EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER THROUGH RECTANGULAR AND TRAPEZOIDAL FINS MADE OF ALUMINUM 6063 ALLOY

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Abstract - In various applications, rectangular and trapezoidal finned surfaces are used to enhance the heat transfer in most of the equipment's. In this paper an experimental attempt has been made to compare the performance of free and forced convective heat transfer form rectangular and trapezoidal fins attached to a heated horizontal base. For the experimentation fins are fabricated of dimensions 110*50*10mm for rectangular fin and length of 110x30x10 mm, (lengthXbaseX width) for trapezoidal fin by using aluminium 6063 alloy. The inherent thermal conductivity of aluminium 6063 alloy is 200w/m-k which improves the efficiency of the rate of heat dissipation in rectangular and trapezoidal fins. Experiments have been carried out under steady state conditions. Local values of heat flux, temperature, heat transfer coefficients, Reynolds numbers have been estimated. experimental findings shows that forced convection is most effective than the free convection and Heat-transfer coefficient is enhanced for trapezoidal fin for the heat supply of 55W, 67W, 80W and 93W by 37%, 48%, 37%, and 22% at respective heat supply.

Key Words: Free convection, Forced convection, extended surfaces, heat transfer coefficient, efficiency and effectiveness

1. INTRODUCTION

Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface thin metallic strips called Fins. The heat conducting through solids, walls or boundaries has to be continuously dissipated to the surrounding or environment to maintain the system in a steady state condition. In many engineering applications large quantities of heat need to be dissipated from small area. The fins increase the effective area of the surface there by increasing the heat transfer by convection.

The fin is generally used when the convection heat transfer coefficient is low, especially under free convection. In the field of industry the fin is used widely, for instance, in cooling of electronic accessories, motorcycle engine and in air cooling of molecules with in a material

1.1 Types of fins

The fins are also referred as 'extended surfaces'. Fins are manufactured in different geometries, depending upon the practical applications. The ribs attached along the length of a tube are called longitudinal fins. The concentric macular discs around a tube are termed circumferential fins. Pin fins or spines are rods protruding from a surface. The fins may be of uniform or variable cross-section. They have many different practical applications, via cooling of electronic components, cooling of motor cycle engines, compressors, electric motors transformers, refrigerators, high-efficiency boiler super heater tubes etc. Solid gas turbines blades often act as fins, conducting heat down their length to a cool disc.

Types of fins:

1) Triangular fin
2) Rectangular fin
3) Cylindrical fin
4) Trapezoidal fin
5)Parabolic fin

2. Literature review

Christopher L. Chapman et al [1994] Study of these papers comparative thermal tests has been carried out using aluminium 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 modelling 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.
Ellison (1) and Kraus and Bar-Cohen (5) has presented the fundamentals of heat transfer and hydrodynamics characteristics of heat sinks including the fin efficiency, forced convective correlations, applications in heat sinks, etc.. Iyengar and Bar-Cohen (6) determined the least-energy optimization of plate fin heat sinks in the status of forced convection. Park et al. (7, 8) performed an investigation of numerical shape optimization for high performance of a heat sink with pin-fins. Park and Moon (9) proposed the progressive quadratic response surface model to obtain the optimal values of design variables for a plate-fin type heat sink. Sahin et al. (10) Investigated the effect of design parameters on the heat transfer and pressure drop characteristics of a heat exchanger using the Taguchi experimental design method. From the above descriptive analysis, the optimal design and selection of effective heat sink modules is becoming one of the primary challenges of the computer science and technology industry. In this study, the optimal values of designing parameters of a pin-fin type heat sink (PFHS) are numerically acquired using the quadratic model of response surface methodology (RSM), associated with a sequential approximation optimization (SAO) method to reach the high thermal performance (or cooling efficiency). The RSM relates to the regression analysis and the statistical design of experiments for constructing the global optimization (11) and is one of the most widely used methods to solve the optimization problem in the manufacturing environments (12–14). To achieve the high thermal performance (or cooling efficiency) under the given design constraint, the predictive model for thermal performance characteristics will be created using the RSM. (15) Sukhvinder Kang, Maurice Holahan presents a physics based analytical model to predict the thermal behaviour of pin fin heat sinks in transverse forced flow. The key feature of the model is the recognition that unlike plate fins, stream wise conduction does not occur in pin fin heat sinks. Thus, the heat transfer from each fin depends on its local air temperature or adiabatic temperature and the local adiabatic heat transfer coefficient.(16).ko-Ta chiangand Fu Ping Chang has developed an effective procedure of response surface methodology (RSM) for finding optimal values of designing parameters ofa pin fin type heat sink (PFHS) under constrains of mass and space limitations to achieve the high thermal performance (or cooling efficiency).various design parameters such as height and diameter of pin fin and width of pitch between fins are explored by experiment. The Thermal resistance and pressure drop are considered as the multiple thermal performance characteristics.

