JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

THERMAL ANALYSIS OF A STRAIGHT PLATE FIN HEAT SINK

[1]Dr. S. SUDHAKAR BABU, [2]D. MAVEEN, [3]P. ADITYA VARDHAN, [4]S. SIVA KOTESWARA RAO, [5]A. JAGADEESH REDDY, [6]E. SAI KALYAN,

[1]Professor in Mechanical engineering department, NRI Institute of Technology, Pothavarappadu, Eluru(Dist.), A.P, India, 521212.
[2,3,4,5,6]Student in Mechanical engineering department, NRI Institute of Technology, Pothavarappadu, Eluru(Dist),A.P, India, 521212.

Abstract : Heat dissipation is becoming more and more challenging with the preface of increased miniaturization of electronic components having staggering heat generation levels. So efficient cooling of the electronic devices becomes a challenging task in thermal area .Innovation in technology has made a large leap towards compact, so equipment size variation has changed to miniature size. For optimum working condition of electronic systems energy-efficient heat sink is needed. To overcome the problem of overheating, numerous heat sink designs are proposed including straight plate fin heat sink. Finned Heat Sinks are used to cool power Electronic Components The temperature difference is analyzed to get better understanding of heat transfer from the sink to ambient air. Three-dimensional numerical simulations with different parameters will be studied for the straight plate-add fin heat sinks model in forced-convection regime. The results obtained through ANSYS. We had performed steady state thermal analysis here. Comprehensive parametric studies will be performed by varying parameters such as thermal conductivity, convection heat transfer coefficient, emissivity, etc. on temperature distribution.

Key words: Thermal analysis, Plate fin heat sink, Heat transfer, ANSYS.

