Design And Analysis on Different Fin Perforations Heat Sink

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Abstract- *In many engineering applications extended surface known as fins, are used to enhance convective heat transfer. The problem of natural convection heat transfer for perforated fins was investigated in this work. A study was conducted to investigate the natural convection heat transfer in a rectangular fin plate with no perforation, square perforation, triangular perforations and circular perforations. The investigation has been conducted to compare heat transfer rate of different fins embedded with the different types of perforations. The heat transfer coefficient was calculated using ANSYS Workbench 18.2 and Furthermore, for different perforation the heat transfer rate and the coefficient of heat transfer also varied giving better results. The work done on various types of fins, effect of perforation shape or geometry on the heat transfer was simulated in ANSYS to determine best type of fin to be used. The comparison between non perforated and different types of perforated fins were analysed. The heat transfer coefficient between the fins was found to be better in perforation shape for the required application.*

Keywords- Perforated Fins, Non- Perforated Fins, Steady State thermal, Natural Convection, Heat sink

I. INTRODUCTION

Fins are a useful way to increase heat transfer with minimal increase in volume.Fins transfer heat either through free or forced convection. Heat transfer between a solid surface and a moving fluid. Therefore, to increase the convective heat transfer, one can Increase the temperature difference (Ts-Ta) between the surface and the fluid. Increase the convection coefficient h. This can be accomplished by increasing the fluid flow over the surface since h is a function of the flow velocity and the higher the velocity, the higher the h. Example: a cooling fan. Increase the contact surface area A. Heat exchangers are widely used in various, transportation, industrial, or domestic applications such as thermal power plants, means of heating, transporting and air conditioning systems, electronic equipment and space vehicles. In all these applications improvement in the efficiency of the heat exchangers can lead to substantial cost, space and material savings. Hence considerable research work has been done in the past to seek effective ways to improve the efficiency of heat exchangers. The major heat transfer enhancement techniques that have found widely spread commercial application are those which possess heat transfer enhancement elements. All passive techniques aim for the same, namely to achieve higher values of product of the heat transfer coefficient and heat transfer surface area. A distinguish between the way how the heat transfer enhancement is achieved, is common in the heat transfer community. Here in the present work, a terminology similar to the literature is followed although for practical applications are irrelevant how the heat transfer enhancement is achieved.

1.1 HEAT SINK

A heat sink (also commonly spelled heatsink is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant, where it is dissipated away from the device, thereby allowing regulation of the device's temperature. In computers, heat sinks are used to cool CPUs, GPUs, and some chipsets and RAM modules. Heat sinks are used with high-power semiconductor devices such as power transistors and optoelectronics such as lasers and light-emitting diodes (LEDs), where the heat dissipation ability of the component itself is insufficient to moderate its temperature. A heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it, such as the air. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink. Heat sink attachment methods and thermal interface materials also affect the die temperature of the integrated circuit. Thermal adhesive or thermal paste improve the heat sink's performance by filling air gaps between the heat sink and the heat spreader on the device. A heat sink is usually made out of aluminium or copper.

1.2 HEAT TRANSFER PRINCIPLE

A heat sink transfers thermal energy from a higher-temperature device to a lower- temperature fluid medium. The fluid medium is frequently air, but can also be water, refrigerants or oil. If the fluid medium is water, the heat sink is frequently called a cold plate. In thermodynamics a heat sink is a heat reservoir that can absorb an arbitrary amount of heat without significantly changing temperature. Practical heat sinks for electronic devices must have a temperature higher than the surroundings to transfer heat by convection, radiation, and conduction. The power supplies of electronics are not absolutely efficient, so extra heat is produced that may be detrimental to the function of the device. As such, a heat sink is included in the design to disperse heat. To understand the principle of a heat sink, consider Fourier's law of heat conduction. Simplified to a one-dimensional form in the x direction, it shows that when there is a temperature gradient in a body, heat will be transferred from the higher-temperature region to the lower- temperature region. The rate at which heat is transferred by conduction, is proportional to the product of the temperature gradient and the cross-sectional area through which heat is transferred When the air flow through the heat sink decreases, this results in an increase in the average air temperature. This in turn increases the heat-sink base temperature. And additionally, the thermal resistance of the heat sink will also increase. The net result is a higher heat-sink base temperature. The increase in heat-sink thermal resistance with decrease in flow rate will be shown later in this article.

