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FIN EFFICIENCY ANALYSIS IN ELECTRONIC DEVICES CONSIDERING TEMPERATURE, HEAT TRANSFER COEFFICIENT, FIN LENGTH: A REVIEW

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Abstract: Temperature, Heat Transfer, Coefficient, Fin Length are considered in the research work to review the Fin Efficiency in Electronic Devices. There are several researches related to the fin efficiency in which some of them have been listed in this work. In this research work, simulation of fin array is done by using MATLAB GUI system. Results for increasing and decreasing of various factors are calculated. Comparative analysis has been proposed related to cases when heat transfer, length and temperature are varied. The present work would be able to optimize the problem related to natural convection heat transfer. The variation related to effectiveness with respect to base temperature. There would be decrement in the effectiveness related to rectangular and triangular at the time of the increment of base temperature. The rectangular fin would exhibit with more effectiveness.

Keywords: Heat Transfer, Coefficient, Fin Length, Baffle, Surface Roughness, Plate Fins, Offset Strip Fins, Matlab Script

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[1]INTRODUCTION

A fin has been considered as the surface. It has been extended from an object. It has been done in order to increase the rate related to heat transfer. This heat transfer may be to the environment with the increment of the convection. For the principle related to conduction, convection radiation related to pin configuration determines the amount related to heat it transfers. Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface is called as fins. [25]

Rectangular fin

A rectangular fin with constant fin base thickness was analysed by using numerical and an analytical method. The heat source is added to the fin which provides an additional heat source. It dissipates more heat rate to the surrounding.

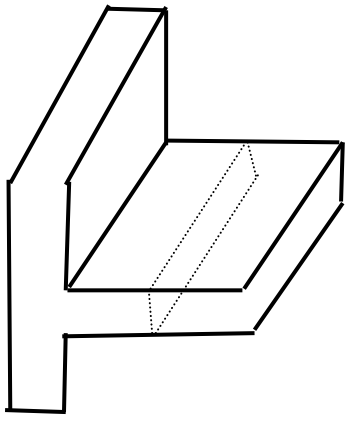

Figure 1 Rectangular Fin (Source:[26])

In order to increase the temperature variation between fin configurations and varies as per the environment, slightly increasing the convection coefficient of the heat transfer. Extension on the finned surfaces has been applied in orderto increase the surface area. This area is related to fin in contact within fluid flowing that is situated around it. Therefore, as the surface area more fluid contact to increase the rate related toheat transfer related to extension provided on fin such as (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extension, and (d) Circular Segmental extension. [22]

Triangular fin

It is the fact that the Triangular fins are attractive. Since for an equal heat transfer it needs much less volume as compare to rectangular fin.

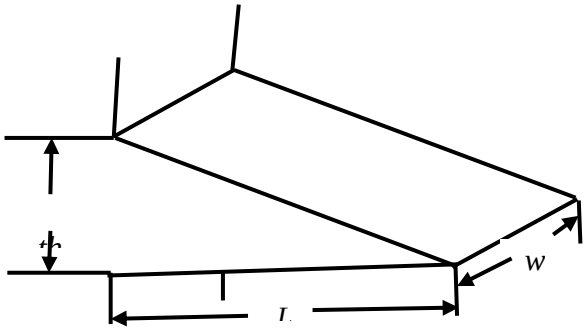

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Figure 2 Triangular Fin (Source:[26])

Therefore, the fins have practical importance. Its reason is that it provides the maximum heat flow per unit mass with ease related to manufacture. In an air-cooled engine, rectangular and triangular fins are provided. It is depend on the periphery related to engine cylinder.Triangular fin has applications on cylinders. It is related to aircooled cylinders and compressors. Here the outer space radiator as well as thesystems which are air conditioned in space craft. [25]

[2] METHOD TO INCREASE THE HEAT TRANSFER

Surface Roughness: using the rough surfaces, the heat transfer has been increased. Four shapes are used for the investigation of the heat transfer enhancement. These shapes are semicircle, sine wave, trapezoid, and arc. Here using such shapes, the friction factor on rectangular duct is also used. [30]

Baffle: In complicated component, the turbulent flow is able to increase the heat transfer. As the example the design related to nuclear reactors, exchangers of the heat, machine used for cooling etc can be discussed. [31] Baffles are able to enhance the pressure losses and the heat transfer coefficients. [23]

Perforated baffle: The heat transfer and friction in an asymmetrical rectangular duct with some solid and perforated baffles with relative roughness. It has been seen that the friction factor has been achieved between 9.6-11.1 times as compare to smooth duct. It is able to make in perforated baffle. The open area baffle provides the highest. [32]