Mohammad Mashud, Md. IliasInam, Zinat Rahman Arani and AfsanulTanveer [14] research, a solid cylindrical fin and two other cylindrical fins with circular grooves and threads on their outside surface are investigated experimentally. The heat input to the fin is varied such that the base temperature is maintained constant under steady state. Based on a study of effect of pressure reduction, using available resources, the chamber is designed for a vacuum of 680 mm Hg. The experimental result shows that for cylindrical fin with circular grooves (depth 3.5mm) heat loss is a maximum. The grooved cylindrical fin loses approximately1.23 times greater heat per unit area, compared to the threaded cylindrical fin, and 2.17 times greater heat per unit area, respectively compared to the solid pin fin at a pressure lower than atmospheric pressure. As pressure decreases heat loss reduces and contribution of radiation heat transfer on total heat loss increases.

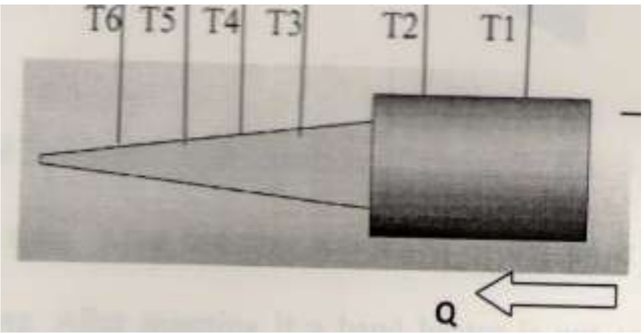
Yue-Tzu Yang , Huan-Sen Peng, [2009] In this paper the numerical study of the thermal performances of the heat sink with un-uniform fin width designs with an impingement cooling were investigated numerically. The coupling of the velocity and the pressure terms of momentum equations are solved by the SIMPLEC algorithm. The well-known k –e two equation turbulence model is employed to describe the turbulent structure and behaviour. The parameters include the five Reynolds number (Re = 5000–25000), three fin heights (H = 35, 40, 45 mm), and five fin width designs (Type-1–Type-5). The objective of this study is to examine the effects of the fin shape of the heat sink on the thermal performance. The results show that the Nusselt number increases with the Reynolds number. The increment of the Nusselt number decreases gradually with the increasing Reynolds number. The numerical simulation of the heat sink with an impingement cooling at various Reynolds numbers and fin dimensions are proposed. The purpose of this study is to evaluate the possibility of improving the thermal performance by utilizing the un-uniform fin width design of the heat sink