- The inlet air temperature relates strongly with the heat-sink base temperature. For example, if there is recirculation of air in a product, the inlet air temperature is not theambient air temperature. The inlet air temperature of the heat sink is therefore higher, which also results in a higher heat-sink base temperature.
- If there is no air flow around the heat sink, energy cannot be transferred.
- A heat sink is not a device with the "magical ability to absorb heat like a sponge and send it off to a parallel universe". Natural convection requires free flow of air over the heat sink. If fins are not aligned vertically, or if fins are too close together to allow sufficient air flow between them, the efficiency of the heat sink. Ss

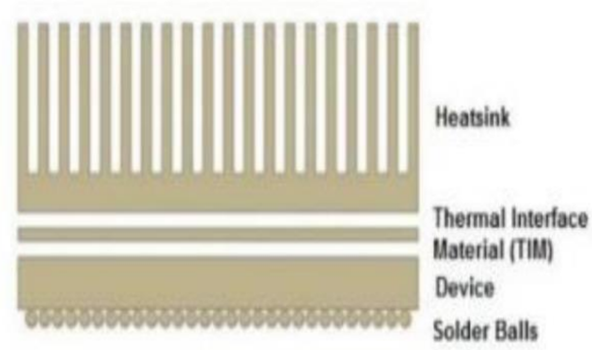


Fig 1. Heat Sink

II. IMPORTANCE OF HEAT SINK IN ELECTRONIC CIRCUITS

The paper entitled “Computational analysis of perforation effect on the thermo-hydraulic performance of micro pin-fin heat sink” by Deepa Gupta et.al., has investigates the hydrodynamic and thermal characteristics of perforated micro pin-fin (MPF) heat sink with different shapes and numbers of perforations under a low range (100–1000) of Reynolds number (Re) and constant base wall heat flux thermal boundary condition with air as the working fluid. The results show that the perforated MPFs provide higher Nusselt number (Nu) values and lower pressure drop levels (ΔP) than a solid MPF. These perforations have also shown higher fin effectiveness compared to solid square-shaped MPFs. Besides, the perforated MPFs show a superior performance (i.e., ≥45%) than solid MPFs. This study also infers that the circular-shaped perforation offers the best system performance (η) amidst the all different perforation shapes irrespective of the perforation number, followed by the elliptical and square-shaped perforation. For the circular-shaped perforation, performance improves by 30% when going from one to two perforations, and it improves up to 28% while moving from two to three perforations. This study reveals that there is a greater potential to employ circular perforation on a solid square MPF heat sink for better thermal management in electronic devices..

A heat sink is a passive heat exchanger, and it is designed to have large surface area in contact with the surrounding (cooling) medium like air. The components or electronic parts or devices which are insufficient to moderate their temperature, require heat sinks for cooling. Heat generated by every element or component of electronic circuit must be dissipated for improving its reliability and preventing the premature failure of the component.

- It maintains thermal stability in limits for every electrical and electronic component of any circuit or electronics parts of any system. The performance of the heat sink depends on the factors like the choice of a material, protrusion design, surface treatment and air velocity.

- The central processing units and graphic processors of a computer are also cooled by using the heat sinks. Heat sinks are also called as Heat spreaders, which are frequently used as covers on a computer's memory to dissipate its heat.
- If heat sinks are not provided for electronic circuits ,then there will be a chance of failure of components such as transistors, voltage regulators, ICs, LEDs and power transistors. Even while soldering an electronic circuit, it is recommended to use heat sink to avoid over heating of the elements.
- Heat sinks not only provide heat dissipation, but also used for thermal energy management done by dissipating heat when heat is more. In case of low temperatures, heat sinks are intended to provide heat by releasing thermal energy
- for proper operation of the circuit.