[3]LITERATURE REVIEW

There are several researches related to the fin efficiency in which some of them have been listed here such as:

M. S. Abdel Latif et. al (2015) conclude exact implicit solution related to non-linear differential equation governing heat transfer in fins (2.4) subject to boundary conditions (2.7) has been obtained using λ-symmetry reduction method as well as the Lie point symmetry method. [1]

Hie Chan KANG et. al (2012) studied fin efficiency in real heat exchanger. It has been proposed as ratio related to real heat transfer to maximum heat transfer related to fin as thermal conductivity related to fin approaches infinite. Fin efficiency was approx similar to the non-dimensional fin temperature. It was normalized with inlet as well as wall temperatures. It has been done in order to increase the rate related to heat transfer. This heat transfer may be to the environment with the increment of the convection. For the principle related to conduction, convection radiation related to pin configuration determines the amount related to heat it transfer. [2]

Samyak Shah et. al (2018) obtained Split fin pattern out three pattern applied where others are Parallel horizontal fin pattern as well as the V fin pattern has best effectiveness value. In this project has been that, design related to fin pattern has been also important for enhancing heat transfer because value related to surface area to a which heat transfer take place has been minimum in case related to Split fin pattern but it gives maximum value related to effectiveness which means greater heat transfer. [3]

Abdullah, H. Alessa et. al. (2009) had studied natural convection heat transfer enhancement. It is related to a horizontal rectangular fin. It was embedded along with perforations of the equilateral triangular. In order to increase the temperature variation between fin configurations and varies as per the environment, slightly increasing the convection coefficient of the heat transfer. [4]

GolnooshMostafavi et. al (2012) studied steady-state external natural convection heat transfer. It was related to a vertically mounted rectangular which is finned heat sinks. The heat transfer can be enhanced by the use related to rough surfaces. Four shapes are used for the investigation of the heat transfer enhancement. These shapes are semicircle, sine wave, trapezoid, and arc. Here using such shapes, the friction factor on rectangular duct is also used. [5]

Sable, M.J. et. al. (2010) had investigated for natural convection adjacent to a vertical heated plate. It has been done with a multiple v- type partition plates. The researchers have observed one fact. It was that -type fin array design performs better between three several fin array configurations. This configuration is on vertical heated plate. It is better than the V than rectangular vertical fin array. [6]

Misumi with Kitamura et. Al (1990) has reported an experimental work. This work was related to the

enhancement related to natural convection heat transfer. It has a horizontal partition plate as well as the V-plates in water ambience. The researcher have evaluated that heat transfer in region of downstream related to partition plate has been enhanced markedly. [7]

Guillaumpolidori and padetet. al (2003) studied natural convection on vertical ribbed wall experimentally with a wall boundary condition. It is related to uniform heat flux. It has been used to get an idea related to the roughness geometry. It influences the heat transfer. [8]

Katerina Ralevaet. al (2008) investigate influenced related to gate temperature on amount related to current degradation due to heating effects. Gate contacts as a heat sink to properly solve phonon balance equations. [10]

R.J. Romero et al (2010) proposed research work on First Double Stage Heat Transformer (Dsht) In Latin America. A detailed study related to design as well as the thermodynamic modelling related to first system related to double staged heat transformer which was installed in Latin America has been given. To calculate this system, a ternary mixture related to hydroxides has applied. [11]

Shivdas S. Kharche, et al (2012) discussed Heat shifting Analysis by Fin Array Using Natural Convection. Main purpose related to extensive surface has been called fins for increasing heat shifting rate. Fins offer a trouble free & economical solution in various situations which demands natural convection related to heat shifting. Heat sinks were found form related to fin arrays on horizontal & vertical surfaces. [12]

Dr D P Mishra, et al (2013) provided experimental analysis related to Heat Transfer as well as the Average Heat Transfer Coefficient through Fin Array With or Without Notch Using Free Convection.
No one use other material than aluminium. In base research author has planned to modify material related to fin. [13]

Guei-Jang Huang, et al, (2012) flow fields as well as the longitudinal distributions related to height-averaged local heat flux to a fin surface are analysed to describe effects related to fin-base perforations. Overall heat transfer coefficients with perforations are enhanced by a factor related to 2.0 to 2.7. Under a fixed total perforation length, conditions with more distributed shorter perforations exhibit higher improvements. [14]

Hu, T. Sarvey, et al (2017) stated Single phase liquid cooling related to hotspots in a heterogeneous pin-fin-enhanced micro-gap with non-uniform fin array. Thermal performance related to cylindrical fin-enhanced TDVs as well as the hydrofoil fin-enhanced TDVs are examined. [15]