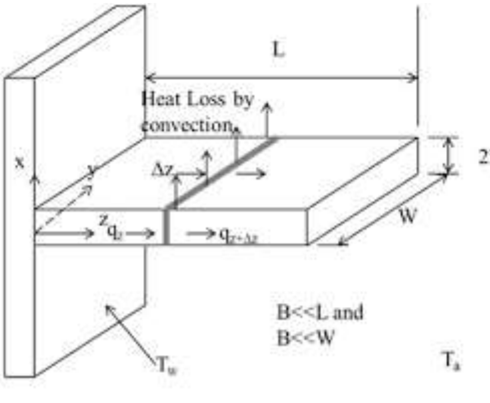
Hamid Reza Seyf and Mod. Layeghi [2010] A numerical analysis of forced convective heat transfer from an elliptical pin fin heat sink with and without metal foam inserts is conducted using three-dimensional conjugate heat transfer model. The pin fin heat sink model consists of six elliptical pin rows with 3 mm major diameter, 2 mm minor diameter, and 20 mm height. The Darcy–Brinkman–Forchheimer and classical N–S equations, together with corresponding energy equations are used in the numerical analysis of flow field and heat transfer in the heat sink with and without metal foam inserts, respectively. A finite volume code with point implicit Gauss–Seidel solver in conjunction with algebraic multi grid method is used to solve the governing equations. The code is validated by comparing the numerical results with available experimental results for a pin fin heat sink without porous metal foam insert. Different metallic foams with various porosities and permeability are used in the numerical analysis. The effects of air flow Reynolds number and metal foam porosity and permeability on the overall Nusselt number, pressure drop, and the efficiency of heat sink are investigated. The results indicate that structural properties of metal foam insert can significantly influence on both flow and heat transfer in a pin fin heat sink. The Nusselt number is shown to increase more than 400% in some cases with a decrease in porosity and an increase in Reynolds number. However, the pressure drop increases with decreasing permeability and increasing Reynolds number.

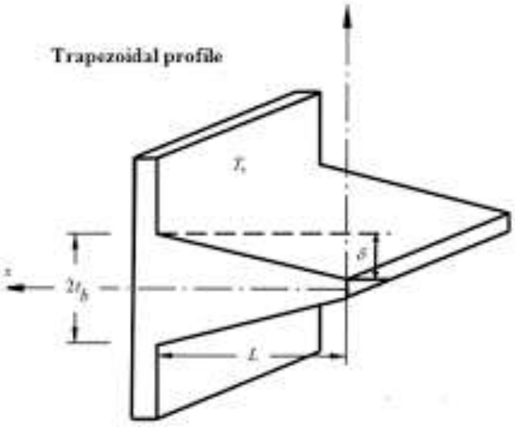
N. Nagarani et al. [2012] The study of this paper presents numerical and experimental comparative study of elliptical and circular fins which are made up of same kind of metal with same surface area and fed with constant heat inputs under free convection. The numerical result show more distribution of isotherms and elevated rate of temperature distribution along the major axis of elliptical fin than those of circular fin. The experimental result proved that the surface temperature of elliptical fin decreased with increase in fin length along major axis. For elliptical fin made up of AISI SS304steel, the shaped tube efficiency is better with Biot number up to 0.13 and fin effectiveness is greater with Biot number up to 0.151 than that of circular fin. The aforementioned limit of Biot number for the shaped tube efficiency and the effectiveness of elliptical fins is an optimized range beyond which there will be a reduction in heat transfer rate in spite of adding metal to the base tube. In this research work, the heat transfer of elliptical and circular fins which are made up of same kind of metal with same surface area has been analyzed experimentally by feeding constant heat inputs under free convection. In elliptical fin, the surface temperature goes on decreasing gradually and continuously. The experimental results show that the performances of elliptical fins are better in respect of isotherms, temperature distribution, shaped tube efficiency and effectiveness when compared to those of circular fins.

3. FABRICATION OF EXPERIMENTAL SETUP

The experimental setup consists of two Aluminum rods of 20cm long and 5*5 cm area, voltmeter of 0-400v, ammeter of 0-20amps, temperature indicator 0-400 degree centigrade, 2-pole 6 way selector switch, 6 way peri connector, k-type thermocouples of 1m length, electronic dimmer 1.5kw or 1kw, band heater 250w,heating test specimen. An Al rod of 15*5*5 cm long is taken and design into required trapezoidal fin and the other into rectangular fin of 110*50*10mm.







4 slots are arranged on the both the fins. First take the trapezoidal fin and from every slot a thermocouple is inserted without any gap. Every thermocouple is connected to the 6 peri connector. Over the fin a band heater is fixed then, asbestos support pipe for heater, glass wool, heater socket and Al rod 110*50*10mm long for it is given power supply. After connecting thermocouples to the peri connector, one end of the peri-connector is connected with wires from there it is connected to the 2-pole 6 way switch. By connecting this we can able to measure the temperature at every node.