III. PROBLEM DESCRIPTION AND OBJECTIVE:

Due to rapid evolution in a wide range of technologies in twentieth century, heat dissipation requirement has increased very rapidly especially from compact systems. There is an urgent need for high-performance heat sinks to ensure the integrity and long life of these petite systems. Use of forced convection cooling has been limited by the requirement of the excessively high flow velocity and associated noise and vibration problems. Along with the rapid growth in electronic industry, applications of miniaturisation are immense in past decades. The miniaturization, however, inevitably generates excessive amount of heat on the highly limited surface area. It is indeed crucial to develop an efficient cooling method, particularly when the conventional heat sink is inadequate to meet the high heat flux requirements. In general, the temperature of the device or component will depend on the thermal resistance from the component to the environment, and the heat dissipated by the component. To ensure that the component does not overheat, a thermal engineer seeks tofind an efficient heat transfer path from the device to the environment. It is observed from the fins of the literature survey are more demanding to cool electronic equipment, stationary engines and many engineering applications, so we need the optimized designs with minimum material and the maximum rate of heat transfer. But due to many factors such as material, fluid velocity, cross section, the climatic condition affects the heat transfer rate of the fin, the main control variable generally available to the designer is geometry of fin.

- To construct a setup to allow experimental data to be obtained under different fin profile.
- To reduce temperature of heat sink by maximizing heat dissipation rate.
- To produce a material for heat sink same cost as that existing heat sink.
- Good performance with etiquette design.
- The fins are made of Aluminium.

IV. CFD APPROACH:

The science of numerically resolving the equations governing these processes to predict heat transfer, fluid movement, mass transfer, chemical reactions, and other phenomena is known as computational fluid dynamics (CFD). Important engineering data from CFD simulations can be applied to conceptual design studies, problem-solving, in-depth product development, and redesign. To minimize the total amount of work required in the lab, CFD analysis is utilized in conjunction with research and testing. The study of utilizing a computational approach to solve the equations that control fluid flow is known as computational fluid dynamics (CFD). Various procedures to forecast heat transfer, fluid flow, and phenomena such as mass transport, chemical reactions, and others.CFD analyses produce useful engineering information that can be utilized in concept research for fresh designs, thorough invention, troubleshooting, and redesign of products.

V. MODELLING

Computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), PLM, and 3D are all applications included in the multi-platform SolidWorks software suite. It provides a way to build, alter, and validate complex, novel shapes from industrial design to Class-A surfacing using the ICEM surfacing technologies. It also offers solutions for shape design, styling, surfacing workflow, and visualization. Whether the product design process is initiated from scratch or from 2D sketches, SolidWorks enables various stages. An symmetric inlet is present in the ramjet engine combustion chamber. Therefore, CFD analyses for cold flow simulations are performed using a two-dimensional model. Regarding diffuser design and flame holder layout, various changes were done. Ultimately, 3 layouts were chosen based on a few factors, including: The velocity must be uniform at least 400 to 500 mm from the diffuser end. There should be little total pressure loss over the combustion.

5.1 BOUNDARY CONDITIONS:

Boundary conditions are needed to be specified for obtaining the output results. Proper selection of boundary condition leads to proper results and their improper selection lead to wrong solutions. Boundary conditions specified in Table 2 which have been used for present research work. The boundary conditions which are as follows to analyse the temperature difference, heat flux and directional of heat flux. As per the calculated values of heat flux and directional of heat flux the perforated and non- perforated heat sinks fins are analysed with the help of the boundary conditions as mentioned below the table 5.1

Table 1: Inlet Boundary conditions

MATERIAL	ALUMINIUM
Youngs modulus	E=70GPa
Poisson Ratio	0.3
Density	2800kg/m3
Thermal Conductivity	170W/mk
Specific Heat	870J/kgK
Thermal expansion coefficient	22*10e-6/ºC
Atmospheric temperature	28^0C
Heat transfer coefficient	30W(m^{20}c)

5.2 SOLVERS:

The geometry of helical coil heat exchanger has been made in Solid works software. The geometry has been imported to ANSYS 16.2 for the analysis.2 The geometric dimensions of the heat sink has be created with the dimensions of A flat platform of 100 X 100 X 5 mm is common in all designs. Fin height for all models is 50 mm. There are a total number 10 fins in line arrangement with fin spacing of 10 mm between them. And thickness of each fin is 3mm.