Ali. et al. (2016) reviewed Applications related to Nanotechnology in Science as well as the Engineering**.** Nanotechnology has been found helpful to upgrade as well as the revolutionize multiple methods in industrial fields: data technology etc. [16]

Prantosh K. Paul et al. (2018) developed with aspects considering issues as well as the challenges. In this paper basics related to nanotechnology such as its applications in computing as well as the information technology are well illustrated. Cloud computing as well as the big Data Management as well as the current opportunities has been relation to nanotechnology is defined. [17]

B. Ramdas Pradipet et al. (2013) He studied that there are several companies industries which are applying the thermal systems. In these systems the overheating is common and could influence the system components as well as the lead to failure related to system. [19]

Golnoosh Mostafaviet et al. (2012) they investigated the steady-state external natural convection heat transfer. It was done with vertically increased rectangular interrupted finned heat sinks. After regenerating as well as the validating existing analytical results for continuous fins, the Results of the research work have shown that adding interruptions to vertical rectangular fins enhances thermal performance related to fins. The proposed work is able to reduce the weight of the fin arrays. [20]

L.Prabhuet. al (2018) the use related to fin (extended surface), provide efficient heat transfer. Effectiveness related to fin with rectangular configuration has been greater than other configurations. It has been done in order to increase the rate related to heat transfer. This heat transfer may be to the environment with the increment of the convection. For the principle related to conduction, convection radiation related to pin configuration determines the amount related to heat it transfer. In order to increase the temperature variation between fin configurations and varies as per the environment, slightly increasing the convection coefficient of the heat transfer.

Heat transfer enhancement or heat transfer intensification is related to very importance in the applications related to thermal systems where overheating can damage the components or assemblies related to the system. [21]

Hyung S.et. al (2007) studied influence related to fin base height as well as the fin base thickness on temperature related to a rectangular fin.[48]

S. Sunil et al. (1996) investigated 1D transient thin rectangular fin. the researcher studied temperature within velocity distributions in field. It plays an important part in the apps of thermal systems. Here are the chances of overheating side effect on the components related to architecture. In that situation, transfer intensification methods have been used in apps applicable in industrial [23]. To avoid such issues, these techniques are applicable Heat transfer enhancement can be referred as the heat transfer intensification. [49]

A.A.Walunj et al. (2004) investigated performance related to rectangular fins. It is under natural convection within numerical orientation related to heat sink. [51]

C. Harley as well as the R.J. Moitsheki et. al (2013)obtained numerical solutions for relevant energy balance equation. It is applicable in longitudinal fin in without dimension variables. It has been done using implementation related to inbuilt functions within MATLAB. [52]

Raseelo J. Moitsheki as well as the Atish R. et. al (2011)studied two-dimensional steady rectangular fin. the researcher assumed that thermal conductivityand heat transfer coefficient are dependent on temperature. The researcher employed Kirchoff transformation on governing equation. [53]

Masoud A. investigated et. al (2013) interaction related to thermal radiation with convection has been numerically investigated and an exact solution has been performed for temperature distribution related to fin constant cross -sectional area. [54]

A. Moradiet. al (2011)employed differential transformation technique. It has been used (DTM) for thermal characteristics. These are related to straight rectangular fins. These are used for every type related to heat transfer. Here the numerical comparison among the DTM, domain decomposition mechanisms as well as the exact analytical solution mechanisms. [55]

A. Campo as well as the I. Lira et. al (2012) they applied a simple approximate to get analytic solution related to quasi 1-D heat equation for annular fins related to variable profile. In their study annular fin related to hyperbolic profile was selected. To solve governing quasi 1-D heat equation in this annular fin approximately, usage related to mean value theorem for integration to a calculus was made. [56]

Dr. Saeed J. Almalowi et. al (2016) effect related to Biot number on fin effectiveness.they find that fin effectiveness decreases with increasing. [59]

Rahul C. Chikurde et. al (2019)Numerical study related to Natural convection heat transfer has been carried out for horizontal base vertical fin array consisting related to plane fins as well as the knurled fins with various knurling height as well as the depth configurations. Numerical model has been checked for grid independency as well as the also validated against experimental data to a literature. Flow characteristics to a numerical as well as the experiments for plane as well as the knurled fin configurations are compared. More attention has been devoted to understand flow physics as well as the heat transfer phenomena as well as the effect related to knurling on flow has been studied. Results are plotted in terms related to average Nu_a vs Ra for various fin spacing as well as the values compared with experimental data. [60]