I. INTRODUCTION

Due to compact structural design of the modern electronic devices, unwanted heat is produced in the circuit boards. High thermal densities decrease the life of the electronic chip, hence, proper thermal management is needed to extract unwanted heat from the system. Heat sinks made of aluminium alloy are commonly used cooling systems to extract heat from the system and dump into the environment. Heat Sink gives excess heat a place to go. Appropriately sized heat sinks maintain the semiconductor junction temperature at or lower than the maximum allowable temperature. Heat Sink is used in a place where the elements turn out heat. The elements that turn out the most heat is the Processor. Heat Sinks are conventionally used in various industrial purposes to cool electronic, Power electronic, telecommunication and automotive elements, those elements might be either high power semi-conductor devices, audio amplifiers, microcontrollers and microprocessors. Heat transfer depends on the material properties and contact area between two materials. Many fins are mounted vertically on the horizontal base plate to maximize the area of contact. Currently, conventional heat sink with straight fins is commonly used due to the simple geometry, low cost of manufacturing and high heat transfer rate. Application of cooling system in thermal engineering is recognized and have been studied both theoretically and practically in building energy system, electronic devices, chemical vapor deposition instruments, solar energy collectors, furnace engineering, and many more. In recent years, thermal management of electronic devices is of interest as a new generation of high performing dense chip packages that function at high frequency produces a very high heat flux on the electronic devices. Prolonged heat flux creates a hot spot on the electronic devices and reduces the lifespan of the electronic devices because of the acceleration of the mean time to failure. Thermal management of compact electronic devices that operate at high power density is critical as there is a lack of efficient technique to remove heat dissipation from the electronic devices. A heat exchanger is a machine that transfers the heat of a fluid to one or more other fluids with different temperatures. As a result, the heat exchangers are implemented in all industrial and commercial usages, and even those aspects of normal life that are related to energy transfer. Each living creature is somehow equipped with a heat exchanger. Heat exchangers are manufactured in very small and very huge sizes. The smallest heat exchangers (less than 1 W) are used for superconductor electronic applications, guiding missiles controlled by the thermal source, etc. The biggest heat exchangers (more than 1000 MW) are implemented in large power plants as boiler, condenser or cooling tower. Heat exchangers are widely used in different industrial units like power plants, refineries, metal molding and glass industries, food and medicine industries, paper making, petrochemistry, cold storage, heating and cooling systems for buildings, gas congestion industries, land, sea and space vehicles, and finally electronic industries. The current research focusses on the optimization of plate fin type, aluminum structured heat sink, using innovative computational and simulation tool, ANSYS software. V. Naga Raju et. al. [1] Performed Steady State Thermal Analysis on different types of fins they were rectangular fins, Circular fins, Triangular fins, and Interrupted Rectangular fins. They had determined Temperature Distribution, Total Heat flux, directional heat flux of all these fins. Here they used ANSYS software for the design and analysis purpose. Finally, by observing the thermal analysis results, Total Heat flux is more for Interrupted Rectangular fin than another rectangular fin, Circular fin and Triangular fin. J.M. Blanco et. al. [2] developed a design tool called "Opti-fin" for a MATLAB® environment that allows the user to configure a fin on the basis of the material and the thermal heat that will be released. This tool has been validated by computational fluid dynamic simulations using ANSYS-FLUENT®, in which the results of the simulation and the actual triangular shaped fin showed a remarkable similarity. The "Opti-Fin" tool under predicts temperature values by a maximum of 3% with regard to the results obtained by CFD with ANSYS FLUENT Comparative studies have been conducted to evaluate the influence of the different parameters of the fin on the performance of the fin in terms of cooling capacity. Malukandy Prabisha et. al. [3] discussed the heat sink with thermal aspect of existing-fin circumstance effort to produce an optimum design for the heat sink by assorting its correlated parameters through modeling and analyzing the design through simulation software. Additionally mathematical computation work is done by technical programming to acquire efficiency and effectiveness of heat sink. Iman Shahdad et. al. [4] investigates the flow field and turbulent flow heat transfer around an array of plain and perforated fin using Fluent software within the range of 20,000–50,000 Reynolds. In the simulation process, air was considered as the working fluid with consistent physical properties. The highest heat transfer coefficient and Nusselt number was achieved for perforated fins with two square holes. Saket Gourav et. al. [5] uses three different geometries like rectangular heat sink, Circular heat sink, and Tapered heat sink and material used is Aluminium alloy and CAD model have prepared on SOUDEDGE and thermal analysis has done on ANSYS thermal transient analysis. Here they can obviously saw that Circular heat sink Aluminium materials have less estimation of temperature contrast with different geometries. So, it is used for future design. Bhushan G. Pawar et. al. [6] performed an experimentation of two different orientations of fan i.e., "fanon-top" and "fan-on-side" are tested for different air mass flow rate and cooling rate is validated with numerical results for the same amount of heat flux. Different heat inputs are given to the heater through power source and variac is used to regulate power supply and for giving different heat inputs. The temperature across the components is recorded after steady state is reached. The experimentation is performed for the above-mentioned conditions with varying mass flow rate of air and at different heat inputs. The experimental and numerical study is performed. It is observed that fan on side gives the better performance than fan on top. This is achieved with the help of experimental & numerical study. Sharath Kumar S N et. al. [7] aims to find the worthiness for addition of dimples and protrusions to the common plate fin heat sink geometries for heat transfer enhancement. Analysis was carried out in forced convention environment for 9 different velocities computationally for 12 heat sink geometries at constant heat flux boundary condition applied to base of heat sink. The maximum deviation between the two approaches is found to be 8.8% for base temperatures and 9.64% for thermal resistance under same conditions, which is within the acceptable limits. Therefore, it can be concluded that dimples can be effectively used in heat sinks in forced convection environment in electronic cooling industry. Naman Sahu et. al. [8] discussed that the Engine cylinder is one of the primary engine elements, that is subjected to excessive temperature variations and thermal stresses. Fins are placed on the surface of the cylinder to enhance the amount of heat transfer by convection. For thermal analysis of the engine cylinder fins, it is more beneficial to know the heat dissipation inside the cylinder. Benyamin Naranjani et. al. [9] described that the Three-dimensional simulations were performed to investigate conjugated heat transfer in heat sinks with various configurations and coolants. The effects of utilizing corrugated channels and water–Al2O3 nanofluids with different volume fractions and nanoparticle sizes were studied for different coolant mass flow rates. Additionally, the influence of different heat loads on maximum temperature rise in the heat sink was investigated and semi-empirical correlations were introduced for the proposed design. Karan Sangaj et. al. [10] proposed that they did an experimental setup here. It is explained in step-by-step procedure. i.e., Insert the required fin and make proper connections. Then Switch on the main supply. Then Start heating the fin by switching ON the heater. After Adjust dimmer stat voltage equal to 80 volts and wait for 20 minutes and adjust the voltage to 60 volts. After that wait to obtain the steady state condition. Then start the blower and measure air flow by anemometer. Then Note down the thermocouple readings at a time interval of 5-10 minutes. When the steady state is reached, record the final readings. Repeat the same experiment with different air flow readings. Remove the fin when it is cooled. In this they had discussed the objectives, design parameters and factors affecting the performance of heat transfer. They had also discussed the manufacturing process, instrumentation and working of experimental setup. Hong-sen kou et. al. [11] did a theoretical analysis of the cooling effect of a heat sink. With the input data of Biot number, and heat transfer coefficient ratios, the optimum heat transfer equation can be utilized to obtain the optimum length of fins in a heat sink, which affects the overall thermal effectiveness of the heat sink. Recently, with the development of powerful chips for computer systems, electronic devices such as CPUs require very efficient techniques for cooling. So far, cooling with air is recognized as an important technique in the thermal design of electronic packages. Pawar Shreekant Prabhakar et. al. [12] discussed that the modern portable electronic devices are becoming more compact in space, The exponential increase in thermal load in air cooling devices require the thermal management system to be optimized to attain the highest performance in the given space. In this work, experimentation is performed for high heat flux condition. The heat sink mounted on the hot component for cooling the component under forced convection. The two different orientations of fan i.e., "fan-on-top" and "fan-on-side" are tested for different air mass flow rate and cooling rate is validated with numerical results for the same amount of heat flux. The numerical simulation is performed using computational fluid dynamics (CFD). The CFD simulations are performed for optimization of heat sink parameters with objective function of maximization of heat transfer coefficient. It is clear that for forced convection cooling fan on side orientation gives the better results than fan on top orientation. Saroj Yadav et. al. [13] discussed the thermal management systems in electronic devices require a reduction in size due to improve the overall performance of the system. The aim is to improve the heat transfer with reduction in weight of the system. Fins are the extended surfaces that ease the heat transfer process by increasing the wetted surface area. The thermal diffusion in a fin is always affected by parameters like the size, the shape, the material, the relative arrangement, orientation and position of the fins, the working fluid and its velocity, etc. Karan Sangaj et. al. [14] give an overview of the Fins and description of recent improvement of fin geometries that increase the heat transfer rate. The objective or main purpose of this project is to improve the performance of the fins using different geometry and material. In recent years, advance devices generate and dissipate tremendous amount of heat and power. For many cooling applications these devices have become a major challenge. Older style heat sinks were often insufficient for cooling newer, hotter running components. So, for determining optimum fin geometry, we have considered different shapes and different materials. C. H. Liang et. al. [15] proposed that the purpose of this study is to find the optimal designing parameters of a plate-fin heat sink under natural convection using the Particle Swarm Optimization (PSO) Algorithm. Minimization of entropy generation rate under given space restrictions is considered as objective functions. All relevant design parameters for plate-fin heat sinks are the fin height, fin number, fin thickness. The constraints of the variables are set according to the suggestion structure design. And these three variables influence on entropy generation are presented. In the present study, in order to prevent the size of the heat sink is too large, we use the penalty function method in this study. Then the code for the PSO is written in MATLAB. Zulfiqar khattak et. al. [16] discussed about different problems due to heat dissipation. In order to reduce those heat dissipation, they designed a fin by using the COMSOL Multiphysics software. Here they used The Levenberg–Marquardt algorithm. It is a technique that has been used for parameter extraction of semiconductor devices, and is a hybrid technique that uses both Gauss–Newton and steepest descent approaches to converge to an optimal solution. After that they used FEM tool for the solving process. Numan Habib et. al. [17] designed L-shaped fin heat sink. The fin is made up of Aluminium alloy. Here ANOVA and TAGUCHI statistical methods are used to predict parameters that affect the heat transfer. Analysis of variance (ANOVA) is an analysis tool used in statistics that splits an observed aggregate variability found inside a data set into two parts: systematic factors and random factors. The systematic factors have a statistical influence on the given data set, while the random factors do not. Taguchi developed his method for designing experiments to investigate how different process factors will affect the mean and variance of a process performance characteristic. The experimental and numerical results on the bases of temperature difference for L-shape fins heat sink are plotted, between experimental and numerical results, a slight difference of less than 9% is observed. Livia M. Correa et. al. [18] talk about the Classical Integral Transform Technique here. This is an analytical technique that uses expansions of the sought solution in terms of an infinite orthogonal basis of eigenfunctions, keeping the solution process always within a continuous domain. Here two dimensional and three-dimensional plate fins are discussed and they solved it. Bhushan G. Pawar et. al. [19] performed an experimentation for high heat flux condition. The heat sink mounted on the hot component for cooling the component under forced convection. The two different orientations of fan i.e., “fanon-top” and “fan-on-side” are tested for different air mass flow rate and cooling rate is validated with numerical results for the same amount of heat flux. Different heat inputs are given to the heater through power source and variac is used to regulate power supply and for giving different heat inputs. The temperature across the components is recorded after steady state is reached. The experimentation is performed for the above-mentioned conditions with varying mass flow rate of air and at different heat inputs. The experimental and numerical study is performed. It is observed that fan on side gives the better performance than fan on top. Somesh Deshmukh et. al. [20] discussed that the objective of current research is to conduct thermal analysis of heat sink using FEA and to investigate the effect of individual design parameters on heat dissipation by generating contours of temperature and heat flux. The CAD model of heat sink is developed in ANSYS design modeler and design parameters are optimized using Taguchi response surface optimization technique. The FEA thermal analysis of heat sink used in electronic equipment is conducted using ANSYS software. By considering all the above-mentioned journals, as per our knowledge we observed that different types of fins are considered and it should be done in the natural or forced convection only and some of the fins are compared with each other. Here we are doing the thermal analysis of a straight plate fin heat sink with convection regimes such as natural convection, forced convection, with and without radiation.