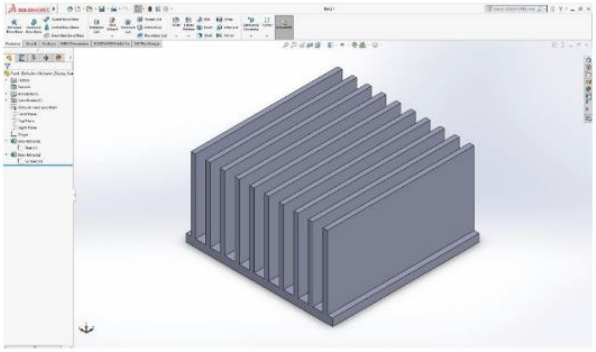


Fig .2 Non Perforated Fins

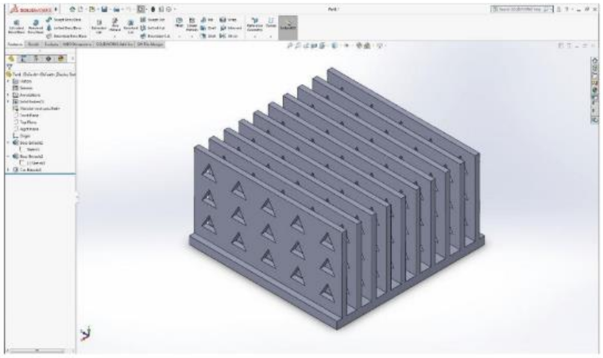


Fig .3 Triangular Perforated Fins

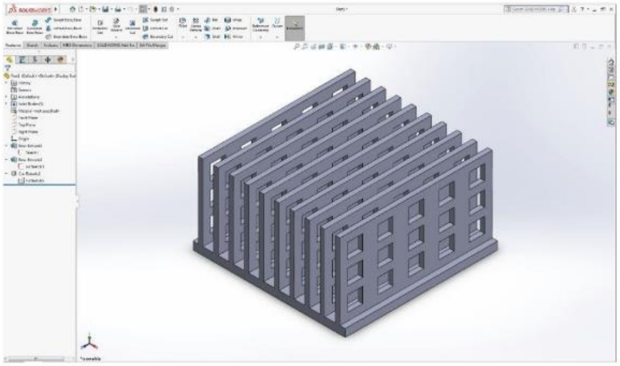


Fig .4 Rectangular Perforated Fins

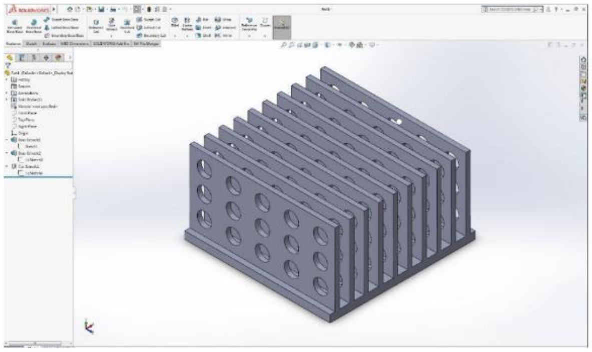


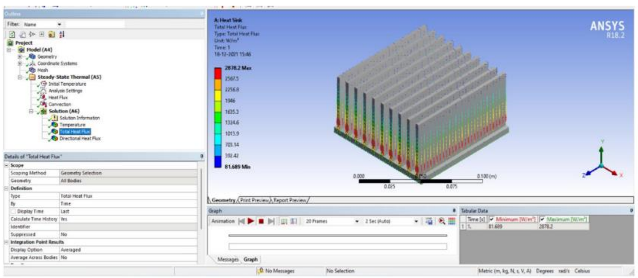
Fig .5 Circular Perforated Fins

VI. RESULT AND DISCUSSION

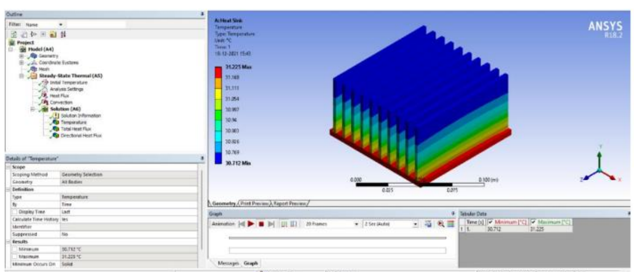
Perforated fins has better heat transfer rate as compared to Non- Perforated fins heat sink. On increasing the no of fins and number of perforated holes the temperature difference has been increased. So to increase heat flux a number of perforated holes has to be used. Temperature difference, Heat flux and Directional of heat flux can be identified by increasing the number of perforated holes and changing the design parameters.

6.1 Non perforated and Perforated fins Analysis:

The model of Non-perforated, circular perforated, Triangular perforated and Rectangular perforated Heat sink has been developed using Solidworks software and analysis has been done using ANSYS Workbench 18.2 code. The analysis has been performed for four different Non-perforated, circular perforated, Triangular perforated and Rectangular perforated Fin heat sinks. Computational analysis has been performed for finding parameters like temperature difference, Total heat flux and directional of heat flux**.