[4] PROPOSED WORK

Between a hot solid surface as well as the surrounding colder fluid, Convection heat transfer has been managed by cooling law of the Newton. His law is expressed as

$$Q_{conv} = hA(T_S - T_\infty) \quad (4.1)$$

Where, h = convection heat transfer coefficient

T_S =Hot surface temperature

T_∞ =Fluid temperature

A=area of contact or exposure

Thus, increment in convection heat transfer has been made by below given steps -

1. Make the increment in temperature difference ($T_S - T_\infty$) among surface as well as the fluid.

2. To increase the convection heat transfer coefficient with the increment of the fluid flow on body.

3. Enhance the area related to the contact\ exposure among the surface and the fluid.

[5] FINS PERFORMANCE PARAMETERS

Regardless of the fin geometry, an exact theoretical analysis of their heat transfer mode is in most practical cases not possible. The large variety of fins used up to now can be grouped as longitudinal, radial and in pin fins. [87]

- There are long list of assumptions for analysis for fins some of these assumptions, such as
- The thermal conductivity of the fin material is constant. [26,86]
- The heat transfer coefficient is the same over the entire fin surface. [26, 86]
- The temperature at the base of the fin is uniform. [26, 86]
- The heat transfer through the tip of the fin is negligible compared with the heat leaving its lateral surface. [26,86]
- The fin thickness is so small compared with its length that temperature gradients normal to the surface may be neglected. [26,86]

[6]CONCLUSION

Temperature, Heat Transfer, Coefficient, Fin Length are considered in the research work to review the Fin Efficiency in Electronic Devices. In this research work, simulation of fin array is done by using MATLAB GUI system. Results for increasing and decreasing of various factors are calculated. If temperature has been increased then heat transfer got increased but the efficiency and effectiveness is not affected. If the heat transfer coefficient has been reduced then efficiency and effectiveness got increased but the Heat transfer got reduced. If length has been increased then heat transfer and effectiveness got increased but the efficiency got reduced. Comparative analysis has been proposed related to cases when heat transfer, length and temperature are varied.

[7]SCOPE OF RESEARCH

The research work would provide the review of Fin Efficiency in Electronic Devices for which the Temperature, Heat Transfer, Coefficient, Fin Length are considered. The various factors which are considered in the research work would solve the problem related to heating in nanodevice. The present work would be able to optimize the problem related to natural convection heat transfer. The variation related to effectiveness with respect to base temperature. There would be decrement in the effectiveness related to rectangular and triangular at the time of the increment of base temperature. The rectangular fin would exhibit with more effectiveness.

REFERENCES

[1]M. S. Abdel Latif, A. H. Abdel Kader and H. M. Nour" Exact implicit Solution of Nonlinear Heat Transfer in Rectangular Straight Fin Using Symmetry Reduction Methods

[2]Hie Chan KANG1"Evaluation of Fin Efficiency and Heat Transfer Coefficient of Heat Exchanger Having Plate Fins

[3]Samyak Shah1, Rushabh Sanghavi2, Krunal Rathod3"EFFECT ARRAY SHAPE ON THE PERFORMANCE OF FIN

[4] Abdullah, H. Alessa and Mohammed, Q. Al-Odat, "Enhancement of Natural Convection Heat Transfer from a Fin by Triangular Perforations of Bases Parallel and Toward its Base", The Arabian Journal for Science and Engineering, vol. 34, pp. 531-544, 2009.

[5]Golnoosh Mostafavi, "Natural Convective Heat Transfer from Interrupted Rectangular Fins", MASc, Simon Fraser University, Canada, 2012.

[6]Sable M.J., Jagtap S.J., Patil P.S., Baviskar P.R. and Barve S.B., "Enhancement of Natural Convection Heat Transfer on Vertical Heated Plate by Multiple V-fin array", IJRRAS, vol. 5, issue 2, pp. 123-128, 2010.

[7]Misumi Toshiyuki and Kitamura Kenzo "Natural convection heat transfer from a vertical heated plate." Heat transfer –Japanese Research, Vol-19 No.1 pp-57.1990

[8]Guillaume Polidori and Jaques Padet. "Transient free convection flow on a vertical surface with an array of large scale roughness elements". Experimental thermal and fluid science no-27 pp-251-260,2003.