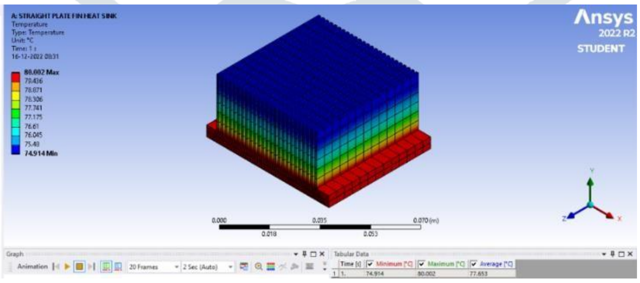
II. METHODOLOGY

Here we are using Analysis methodology by using ANSYS software. First, we took the steady state thermal analysis and we give the material selection. We designed the sketch in the geometry with specific dimensions. After the sketch is modelled, we did mesh to that sketch with default size. Here we choose Aluminum as the heat sink material. After meshing is done, we applied the boundary conditions as Temperature of 80°C is applied to the base and side parts of that fin. After the heat flux convection is given with an ambient temperature of 27°C to all the fins in the plate. After convection is given, radiation is also given to all the fins that are applied with convection. Here natural convection and forced convection is applied for the fins and also, we did analysis by considering with radiation and without radiation.

III. ANALYSIS

By performing the analysis, we got different temperature contours and are mentioned as follows:

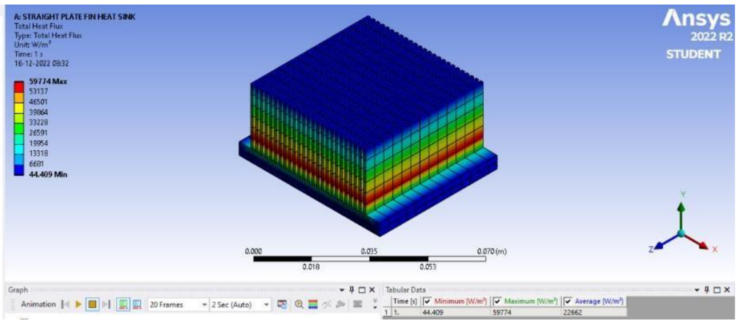
Fig 1 shows the resulted temperature of a straight plate fin heat sink. Here the minimum temperature is 74.914°C, average temperature is 77.653°C and the maximum temperature is 80.002°C.