** From Figures it is observed that the temperature gradient is observed between 251 degree to 450 degree Celsius then, in fig 6.1 the total heat flux is observed that 2872.4 to 81.3 W/m2 and the directional of heat flux which is in fig 6.3 is in Y direction which is 2858.6 to -170.56 W/m2. Hence we have observed that temperature, Heat flux and Directional of heat flux from Ansys results.



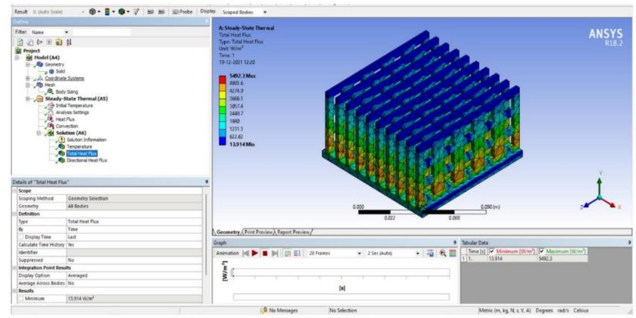
Case 1



Case 2

Fig: 6 Non Perforated fins temperature distribution and total heat flux

From the Fig 7 the temperature gradient is observed between 315.1 to 450 degree Celsius and in Fig 6.4 the total heat flux is observed 5492.3 W/m2 to 13.914 W/m2 and then directional of heat flux is observed from the Ansys results which is from maximum 5037.6 W/m2 to minimum -7.48 W/m2. Therefore, we have observed the Temperature gradient, Total heat flux and Directional of heat flux from the Ansys 18. 2 software results.



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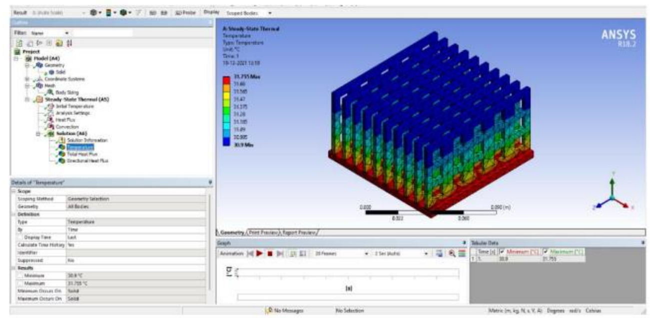
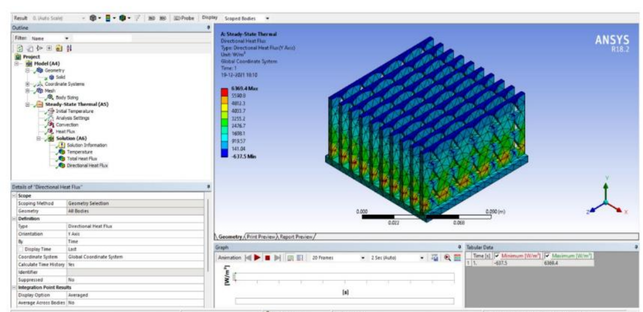