[9]PYunus A. Cengel, 2004, "Heat Transfer- a Practical Approach", SI units 2nd Edition, Tata McGraw Hill Co., Pg. No. : 156-168, 333-352& 459-500

[10]Katerina Raleva, Dragica Vasileska, Mihail Nedjalkov,Stephen M. Goodnick"Modeling Thermal Effects in Nanodevices, IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 55, NO. 6, JUNE 2008

[11] R.J. Romero, Sotsil Silva (2010) "First Double Stage Heat Transformer (Dsht) In Latinamerica",

[12] Shivdas S. Kharche, Hemant S. Farkade (2012) "Heat shifting Analysis by Fin Array Using Natural Convection", International Journal of Emerging Technology & highly developed Engineering Volume 2, Issue 4, April 2012
[13]Dr D P Mishra, S R Dixit, (2013) "Experimental Analysis of Heat Transfer And Average Heat Transfer Coefficient Through Fin Array With or With out Notch Using Free Convection
[14] Guei-Jang Huang, Shwin-Chung Wong and Chun-Pei Lin, "Enhancement of natural convection heat transfer from horizontal rectangular fin arrays with perforations in fin base," 2012 7th International Microsystems, Packaging, Assembly and Circuits Technology Conference (IMPACT), Taipei, 2012, pp. 295-298.
[15] Hu, T. Sarvey, M. Bakir and Y. Joshi, "Single phase liquid cooling of hotspots in a heterogeneous pin-fin-enhanced microgap with non-uniform fin array," 2017 16th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (ITherm), Orlando, FL, 2017, pp. 500-504
[16] C. Lee and H. Juo, "Multiple-Submicron Channel Array Gate-Recessed AlGaN/GaN Fin-MOSHEMTs," in IEEE Journal of the Electron Devices Society, vol. 6, pp. 183-188, 2018.
[17] Y. Han, B. L. Lau, G. Tang, H. Chen and X. Zhang, "Si Micro-fluid Cooler with Jet-Slot Array for Server Processor Direct Liquid Cooling," in IEEE Transactions on Components, Packaging and Manufacturing Technology.
[18]Mobasser, ShariatandFiroozi, Ali. (2016). Review of Nanotechnology Applications in Science and Engineering. 6. 84-93. C. R. K. Marrian, "Investing in nanotechnology" 1 p-4-1, p. 72.
[19]B. Ramdas, Pradip and K. Kumar, Dinesh, "A Study on the Heat Transfer Enhancement for Air Flow through a Duct with Various Rib Inserts", International Journal of Latest Trends in Engineering and Technology, vol. 2, issue 4, pp. 479-485, 2013.
[20]. Golnoosh Mostafavi, "Natural Convective Heat Transfer from Interrupted Rectangular Fins", MASc, Simon Fraser University, Canada, 2012.
[21]. L.Prabhu, 2M.Ganesh Kumar 3 Prasanth M, 4 Parthasarathy M"DESIGN AND ANALYSIS OF DIFFERENT TYPES OF FIN CONFIGURATIONS USING ANSYS,Volume 118 No. 5 2018, 1011-1017
[22]Pardeep Singh, Harvinder lal, Baljit Singh Ubhi"Design and Analysis for Heat Transfer through Fin with Extensions, Vol. 3, Issue 5, May 2014
[23]Pradip Ramdas Bodade and Dinesh Kumar Koli "A study on the heat transfer enhancement for air flow through a duct with various rib inserts,Vol. 2 Issue 4 July 2013
[24]Saeed J. Almalowi "Analytical and Numerical Solution of One-Dimensional a Rectangular Fin with an Additional Heat Source ,Nov-2015
[25]Sandhya Mirapalli, Kishore.P.S "Heat Transfer Analysis on a Triangular Fin,Volume 19 Number 5 – Jan 2015
[26]Pandya Bhavik J. & Megha C. Karia "A BRIEF OVERVIEW OF APPLICATION OF EXTENDED SURFACES (FINS) FOR ENHANCEMENT OF HEAT TRANSFER,[Kumar, 6(2): February 2019]
[27] George Oguntala a, Raed Abd-Alhameed a, Gbeminiyi Sobamowo b, Halimatu-Sadiyah Abdullahi a, Improved thermal management of computer microprocessors using cylindrical-coordinate micro-fin heat sink with artificial surface roughness, Engineering Science and Technology, an International Journal 21 (2018) 736–744
[28] B. Rajesh Reguram , S. Surendran a, Seung Keon Lee , Application of fin system to reduce pitch motion, International Journal of Naval Architecture and Ocean Engineering
[29]Claudio Corgnalea, Bruce Hardya, Richard Chahinec, Daniel Cossementc, Hydrogen desorption using honeycomb finned heat exchangers integrated in adsorbent storage systems, journal homepage: www.elsevier.com/locate/apenergy
[30]Soo Wban Abn and Kang Pil Son "An Investigation on Friction Factors and Heat Transfer Coefficients in a Rectangular Duct with Surface Roughness" KSME International Journal Vol 16 No.4, pp. 549-556, 2002.
[31] Hamidou Benzenine , Rachid Saim and Said Abboudi, Omar Imine " Numerical analysis of a turbulent flow in a channel provided with transversal waved baffles".
[32] Rajendra Karwa and B.K. Maheshwari "Heat transfer and friction in an asymmetrically heated rectangular duct with half and fully perforated baffles at different pitches" International Communications in Heat and Mass Transfer 36 (2009) pp. 264–268.
[33] Prashanta Dutta and Akram Hossain "Internal cooling augmentation in rectangular channel using two inclined baffles" International Journal of Heat and Fluid Flow 26 (2005),pp. 223–232
[34] Kang- Hoon Ko and N.K. Anand "Use of porous baffles to enhance heat transfer in a rectangular channel" International Journal of Heat and Mass Transfers 46 (2003) pp. 4191– 4199.
[35] Waleed Mohammed Abed and Mohammed Abed Ahmed "Numerical Study Of Laminar Forced Convection Heat Transfer And Fluid Flow Characteristics In A Corrugated Channel" Journal of