Table: 1 Specification of experiential setup:

S.L.NO	EQUIPMENT	QUANTITY
1	Aluminum 6063 alloy circular rods	20cm length
2	Voltmeter	0-400v
3	Ammeter	0-20amps
4	Temp. Indicator	0-400c0
5	Switch	2-pole 6waysector switch
6	k-type thermocouple	1m
7	Heater	250w

Fig-1:Experimental set up

2. Composition of Aluminum 6063 Alloy:

Aluminum Alloy 6063 is one of the most popular alloy in the 6000 series, provides good extrudebility and high quality surface finish. In heat treated condition .alloy 6063 provides good resistance to general corrosion, including resistance to stress corrosion cracking. A 6063 is an aluminum alloy, with magnesium and silicon as the alloying elements. The standard controlling its composition is maintained by The Aluminum Association. It has generally good mechanical properties and is heat treatable and weld able.

Table2: Chemical composition of 6063 is:

Material	Si	Fe	Cu	Mn	Mg	Cr	Ti	Other
Max%	0.6	0.35	0.10	0.10	0.9	0.10	0.10	0.15
Min %	0.2	0.35	0.10	0.10	0.45	0.10	0.10	0.05

3. Experimental values:

For each heat input of fixed value the temperature along the length of the fin are recorded and tabulated. Nearly 20 such readings are taken at one fixed input with a time interval of 15-20min to reached study state condition. After obtaining satisfactory study state the readings are taken as final readings. However only the last sets of 3 readings taken before attaining steady state are presented for simplicity and convince in present work.

Table 3: Rectangular fin - Forced Convection:

SNO	V	Q	A	T_1	T_2	T_3	T_4	T5	T6
1	100	55	0.55	30	101	97	93	92	87.3
2	110	67	0.61	31	169	166	64	162	157
3	120	80	0.67	31	190	185	182	181	176
4	130	93	0.73	31	201	197	193	189	186

Table 4: Trapezoidal fin - Forced Convection

Sno	V	A	Q	T_1	T_2	T_3	T_4	T_5	T_6
1	100	0.57	57	31	92	82	81	66	54
2	110	0.64	70	31	100	92	88	69	59
3	120	0.67	80	31	108	100	95	72	70
4	130	0.72	93	31	124	115	113	85	78

Table 5: Result table for rectangular fin forced convection

no	V	A	Qi	Vo	Va	Re	h	E	Ƞ(%)
1	100	0.55	55	31.12	0.857	5116.4	12.26	0.057	99.3
2	110	0.61	67	35.31	0.97	5112.35	13.89	0.517	85.4
3	120	0.67	80	35.76	0.985	5102.8	14.14	0.525	85.3
4	130	0.72	93	35.93	0.99	5006.32	14.51	0.53	85.0

Table 6: Result table for trapezoidal fin forced convection

s.n	V	A	Qi	Vo	Va	Ra	h	E	η(%)
1	100	0.57	57	32.1	0.881	5134.5	12.56	0.2425	94.35
2	110	0.64	70.4	35.90	0.9904	5637.9	15.59	0.242	94
3	120	0.67	80.4	35.92	1.069	5972.0	14.54	0.249	92.18
4	130	0.72	93.6	35.94	0.9905	5434.8	14.07	0.25	91

WhereV- voltage; Re- Renolds number; A-amperes ;Vo- Velocity of orifice; h- heat transfer co-efficie ; Qi- power input ;Va- Velocity of air in duct