	Time [s]	☑ Minimum [°C]	☑ Maximum [°C]	☑ Average [°C]
1	1.	74.914	80.002	77.653

Fig1: Resulted temperature

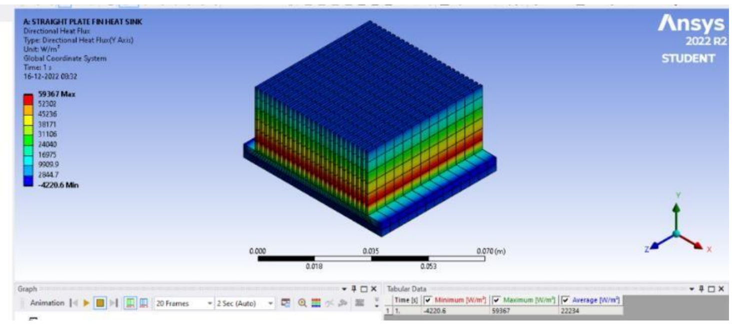
Fig 2 shows the total heat flux of the straight plate fin heat sink. Here the minimum heat flux is 44.409W/M^2, average heat flux is 22662W/M^2 and the maximum heat flux is 59774W/M^2.



	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	44.409	59774	22662

Fig 2: Total heat flux

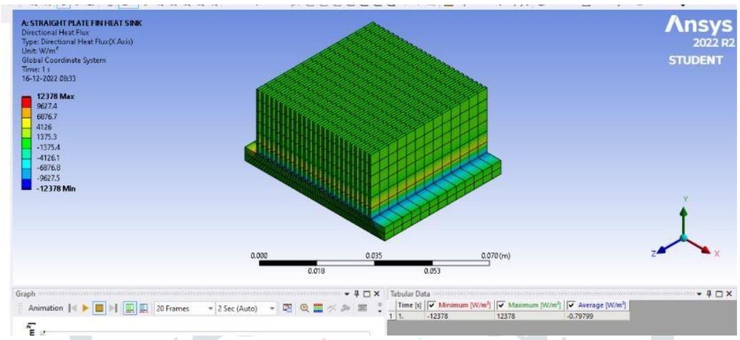
The X – direction of heat flux is as shown in the Fig 3. Here the minimum heat flux is -12378W/M^2, average heat flux is -0.79799W/M^2 and the maximum heat flux is 12378W/M^2.



	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	-4220.6	59367	22234

Fig 3: Heat flux in X-direction

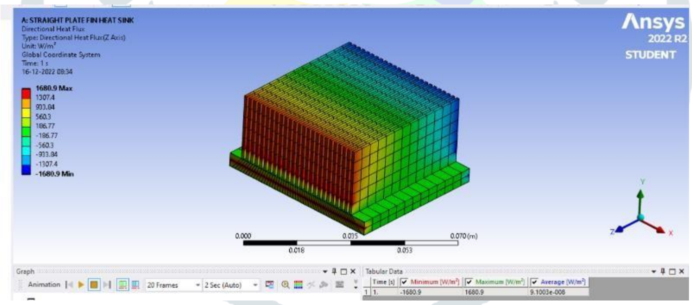
The Y – direction of heat flux is as shown in the Fig 4. Here the minimum heat flux is -4220.6W/M^2, average heat flux is 22234W/M^2 and the maximum heat flux is 59367W/M^2.



	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	-12378	12378	-0.79799

Fig 4: Heat flux in Y-direction

The Z – direction of heat flux is as shown in the Fig 5. Here the minimum heat flux is -1680.9W/M^2, average heat flux is -9.1003e-008W/M^2 and the maximum heat flux is 1680.9W/M^2.



	Time [s]	☑ Minimum [W/m²]	☑ Maximum [W/m²]	☑ Average [W/m²]
1	1.	-1680.9	1680.9	9.1003e-008

Fig 5: Heat flux in Z-direction

IV. RESULTS AND DISCUSSION

Table 1 shows about the temperature results from natural convection to forced convection by considering the radiation as emissivity is 0.45.

Table 1: Radiation of 0.45

NODE NUMBER	SL. NO	h = 5 W/M^{2,O}C	h = 10 W/M^{2,O}C	h = 25 W/M^{2,O}C	h = 50 W/M^{2,O}C	h = 100 W/M^{2,O}C
20873	**1**	79.739	79.591	79.169	78.524	77.412
20872	**2**	79.294	78.897	77.763	76.044	73.122
20871	**3**	78.942	78.348	76.656	74.108	69.825
20870	**4**	78.676	77.933	75.824	72.661	67.387
20869	**5**	78.496	77.653	75.263	71.688	65.762
20748	**6**	78.401	77.505	74.967	71.177	64.913

Table 2 shows about the temperature results from natural convection to forced convection by considering the radiation as emissivity is 1.

Table 2: With Radiation

NODE NUMBER	SL. NO	h = 5 W/M^{2,O}C	h = 10 W/M^{2,O}C	h = 25 W/M^{2,O}C	h = 50 W/M^{2,O}C	h = 100 W/M^{2,O}C
20873	1	79.611	79.466	79.053	78.421	77.328
20872	2	78.949	78.561	77.453	75.772	72.905
20871	3	78.426	77.847	76.197	73.707	69.51
20870	4	78.031	77.308	75.253	72.165	67.003
20869	5	77.764	76.944	74.617	71.13	65.335
20748	6	77.623	76.752	74.282	70.586	64.462

Table 3 shows about the temperature results from natural convection to forced convection by considering without radiation.