Engineering and Development, Vol. 14, No. 3, September (2010) ISSN 1813-7822.

[36] S. Naga Sarada, A.V. Sita Rama Raju, K. Kalyani Radha and L. Shyam Sunder Enhancement of heat transfer using varying width twisted tape inserts International Journal of Engineering, Science and Technology Vol. 2, No. 6, 2010, pp. 107-118.

[37] Tang Xinyi and ZHU Dongsheng "Experimental and Numerical Study on Heat Transfer Enhancement of a Rectangular Channel with Discontinuous Crossed Ribs and Grooves" fliud dynamics and transport phenomena Chinese Journal of Chemiacal Engineering, 20(2) 220— 230 (2012)

[38] M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Dorling Kindersely, 2011. [39] S.C.Arora, S.Domkundwar and Anand V.Domlundwar, A Course in Heat and Mass Transfer, Dhanapati Rai and Co. (P) Ltd, 2004.

[40] F.P.Incropera, Fundamentals of Heat and Mass Transfer, John Wiley and Sons.

[41] Mahesh, M. Rathore, Raul Raymond Kapuno, Engineering Heat Transfer, Jones and Bartlett Learning, 2011.

[42] Gaurav Kumar, Kamal Raj Sharma, Ankur Dwivedi, Alwar Singh Yadav and Hariram Patel, Experimental Investigation of Natural Convection from Heated Triangular Fin Array within a Rectangular Array, Research India Publications, Vol. 4, pp.203-210, 2014.

[43] Dr. Somunk Teerakulpisut, Application of Modified Bessel functions in Extended Surface Heat Transfer, Vol. 22, pp.61-74, 1995.

[44] Abdul Rahim, A.Khaled and A.Abdullatif, Heat Transfer Enhancement via Combined Wall and Triangular- Rooted Fin System, KSA Journal of Electronics Cooling and Thermal Control, Vol. 4, pp.12-21, 2014.

[45] N.G.Narve, N.K.Sane, R.T.Jadhav, Natural Convection Heat Transfer from Symmetrical Triangular Fin Arrays on Vertical Surface, International Journal of Scientific and Engineering Research, Vol.4, May, 2013.

[46] Shahnor Basri, M. M. Fakir, F. Mustapha, D. L. A. Majid, A. A. Jaafar, Heat Distribution In Rectangular Fins Using Efficient Finite Element And Differential Quadrature Methods, 2009, Engineering, Scientific Research

[47] Antonio Acosta-Iborra and Antonio Campo, Approximate Analytic Analysis Of Annular Fins WithUniform Thickness By Way Of The Mean Value Theorem For Integration That Avoids Modified Bessel Functions, 2013, Latin American and Caribbean Journal of Engineering Education Vol. 7(1).

[48] Hyung Suk Kang, Optimization of a Triangular Fin with Variablem Fin Base Thickness, 2007, International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering Vol:1 No:1.

[49] S. Sunil, J. R. N. Reddy, C. B. Sobhan , Natural convection heat transfer from a thin rectangular fin with a line source at the base Ð a finite difference solution, 1996, Heat and Mass Transfer 31 (1996) 127Ð135 (Springer-Verlag.

[50] Lien-Tsai Yu and Chao-Kuang Chen, Application of Taylor transformation to optimize rectangular with variable thermal parameters, 1998, Applied Mathematical Modeling 22 11±21.

[51]A.A.Walunj,V.S. Daund,andD.D.Palande, Review of Performance of Rectangular Fins under Natural Convection at Different Orientation of Heat Sink,2004 International Journal of Innovation and Applied Studies ISSN 2028-9324 Vol. 6 No.pp. 232-238.