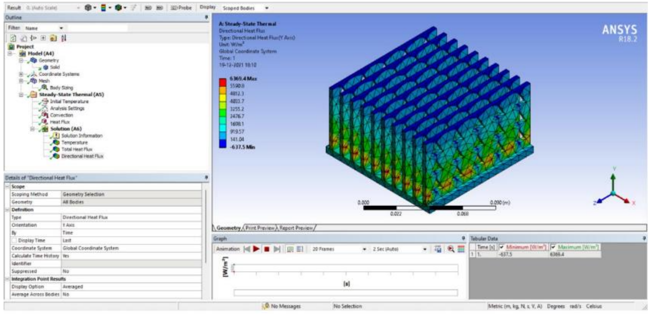
Case 4

Fig: 7 Rectangular Perforated fins temperature distribution and total heat flux

Fig. 8 shows the Total heat flux observed between maximum and minimum value is 655.5 to 6.23 W/m2 and then shows the directional of heat flux in Y direction which is observed between 6369.5 to -637.9 W/m2 and then shows the temperature 30 gradient for triangular perforated fin which from 328.5 to 450 degree Celsius . Therefore, from the triangular perforated fin heat sink we have observed the results of Temperature gradient, Total heat flux and directional of heat flux from the Ansys results.



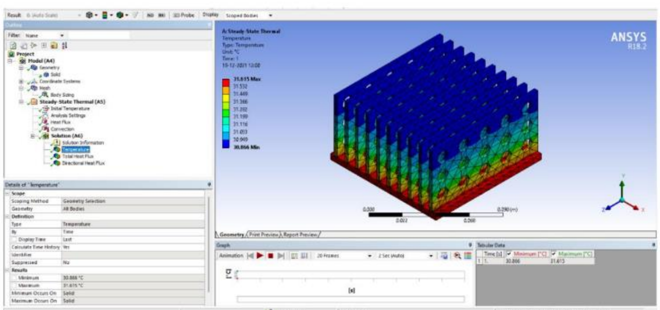
Case 5



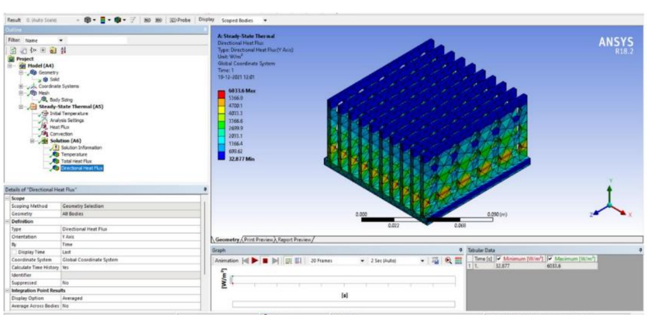
Case 6

Fig: 8 Triangular Perforated fins temperature distribution and total heat flux

From fig 9 the total heat flux, directional of heat flux and temperature gradient is observed. In total heat flux is varies from 6069.3 to 33.69W/m2. Then from the directional of heat flux is in Y direction which is observed from 6033.2 to 32.368 W/m2. The temperature gradient is observed from the fig 6.12 which is varies from 327.06 to 450 degree Celsius. Hence, Circular based perforated fins has been analysed using Ansys 18.2 software they are the temperature gradient, total heat flux and directional of heat flux.



Case 7



Case 8

Fig: 9 Circular Perforated fins temperature distribution and total heat flux

VII. CONCLUSION

The use of perforated fins causes reduction of fin's weight significantly, reduction of weight due to use of new perforations. Certainly reduction of weight leads to saving material in manufacturing fins as well as lighter assembly. This explains cost and energy benefit of utilization of the new perforated fins. However the increase of heat transfer by use of these kinds of perforated fins in comparison with solid fin is not considerable. By giving perforation to the fin will resulting the higher temperature different compared to the non-perforated fins that will affect the temperature distribution of the heat generated at the heat source along the fins. By giving perforation to the fins will increase the heat coefficient of the heat sink by 35.82 – 51.29 % regarding to the perforation shape or geometry.