Table 3: Without Radiation

NODE NUMBER	SL. NO	h = 5 W/M^{2,O}C	h = 10 W/M^{2,O}C	h = 25 W/M^{2,O}C	h = 50 W/M^{2,O}C	h = 100 W/M^{2,O}C
20873	1	79.846	79.696	79.266	78.61	77.482
20872	2	79.584	79.178	78.022	76.272	73.303
20871	3	79.376	78.769	77.042	74.444	70.086
20870	4	79.218	78.459	76.304	73.076	67.706
20869	5	79.112	78.249	75.806	72.156	66.119
20748	6	79.056	78.139	75.543	71.672	65.289

Table 4 shows the temperature results for different emissivity's as 0.05, 0.25, 0.45, 0.85. These are the temperature values for the emissivity's by considering natural convection.

Table 4: Emissivity for Natural convection

NODE NUMBER	SL. NO	E = 0.05	E = 0.25	E = 0.45	E = 0.85
20873	1	79.833	79.782	79.731	79.631
20872	2	79.549	79.41	79.273	79.003
20871	3	79.324	79.116	78.911	78.506
20870	4	79.153	78.893	78.637	78.132
20869	5	79.038	78.743	78.451	77.878
20748	6	78.977	78.663	78.353	77.744

Table 5 shows the temperature results for different emissivity's as 0.05, 0.25, 0.45, 0.85. These are the temperature values for the emissivity's by considering forced convection.

Table 5: Emissivity for Forced convection

NODE NUMBER	SL. NO	E = 0.05	E = 0.25	E = 0.45	E = 0.85
20873	1	77.475	77.439	77.406	77.339
20872	2	73.285	73.193	73.105	72.932
20871	3	70.061	69.927	69.8	69.549
20870	4	67.675	67.511	67.356	67.049
20869	5	66.085	65.901	65.727	65.385
20748	6	65.253	65.059	64.876	64.515

Table 6 shows the temperature values for the emissivity by considering the with radiation and without radiation.

Table 6: with and without radiation in natural convection

NODE NUMBER	SL. NO	E = 0	E = 1
20873	1	79.846	79.594
20872	2	79.584	78.903
20871	3	79.376	78.357
20870	4	79.218	77.945
20869	5	79.112	77.666
20748	6	79.056	77.519

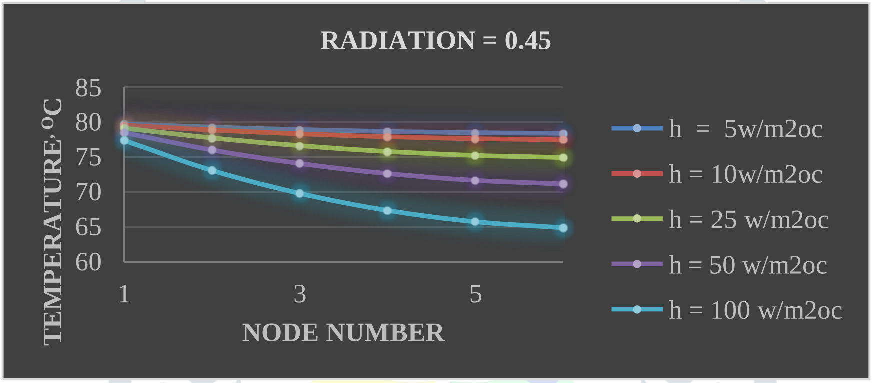
Table 7 shows the temperature values for the emissivity by considering the with radiation and without radiation.

Table 7: with and without radiation in forced convection

NODE NUMBER	SL. NO	E = 0	E = 1
20873	1	77.482	77.314
20872	2	73.303	72.868
20871	3	70.086	69.456
20870	4	67.706	66.935
20869	5	66.119	65.258
20748	6	65.289	64.381

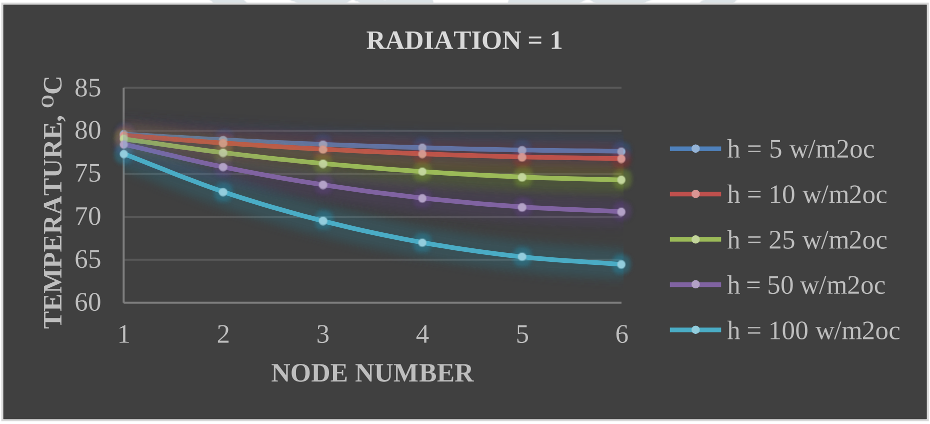
The graphs for temperature drop on various conditions is shown below:

The Graph 1 shows the temperature drops for the different convections. In this graph the X – axis shows the node number and the Y – axis shows the temperature. It is the graph for the different convections by considering the radiation as 0.45. Here the blue line shows the temperature drop for convection of 5 W/M^{2,o}c, orange line shows the temperature drop for convection of 10 W/M^{2,o}c, grey line shows the temperature drop for convection of 25 W/M^{2,o}c, yellow line shows the temperature drop for convection of 50 W/M^{2,o}c and the light blue line shows the temperature drop for the convection of 100 W/M^{2,o}c.



