study in this paper. The optimization processes are carried out using computer simulations performed using Ansys workbench 14.0.

The Heat transfer taken in natural air and aluminum 6063 as a pin fin material. To study of thermal performance of different heat sink of the different fin profile at different velocities 5, 10 & 12 m/s and simulation is done at different heat load of 15W, 20W & 25 W and air inlet temperature is taken as 295 K. The purpose of this study is to examine the effects of the configurations of the different pin-fins design.

It is observed from the results that optimum cooling is achieved by the heat sink design which contains Circular pin fins. After the selection of proper heat sink by CFD simulations the steady state thermal performance is carried out at different fin height of circular pin fin heat sink. The result shows that the temperature is increasing by decreasing the fin height. At different loads the performance of all selected fin profiles is carried out and found that at & above 25 W load the maximum temperature is maximum for interrupted rectangular fin and minimum for circular pin fin. And the value of Nusslet number is also maximum for circular pin fin design.

Hajare Swapnali R [7] et al "Experimental Investigation of Heat Transfer Enhancement from Waveform Pin-Fins" The work reported in this paper is an attempt to enhance heat transfer in electronic devices with the use of waveform pin-finned heat sinks. The cooling performance of electronic devices has attracted increased attention owing to the demand of compact size, higher power densities and demands on system performance andre-liability. Pressure drop across heat sink is one of the key variables that govern the thermal performance of the heat sink in forced convection environment. There are several analytical methods to estimate the heat transfer rate, however correctly selecting one that can represent the reality over a range of airflow found in typical electronics cooling application is difficult. This paper proposes a modified experimental method to estimate the heat transfer and used it to calculate the thermal performance through different theoretical pressure drop equations. The rapid advancement in technology of microprocessors has led electronics thermal system designer is to pay increased attention to the waveform fin heat sink. The advantages of using a waveform fin heat sink are light weight, low profile and small footprint. There are three manufacturing methods for bonding the waveform fin to the base of heat sink: adhesive bonding, soldering, and brazing. The newly developed comparison method allowed a detailed numerical study of the influence of waveform pin cross-section on the performance of pin fin arrays used in the electronics industry.

Shrenikkumar Oswal [8] et al "Factors Affecting on Thermal Performance of Fins & Analysis of Fins with Ansys Icepak" In this paper, various factors affecting on thermal performance of fin are studied. Factors to be considered while designing of pin fin array are investigated. By changing parameters its performance on array such as maximum temperature, pressure and velocity are comparatively studied. From the results obtained we suggested best solution according to the requirement. However following conclusions can be taken from experiments carried out

1. Heat transfer performance is better in staggered arrangement for elliptical pin fins & for In-Line arrangement circular pin fins are better.
2. In-line arrangement gives higher heat sink resistance and lower pressure drop than the staggered arrangement.
Also circular pin fins gives more heat transfer than elliptical pin fins but the pressuredrop is more.
3. The Length of Fin affects more than it's Diameter. The Pin Array having more height at centre has betterperformance.
4. Heat transfer increases with the increase in approach velocity, number of pins &, Reynolds's No.

Z. Staliulionis [9] et al "Investigation of Heat Sink Efficiency for Electronic Component Cooling Applications" Research and optimization of cooling of electronic components using heat sinks becomes increasingly important in modern industry. Numerical methods with experimental real world verification are the main tools to evaluate efficiency of heat sinks or heat sink systems. Here the investigation of relatively simple heat sink application is performed using modeling based on finite element method, and also the potential of suchanalysis was demonstrated by real-world measurements and comparing obtained results. Thermal modeling was accomplished using finite element analysis software COMSOL and thermo-imaging camera was used to measure the thermal field distribution. Ideas for future research involving improvement of the experimentalsetup and modeling verification are given.

Foued Chabane [10] et al "Experimental study of Heat transfer & thermal performance with longitudinalfins of solar air heater." In this paper the thermal performance of a single pass solar air heater with five fins attached was investigated experimentally. Longitudinal fins were used inferior the absorber plate to increase the heat exchange and render the flow fluid in the channel uniform. Experiments were performed for two air mass flow rates of 0.012 & 0.016 kg/s. Moreover, the maximum efficiency values are obtained for the 0.012 & 0.016 kg/s with & without fins were 40.02%, 51.50% & 34.62%, 43.94% resp. A comparison of the results of the mass flow rates by solar collector with & without fins shows a substantial enhancement in the thermal efficiency. Apart from experimentation following conclusions can be derived.

- Solar radiation & surface geometry of the collector will significantly define the efficiency of solar air collector
- The efficiency of solar air collector is proven to be higher. The highest collector efficiency & air temperature rise were achieved by the finned collector with the angle of 45^0, whereas the lowest values were obtained from the collector without fins.
- The efficiency increases as the mass flow rate increases from 0.012 to 0.016 kg/s

3. CONCLUSION

In this study, previous work done on performance analysis of heat sink (fins) under free and has been discussed in order to determine the enhancement in the heat transfer rate. The free and forced convection heat transfer from the fins of different shapes & geometries protruding from a surface has been discussed that have been investigated both experimentally & numerically. The effects of geometric parameters, fin height, fin length, and fin material; thermal conductivity on the heat transfer performance of fin arrays has been discussed. A relation for the optimum fin height that maximizes the heat transfer rate has obtained. Experimental results showed that the larger fin height results in higher convection heat transfer rates from the fin arrays.

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