REFERENCES

[1] C.J.Kobus ,T.Oshio, 2005 "Predicting the thermal performance characteristics of staggered vertical pin fin array heat sinks under combined mode radiation and mixed convection with impinging flow" International Journal of Heat and Mass Transfer 42684–2696.

[2] Hung-Yi Li , Kuan-Ying Chen, 1963– 1970 "Thermal performance of platefin heat sinks under confined impinging jet conditions" International Journal of Heat and Mass Transfer 50 (2007)

[3] G. Hetsroni, M. Gurevich, R. Rozenblit, 2008 "Natural convection in metal foam strip with internal heat generation" Experimental Thermal and Fluid Science 32 1740–1747

[4] H. R Goshayeshi, F. Ampofo, 2009 "Heat Transfer by Natural Convection from a Vertical and Horizontal Surfaces Using Vertical Fins"Energy and Power Engineering, 85-89

[5] Burak yazicioğlu and hafit yüncü, 2009"A correlation for optimum fin spacing of vertically-based rectangular fin arrays subjected to natural convection heat transfer"isı bilimivetekniği dergisi, 29, 1, 99-105, j. of thermal science and technology

[6] Hung-Yi Li *, Shung-Ming Chao, 2009 "Measurement of performance of plate-fin heat sinks with cross flow cooling" International Journal of Heat and Mass Transfer 522949–2955

[7] Dong-Kwon Kim, Sung Jin Kim , Jin-Kwon Bae , 2009 "Comparison of thermal performances of plate-fin and pin-fin heat sinks subject to an impinging flow",International Journal of Heat and Mass Transfer 52 3510–3517

[8] S. V. Naidu, V. Dharma Rao, B. GovindaRao, A. Sombabu and B. Sreenivasulu , 2010 "Natural Convection

heat transfer from fin arrays-experimental and theoretical study on effect of inclination of base on heat transfer"ARPN Journal of Engineering and Applied Sciences VOL. 5, NO. 9, Sepetember

[9] J. Sable, S.J. Jagtap , P.S. Patil , P.R. Baviskar & S.B. Barve , 2010 "Enhancement Of Natural Convection Heat Transfer On Vertical Heated Plate By Multiple V-FIN Array"IJRRAS 5 (2) November

[10] Mahdi Fahiminia, Mohammad Mahdi Naserian, Hamid Reza Goshayeshi1, Davood Majidian, 2011 "Investigation of Natural Convection Heat Transfer Coefficient on Extended Vertical Base Plates"Energy and Power Engineering, , 3, 174-18034

[11] Cheng-Hung Huang , Jon-Jer Lu , Herchang Ay , 2011 "A three dimensional heat sink module design problem with experimental verification" International Journal of Heat and Mass Transfer 54 1482–1492

[12] S. Mahmoud , R. Al-Dadah , D.K. Aspinwall , S.L. Soo , H. Hemida , 2011 "Effect of micro fin geometry on natural convection heat transfer of horizontal microstructures" Applied Thermal Engineering 31 627-633

[13] H. El Qarnia , A. Draoui , E.K. Lakhal , 2013 "Computation of melting with natural convection inside a rectangular enclosure heated by discrete protruding heat sources" Applied Mathematical Modelling 37 3968–3981

[14] Mateusz Korpyś, Mohsen Al-Rashed, Grzegorz Dzido, aJanuszWójcika , 2013 "CPU Heat Sink Cooled by Nanofluids and Water Experimental and Numerical Study" Proceedings of the 23rd European Symposium on Computer Aided Process Engineering – ESCAPE 23, June 9-12, , Lappeenranta, Finland

[15] Mehran Ahmadi, Golnoosh Mostafavi, Majid Bahrami, 2014 "Natural convection from rectangular interrupted fins"International Journal of Thermal Sciences 82 62-71