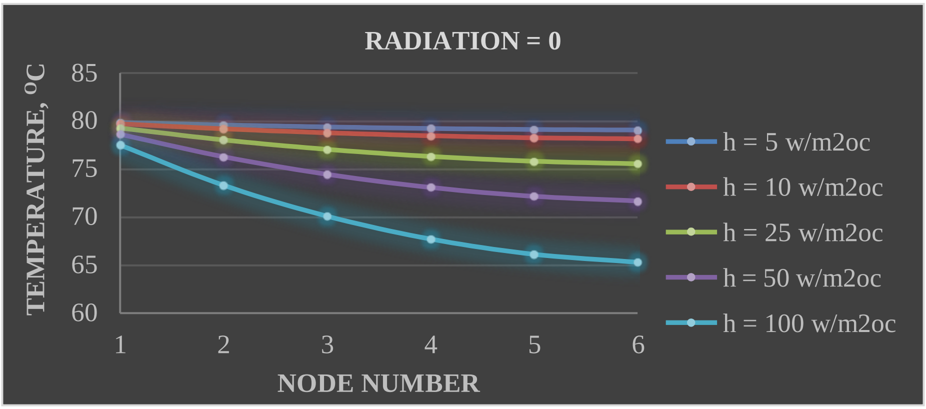
Graph 1: considering radiation of 0.45

The Graph 2 shows the temperature drops for the different convections. In this graph the X – axis shows the node number and the Y – axis shows the temperature. It is the graph for the different convections by considering the radiation as 1. Here the blue line shows the temperature drop for convection of 5 W/M^{2,o}c, orange line shows the temperature drop for convection of 10 W/M^{2,o}c, grey line shows the temperature drop for convection of 25 W/M^{2,o}c, yellow line shows the temperature drop for convection of 50 W/M^{2,o}c and the light blue line shows the temperature drop for the convection of 100 W/M^{2,o}c.



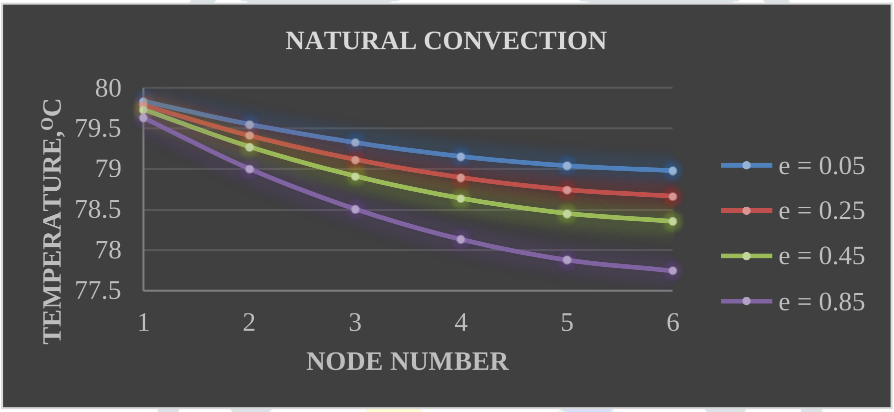
Graph 2: film coefficient with radiation

The Graph 3 shows the temperature drops for the different convections. In this graph the X – axis shows the node number and the Y – axis shows the temperature. It is the graph for the different convections by considering without radiation. Here the blue line shows the temperature drop for convection of 5 W/M^{2,o}c, orange line shows the temperature drop for convection of 10 W/M^{2,o}c, grey line shows the temperature drop for convection of 25 W/M^{2,o}c, yellow line shows the temperature drop for convection of 50 W/M^{2,o}c and the light blue line shows the temperature drop for the convection of 100 W/M^{2,o}c.



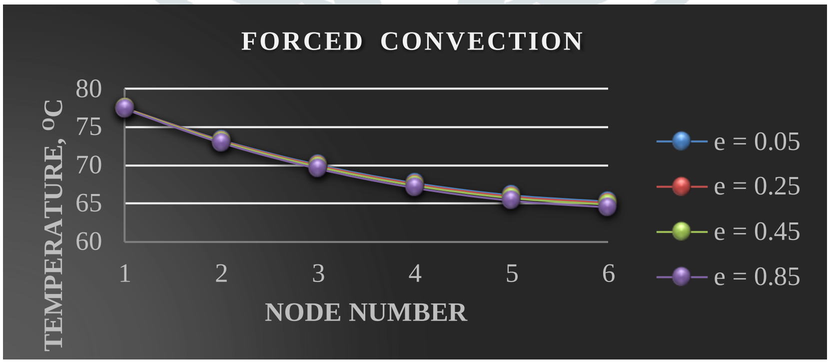
Graph 3: film coefficient without radiation

The Graph 4 shows the temperature drops for the different emissivity's. In this graph the X – axis shows the node number and the Y – axis shows the temperature. It is the graph for the different emissivity's by considering natural convection. Here the blue line shows the temperature drop for emissivity of 0.05, orange line shows the temperature drop for emissivity of 0.25, grey line shows the temperature drop for emissivity of 0.45 and yellow line shows the temperature drop for emissivity of 0.85.