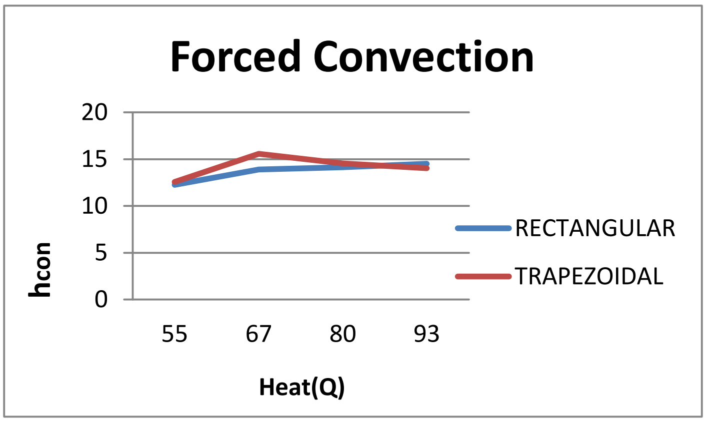


Fig 1: h_{conv} vs Heat

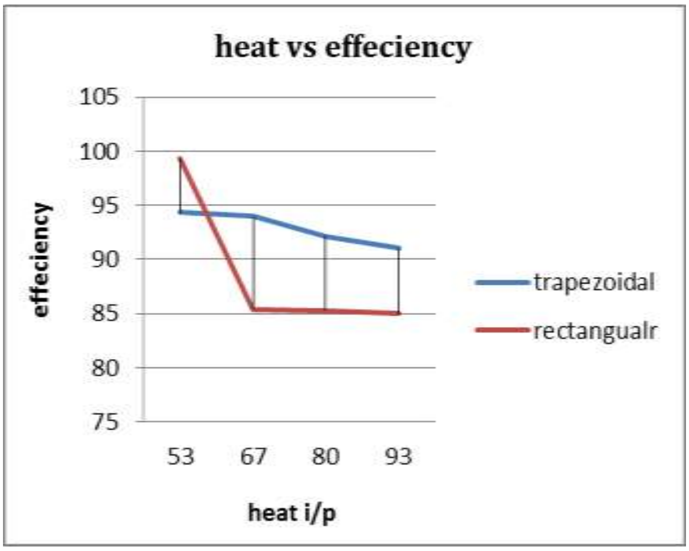


Fig 3: Heat vs. Efficiency

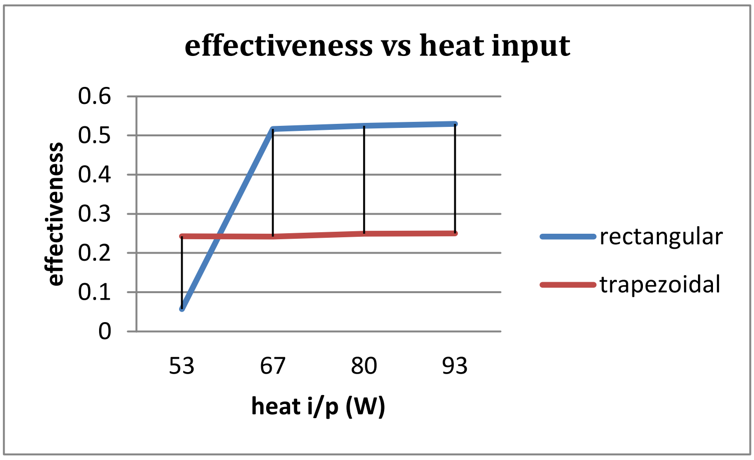


Fig 2: **effectiveness vs heat input**

3. CONCLUSIONS

The experimental comparisons of rectangular and trapezoidal fins were conducted by using Al 6063 alloy fins of dimensions 110x50x10mm for rectangle and 110*30*10mm for trapezoidal and the following observations were drawn.

Fin with extensions Provide near about 5% to 13% has more enhancement of heat transfer as compare to fin without extension. Choosing the minimum value of ambient fluid temperature provide the greater heat transfer rate. Temperature variation at the nodes near the base is more when compared to the distant nodes. A most significant finding of the experimentation is that at heat inputs of 55W, 67W, 80W and 93W heat transfer is enhanced by 37%, 48%, 37%, and 22% for trapezoidal fins in forced convection. The average efficiency of the trapezoidal fin has enhanced by 7.5% in forced convection. The average effectiveness of a trapezoidal fin has increased by 52.8% in forced convection.