[52]C. Harley and R.J. Moitsheki, Numerical investigation of the temperature profile in a rectangular longitudinal fin, 2013, Nonlinear Analysis: Real World Applications 13 2343–2351.

[53] Raseelo J. Moitsheki and Atish Rowjee, Steady Heat Transfer through a Two-Dimensional Rectangular Straight Fin, 2011 Mathematical Problems in Engineering Volume Article ID 826819.

[54] Masoud Asadi and Ramin Haghighi Khoshkho, Temperature Distribution along a Constant Cross Sectional Area Fin,2013, International Journal of Mechanics and Applications , 3(5): 131-137 DOI: 10.5923/j.mechanics.20130305.04.

[55] A. Moradi, Analytical Solution For Fin With Temperature Dependent Heat Transfer Coefficient,2011, International Journal of Engineering & Applied Sciences (IJEAS) Vol.3, Issue 21-12.

[56] Antonio Campo and Ignacio Lira, Simple approximate analytic treatment of annular fins of variable profile in a heat transfer course, 2012, Latin American and Caribbean Journal of Engineering Education, Vol. 6(1).

[57] Dr. Saeed J. Almalowi, smalowi@taibahu.edu.sa

[58] Heat and Mass transfer by R K Rajput

[59] A.H. Abdel Kader, M.S. Abdel Latif, H.M. Nour "EXACT SOLUTION OF FIN PROBLEM WITH LINEAR TEMPERATURE-DEPENDENT THERMAL CONDUCTIVITY, 15 November 2016

[60] Rahul C. Chikurde ,Basavraj S. Kothavale Dr. Prof. ,Narayan. K. Sane Dr."Numerical validation of natural convection heat transfer with horizontal

rectangular fin array using straight knurling patterns on fins—correlation for Nusselt number, March 2019

[61] Pandya Bhavik , Megha C. Karia" Latest Trends in Novel Applications of Various Heat Exchangers for Enhancement of Heat Transfer, Journal of Modern Thermodynamics in Mechanical System Volume 1Issue 1

[62] V.S.Daund, D.D.Palande" Effect of Low Aspect Ratio on Convective Heat Transfer from Rectangular Fin Array in Natural Convection, August, 2014

[63] K. Priyadharshini, "finite element analysis of radiator fins to increase the convection efficiency of radiator by using Al alloy, Cu and brass material.", Journal of Advanced Engineering Research, ISSN: 2393-8447, Volume 3, Issue 1, 2016, pp.78-82

[64] Vivek Kumar Gaba, Anil Kumar Tiwari and Shubhankar Bhowmick "A REPORT ON PERFORMANCE OF ANNULAR FINS HAVING VARYING THICKNESS" Department of Mechanical Engineering, National Institute of Technology Raipur, India, VOL. 11, NO. 8, APRIL 2016

[65] Duffin R.J. and McLain D.T. "Optimum Shape of a cooling fin on a convex cylinder". J. Math. Mech., Vol. 17, pp. 769 – 784.

[66] Yasar Islamoglu "Numerical analysis of the influence of a circular fin with different profiles on the thermal characteristics in a ceramic tube of heat transfer equipment", Department of Mechanical Engineering, Sakarya University, Esentepe Campus, Adapazari 54187, Turkey, International Journal of Pressure Vessels and Piping 81 (2004) 583–587

[67] Kavita H. DhanawadeȦ , Vivek K. SunnapwarȦ and Hanamant S. DhanawadeḂ "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, Special Issue-2, (February 2014)

[68] A. H. AIEssa and Fayez M.S. Al-Hussien, (2004) The effect of orientation of square perforations on the heat transfer enhancement from a fin subjected to natural convection, Heat and Mass Transfer, 40, pp. 509-515 A.

[69] H. AIEssa and Mohmmed I. Al-Widyan,(2008) Enhancement of natural convection heat transfer from a fin by triangular perforations of bases parallel and toward its tip,Applied Mathematics and Mechanics, 29, pp .1033-1044. A.

[70]H. AIEssa and Mohammed Q. Al-Odat,(2009) Enhancement of natural convection heat transfer from a fin by triangular perforations of bases parallel and toward its base, The Arbian Journal for Science and Engineering, 34 2B, pp. 531-544. A.

[71]H. AIEssa, Ayman M.Maqableh and Shatha Ammourah,, (2009) Enhancement of natural convection heat transfer from a fin by rectangular perforations with aspect ratio of two, International journal of Physical Sciences, 4 , pp. 540-547 A.