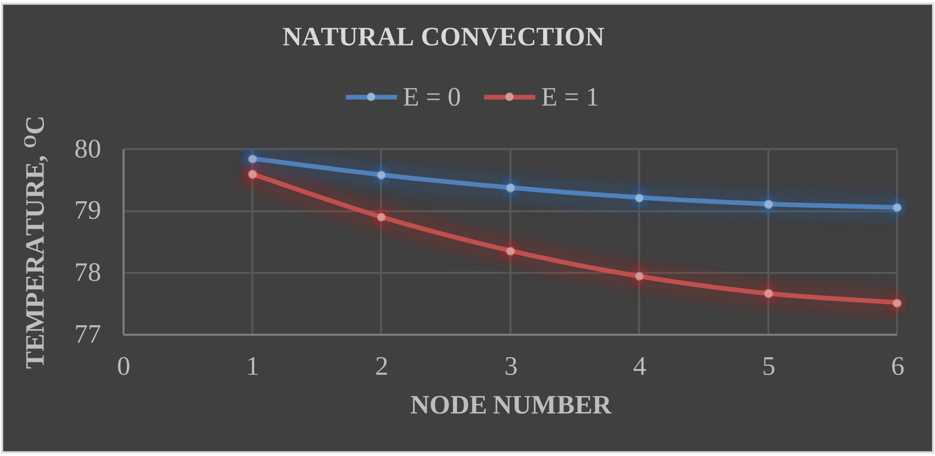
Graph 4: radiation in natural convection

The Graph 5 shows the temperature drops for the different emissivity's. In this graph the X – axis shows the node number and the Y – axis shows the temperature. It is the graph for the different emissivity's by considering forced convection. Here the blue line shows the temperature drop for emissivity of 0.05, orange line shows the temperature drop for emissivity of 0.25, grey line shows the temperature drop for emissivity of 0.45 and yellow line shows the temperature drop for emissivity of 0.85.



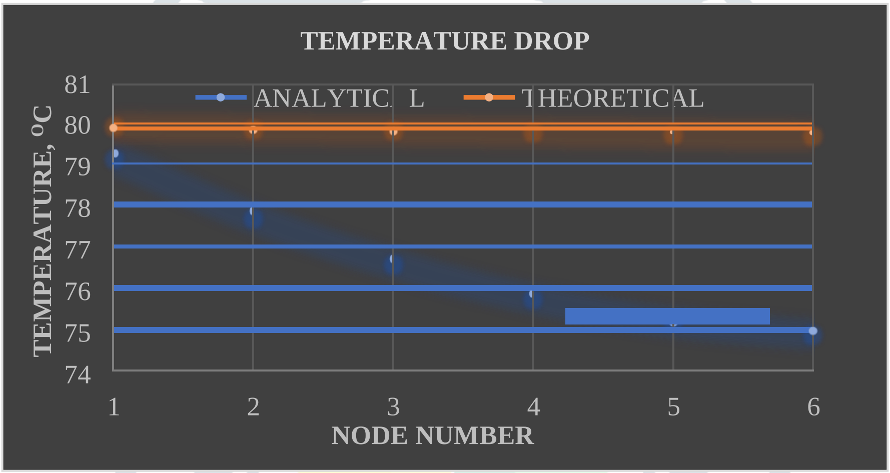
Graph 5: radiation in forced convection

Graph 6 shows the temperature drop for the natural convection by considering the with radiation and without radiation. Here node number is taken on X – axis and the temperature is taken on Y – Axis.



Graph 6: with and without radiation in natural convection

The theoretical and numerical results on the bases of temperature difference for straight plate fin heat sink are plotted as shown in Graph 7. Between theoretical and numerical results, a slight difference between 0.87 to 5% is observed. Overall, the numerical results show good agreement with numerical result. Hence, the model could be used for thermal analysis.



Graph 7: temperature drop between analytical and theoretical values

V. CONCLUSION

In this study, straight plate fin heat sink is modelled and steady state thermal analysis is done by using ANSYS workbench. It is investigated under different convection regimes such as free and forced convection and with radiation and without radiation. The results are presented in the form of temperature, total heat flux and direction of heat flux. In this we also calculated the theoretical results. On comparison between the theoretical and simulation results there is difference between 0.57 to 5% is obtained. By considering all the above conditions the heat transfer will takes place more in forced convection when compared with the natural convection. Hence, we concluded that the heat transfer should takes place maximum under forced convection.

ACKNOWLEDGEMENT

We take immense pleasure in expressing my deep sense of gratitude to my guide for his encouragement all the way during the investigation of the project. His annotations and criticisms are the key behind for successful completion of the project work and our HOD, for his able guidance and for the freedom of thought and action, we had enjoyed during the entire course of my project work.

REFERENCES

[1] V Naga Raju, P. Sivakumar, K Lakshmi Narayana, A Srujan, K Mallikarjun, G Krishna are proposed “steady state thermal analysis of heat sink with fins of different geometry”, International Journal of Mechanical Engineering and Technology, IJMET, Volume 8, Issue 5, ISSN Print: 0976-6340 and ISSN Online: 0976-6359, page no: 196–206, May, 2017.
[2] J.M. Blanco, E. Armendariz and J. Esarte are proposed “a parametric study of heat transfer for the optimization of fin sinks”, Journal of Advanced Thermal Science Research, Avanti, Volume 1, issue 1, DOI: 2409-5826, Page no: 3 – 8, October, 2014.
[3] Malukandy Prabisha, Dr. R. Ramesh are proposed “thermal performance evaluation of heat sink for various fin profiles”, International Journal of Science, Technology & Management, IJSTM, Volume No 04, Special Issue No. 01, ISSN (online): 2394-1537, Page no: 462 – 470, March, 2015.
[4] Iman Shahdad, Farivar Fazelpour is proposed “numerical analysis of the surface and geometry of plate fin heat exchangers for increasing heat transfer rate”, International Journal of Energy and Environmental Engineering, springer, volume 9, DOI: 10.1007/s40095-018-0270-z, Page no: 155 – 167, March, 2018.
[5] Saket Gourav, Dr. Sohail bux proposed “ parametric study and thermal analysis of heat sink in cpu by using ansys software”, research journal of engineering technology and medical sciences, RJETM, volume 5, Issue 2, ISSN: 2582 – 6212, Page no: 12 –

21, June, 2022.