REFERENCES

[1] Y. Xia and A.M Jacobi, 2004, “An exact solution to steady heat conduction I a two-dimensional slab on a one-dimensional fin”, international journal of heat and mass transfer.
[2] Haw-long lee, huann-migchou and yu-ching yang, 2004, “the function estimation in predicting heat flux of pin fins with variable heat transfer coefficients”, energy conversion and management.
[3] Chien-Nan Lin and Jiin-Yuh Jang, 2002, “A two-dimensional fin efficiency analysis of combined heat and mass transfer in elliptic fins”, international journal of heat and mass transfer.
[4] Kang, H. S. ad look, D. C. Jr., 2004, “Thermally Asymmetric Annular Rectangular fin Optimization”, AIAA Journal of Thermophysics and heat transfer
[5] Burmeister, L. C., 1979,” Triangular fin performance by the heat balance integral method”, ASME J. of heat trans., vol. 101, pp. 562-564.
[6] Yüncü H., and Anbar G., "An Experimental Investigation on Performance of Rectangular Fins on a Horizontal Base in Free Convection Heat Transfer," International Journal of Heat and Mass Transfer, Vol. 33, pp. 507-514, 1998
[7] Heat mass transfer- yunus A. Cengel Tata McGraw special edition 2007
[8] Incropera and dewitt, introduction to heat transfer.
[9] Saad M. J. Al-Azawi Mechanical Engineering Department University of Anbar.
[10] Ambeprasad.S.Kushwaha, Prof.RavindraKirar (Mechanical, P.C.S.T, Bhopal/ R.G.P.V, India)
[11] E. M. Sparrow, B. R. Baliga and S. V. Patankar[+] Author and Article Information
[12] E. M. Sparrow and S. Acharya[+] Author and Article Information
[13] EmreOzturk and Ilker Tari “Forced Air Cooling of CPUs with Heat Sinks: A Numerical Study” IEEE transactions on components and packaging technologies, Vol. 31, NO. 3, Sep 2008.
[14] Adomian, G. (1983): Stochastic Systems. Academic Press Inc. New York
[15] Ganji, D.D, Sadighi, A.(2007): Application of homotopy- perturbation and variational iteration methods to nonlinear heat transfer and porous media equations, J. Comput. Appl.Math,207: 24-34
[16] [1] Christopher L. Chapman et al, “THERMAL PERFORMANCE OF AN ELLIPTICAL PIN FIN HEAT SINK”, 0 7803-18S2-8/W/$3 .00 01984 IEEE 24 Tenth IEEE SEMITHERMP

[17] [2] W. Leonard, P. Teertstra, J.R. Culham, "CHARACTERIZATION OF HEAT SINK FLOW BYPASS IN PLATE FIN HEAT SINKS", ASME International Mechanical Engineering Congress & Exposition November 17.22, 2002, New Orleans, Louisiana. June 2001 www.ijird.com December, 2013 Vol 2 Issue 13 INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT Page 78

[18] [3] Sukhvinder Kang et al, "THE THERMAL RESISTANCE OF PIN FIN HEAT SINKS IN TRANSVERSE FLOW" , International Electronic Packaging Technical Conference and Exhibition, July 6–11, 2003, Maui, Hawaii, USA

[19] [3] 4. G.N. Ellison, Thermal Computations for Electronic Equipment, 2nd ed., Van Nostrand Reinhold Corporation, New York, 1989.

[20] [3] 5. A.D. Kraus, A. Bar-Cohen, Thermal Analysis and Control of Electronic Equipment, Hemisphere Publishing Corporation, Washington, 1983.

[21] M. Iyengar, A. Bar-Cohen, Least energy optimization of forced convection plate-fin heat sinks, IEEE Trans Components and Packaging Technologies 26 (2003) 62–70.

[22] K. Park, D.H. Choi, K.S. Lee, Optimum design of plate heat exchange with staggered pin arrays, Numerical Heat Transfer. Part A, Applications 45 (2004) 347–361.

[23] K. Park, D.H. Choi, K.S. Lee, Numerical shape optimization for high performance of a heat sink with pin-fins, Numerical He at Transfer. Part A, Applications 46 (2004) 909–927.

[24] K. Park, S. Moon, Optimal design of heat exchangers using the progressive quadratic response surface model, International Journal of Heat and Mass Transfer 42 (2000) 237–244.

B. Sahin, K. Yakut, I. Kotcioglu, C. Celik, Optimum design parameters of a heat exchanger, Apply Energy 82 (2005) 90–106.

[25] R.H. Myers, D.H. Montgomery, Response Surface Methodology, John Wiley & Sons, USA, 1995.