[72]H. M AIEssa,(2012)Augmentation of Fin Natural convection heat dissipation by square perforations, Journal of mechanical engineering and automation 2, pp. 1-5.

[73] U. Akyol, K. Bilen, (2006) Heat transfer and thermal performance analysis of a surface with hollow rectangular fins, Applied Thermal Engineering, 26 , pp. 209-216.

[74] Adel Ahmed Almubarak "The Effects of Heat on Electronic Components" Int. Journal of Engineering Research and Application" ISSN : 2248-9622, Vol. 7, Issue 5, (Part -5) May 2017, pp.52-57

[75] Liao, B., Maznev, A. A., Nelson, K. A., and Chen, G. (2016). Photo-excited charge carriers suppress sub-terahertz phonon mode in silicon at room temperature. Nature Communications. 7. DOI: 10.1038/ncomms13174

[76] Korotkov, A. N., Samuelsen, M. R., & Vasenco, S. A. (1994). Effects of overheating in a single-electron transistor. Journal of Applied Physics. 76(6).10.1063/1.357424

[77]EE Publishers. (2014, July 8). Thermal stress on capacitors: Failure prevention. EE Publishers. Retrieved on 3 May 2017 from http://www.ee.co.za/article/thermal-stresscapacitors-failure-prevention.html

[78] Berk, J. (2009). Systems Failure Analysis. Ohio: ASM International

[79]Mehoke, V. L. (2005). Spacecraft thermal control. In V. L. Pisacane (ed.), Fundamentals of Space Systems (2nd ed.). Oxford: Oxford University Press

[80]Platt, C. & Jansson, F. (2014). "Solid-state relays." In Encyclopedia of Electronic Components Vol. 2: LEDs, LCDs, Audio, Thyristors, Digital Logic, and Amplification. CA: Maker Media, Inc

[81] Yang, L, Wei, B. & Zhang, J. (2012). Transient thermal characterization of organic light-emitting diodes. Semiconductor Science and Technology. 27

[82]Dede, E. M., Lee, J. & Nomura, T. (2014). Multiphysics simulation: Electrochemical system applications and optimization. London: Springer-Verlag

[83] Cengel, Y. & Ghajar, A. (2015). Heat and mass transfer: Fundamentals and applications (5th ed.). NY: McGraw-Hill

[84] Sangwine, S. (2007). Electronic Components and Technology (3rd ed.). London: CRC Press
[85] Thomas PERROTIN, Denis CLODIC "FIN EFFICIENCY CALCULATION IN ENHANCED FIN-AND-TUBE HEAT EXCHANGERS IN DRY CONDITIONS" ICR0026
[86] Piyush Kumar Kashyap, priyanka jhavar, Enhancement of Heat Exchanger Performance by the Extended Surfaces-Fins, International Journal of Engineering Trends and Technology (IJETT) – Volume 34 Number 6- April 2016
[87] V.P.Isachenko, V. Osipova, A. Sukomel, 1969, Heat Transfer, Mir, Moscow.
[88]] T. Tsutsui and T. Igarashi, 2006, The heat transfer enhancement of a circular cylinder, J. Heat of Transfer Volume128, pp. 226-233.
[89] josh perry "the benefits of pin fin heat sinks in thermal management of electronics"2007. https://www.qats.com/cms/2017/08/22/what-are-benefits-of-using-pin-fin-heat-sinks-in-thermal-management-of-electronics/
[90] http://www.newelectronics.co.uk/electronics-technology/pin-fin-heat-sinks-point-the-way-to-more-efficient-cooling/18641/
[91] https://www.qats.com/News-Room/Press-Releases-Content/1184.aspx
[92] Josh perry " ATS Platform Products Provide Cost-Effective Solutions at High Airflow" https://www.qats.com/News-Room/Press-Releases-Content/1184.aspx
[93] Murray W.M (1938). Heat dissipation through an annular disk or fin of uniform thickness . J. appl. Mech. Trans. ASME Vol. 60,p. 78.
[94] Brown A, (1965). Optimum dimensions of uniform annular fins. Int. J. Heat and mass transfer, Vol.8,pp.655-662
[95] Ullmann A., Kalman H.,(1989).Efficiency and optimized dimensions of annular fins of different cross section shapes. Int. J. heat and mass transfer, Vol. 32, pp. 1105-1105
[96] Hie Chan KANG "Evaluation of Fin Efficiency and Heat Transfer Coefficient of Heat Exchanger Having Plate Fins", Kunsan National University, School of Mechanical and Automotive Engineering 2012
[97] Fundamentals of Engineering Heat and Mass transfer by R C Sachdeva