[6] Bhushan G. Pawar, Dharmendra Yadav, Kunal S. Marathe are proposed “design and comparative study of plate fin heat sink for fan-less cooling in cpu”, International Journal of Engineering Research & Technology, IJERT, Volume 5, Issue 2, ISSN: 2278-0181, 2016.

[7] Sharath Kumar S N, Sathish S and Purushothama H R proposed “heat transfer analysis of plate fin heat sink with dimples and protrusions”, International Journal of Heat and Technology, IJETA, Volume. 39, Issue No. 6, DOI: 10.18280, Page no: 1861-1870, December, 2021.

[8] Naman Sahu1, Vishal Gupta, Pradeep Kr. Kurmi are proposed “international journal of technical innovation in modern engineering & science”, IJTIMES, Volume 4, Issue 8, e-ISSN: 2455-2585, Page no: 711 – 718, August, 2018.

[9] Benyamin Naranjani, Ehsan Roohi, Amin Ebrahimi proposed “thermal and hydraulic performance analysis of a heat sink with corrugated channels and nanofluids”, Journal of Thermal Analysis and Calorimetry, volume 146, Issue 4, DOI: 10.1007/s10973-020-10225-9, Page no: 2549 – 2560, 2021.

[10] Karan Sangaj, Sudarshan Shinde, Aditya Suryawanshi, Rameez Shanediwan, Apurva Potdar proposed “thermal and parametric analysis of pin-fin vol 01”, International Research Journal of Engineering and Technology, IRJET, Volume: 05 Issue: 02, e-ISSN: 2395-0056, p-ISSN: 2395-0072, Page no: 708 – 714, February, 2018.

[11] Hong-sen kou, Ji-jen lee, and Chi-yuan lai proposed “thermal analysis and optimum fin length of a heat sink”, thermal science, springer, volume: 24, Issue: 2, ISSN No: 0145–7632, Page No: 18 – 29, March, 2003.

[12] Pawar Shreekant Prabhakar, Prof. Ghuge N. C proposed “thermal design and analysis of heat sink optimization and its comparison with commercially available heat sink”, International Journal of Engineering Research & Technology, IJERT, Vol. 4 Issue 12, ISSN: 2278-0181, Page No: 210 – 216, December-2015.

[13] Saroj Yadav and Krishna Murari Pandey proposed “a parametric thermal analysis of triangular fins for improved heat transfer in forced convection”, Journal of Mechanical Engineering, MARA, Volume: 64, Issue: 6, DOI: 10.18690/978-961-286-057-8.6, Page No: 401-411, 2018.

[14] Karan Sangaj, Sudarshan Shinde, Rameez Shanediwan, Apurva Potdar, Aditya Suryawanshi proposed “thermal and parametric analysis of pin-fin: vol 2”, International Research Journal of Engineering and Technology, IRJET, Volume: 05, Issue: 02, e-ISSN: 2395-0056, p-ISSN: 2395-0072, Page No: 1113 – 1122, Feb, 2018.

[15] C. H. Liang, S. Zeng , Z. X. Li , D. G. Yang and S. A. Sherif proposed “optimal design of plate-fin heat sink under natural convection using a particle swarm optimization algorithm”, International journal of heat and technology, IIETA, Vol. 34, No. 2, ISSN: 0392-8764, Page No: 275 – 280, June, 2016.

[16] Zulfiqar khattak , Hafiz Muhammad Ali are proposed “thermal analysis and parametric optimization of plate fin heat sinks under forced air convection”, Thermal science, springer, volume 26, Issue 1, DOI: 10.2298/TSCI201227081K, page no: 1 – 13, January, 2021.

[17] Numan habib, Muftooh Ur Rehman siddiqi and Muhammad tahir are proposed “thermal analysis and optimization of l-shape fin heat sink under natural convection using anova and taguchi”, thermal science, springer, volume 26, Issue 2B, page no: 1519-1530, 2022.

[18] Livia M. Correa Daniel J. N. M. Chalhub are proposed “thermal analysis of heat sinks: an analytical approach”, thermal science, springer, DOI: 10.26678/ABCM.COBEM2019.COB2019-0300, January, 2021.

[19] J. Richard Culham, Member, IEEE, and Yuri S. Muzychka proposed “optimization of plate fin heat sinks using entropy generation minimization”, IEEE transactions on components and packaging technologies, Volume 24, Issue 2, DOI: 10.1109/6144.926378 , Page no: 159 – 165, June, 2001.

[20] Somesh Deshmukh, Chandrashekhar Nagendra proposed “thermal analysis and design optimization of heat sink using taguchi method”, Journal of Emerging Technologies and Innovative Research, JETIR, Volume 8, Issue 3, ISSN-2349-5162, Page no: 2516 – 2519, 2021