[26] J. Grum, J.M. Slab, The use of factorial design and response surface methodology for fast determination of optimal heat treatment conditions of Different Ni–Co–Mo surface layers, Journal of Material Processing Technology 155–156 (2004) 2026–2032.

[27] B. Ozcelik, T. Erzurmlu, Determination of effecting dimensional parameters on warpage of thin shell plastic parts using integrated response Surface method and genetic algorithm, International communication of Heat and Mass Transfer 32 (2005) 1085–1094.

[28] H.K. Kansal, S. Singh, P. Kumar, Parametric optimization of powder mixed electrical discharge machining by response surface methodology, Journal of Material Processing Technology 169 (2005) 427-436

[29] Ta Chiang, Fu Ping Chang, Application of response surface methodology in the parametric optimization of a pin fin type heat sink. International communication in heat and mass transfer 33 (2006)836-845

[30] Xiaoling Yu , Jianmei Feng, "Development of a plate-pin fin heat sink and its Performance comparisons with a plate fin heat sink", Applied Thermal Engineering 25 (2005) 173–182.

[31] Mohammad Mashud, Md. IliasInam,ZinatRahmanArani and AfsanulTanveer "Experimental Investigation of Heat Transfer Characteristics of Cylindrical Fin with Different Grooves", International Journal of Mechanical & Mechatronics Engineering IJMME Vol: 9 No: 10

[32] W. A. Khan, J. R. Culham, M. M. Yovanovich "Modeling of Cylindrical Pin-Fin Heat Sinks for Electronic Packaging", 0-7803-8985-9/05/$20.00 ©2005 IEEE 21st IEEE SEMITHERM Symposium.

[33] Kai-Shing Yang a, Wei-Hsin Chu, "A comparative study of the airside performance of heat sinks having pin fin configurations".International Journal of Heat and Mass Transfer 50 (2007) 4661–4667.

[34] Anuradha, Sanyal and Pradip, Dutta and Srinivasan, K (2008) Numerical Study Of Heat Transfer From Pin Fin Heat Sink Using Steady And Pulsated Impinging Jets. In: 8th ASME/ISHMT Heat and Mass Transfer Conference, JNTU, Hyderabad

[35] Yue-Tzu Yang, Huan-Sen Peng, Numerical study of the heat sink with un uniform fin Width designs", International Journal of Heat and Mass Transfer 52 (2009) 3473–3480.

[36] Yue-Tzu Yang, Huan-Sen Peng, "Investigation of planted pin fins for heat transfer Enhancement in plate fin heat sink", Microelectronics Reliability 49 (2009) 163–169.

[37] N.Nagarani et al, "Experimental Heat transfer Analysis on Annular Circular and Elliptical fins", International Journal of Engineering Science and Technology Vol. 2(7), 2010, 2839- 2845.

[38] Ashish Kumar Pandey, "A Computational Fluid Dynamics Study of Fluid Flow and Heat Transfer in a Micro channel", NIT, ROURKELA in 2011.

[39] N. Nagarani, "Experimental Heat Transfer Analysis on Annular Elliptical Fins and Comparison with Circular Fins", European Journal of Scientific Research, ISSN 1450-216X Vol.73 No.2 (2012), pp. 143-156.

[40] H. Oktem, T. Erzurmlu, H. Kurtaran, Application of response surface methodology in the optimization of cutting conditions for surface Roughness, Journal of Material Processing Technology 170 (2005) (11–16) Sukhvinder Kang, Maurice Holahan, THE Thermal Resistance of Pin fin Heat Sink in Transverse Flow, International Electronic Packaging Technical Conference and Exhibition July Sukhvinder Kang, Maurice Holahan, THE Thermal Resistance of Pin fin Heat Sink in Transverse Flow International Electronic Packaging Technical Conference and Exhibition July 6–p11, 2003 Maui, Hawaii, USA

List of Special Symbols

A - Area, m^2
h -Heat transfer convection coefficient, $w/m^2.K$
H-Height of the fin, mm
L -Length of the fin, mm
N -Number of fins
T -Temperature,
K W Width of base surface, mm

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