Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 4; April-June, 2015 pp. 292-297

http://www.krishisanskriti.org/jmsme.html

Modelling and Analysis of Heat Sink with V Shaped Fin Arrays

Monika Solanki1 and Meeta Vedpathak[2]

[1]*Student, M.E. (Thermal) PIIT, New Mumbai*
[2]*Mechanical Engg PIIT, New Mumbai*
E-mail: [1]badgujar.monika@gmail.com, [2]meeta_sajanikar@yahoo.com

Abstract—*For the better life of heat exchanging devices such as electronic equipments, it is very important to have a high heat dissipation rate. Fins are used to dissipate the heat generated and thus helps for the enhancement of heat transfer rate in heat exchanging devices. Though there are number of fins which are in use. But, the work on the geometry of fin is going on because the shape, size and arrangement of fins also result in varying temperature distribution and heat transfer rate. This paper is mainly concerned with the computer simulation study of V shaped fin arrays having staggered arrangement for heat transfer enhancement using natural convection laminar flow. The simulation is done by using computational fluid dynamics software ANSYS 14.0. The models have been modelled in SOLIDWORKS. The CAD models are then imported to ANSYS ICEM. Unstructured mesh has been generated on the models using Delaunay scheme. The quality of mesh is achieved upto 0.4. The meshed models are then imported to ANSYS FLUENT for the simulation. Navier-Stokes and energy equations are solved using FVM approach and boussinesq approximation is applied to achieve the buoyancy effect. The flow is set to Laminar. The working fluid used is Air having Prandtl number 0.7. Material of base plate and fins are taken as steel and aluminium for both the models respectively. The simulation is run for different values of heat input i.e. 100 W, 150 W, 200 W, 250 W.*

1. INTRODUCTION

In most of the electronic devices, rectangular fins are used on horizontal or vertical surfaces. But, the current trend is more towards the miniature manufacturing. But then it creates the problem reduction in surface area available for heat dissipation and results in over heating of the equipment. In order to overcome this problem, a new geometry has been designed and modelled taking V shaped fin arrays. Thus, the heat transfer from the fin arrays has been studied numerically.

[1] Mohammad Mahdi Naserian et. al. have done experimental and numerical analysis of natural convection heat transfer coefficient of V-type fin configurations and the effect of varying space and number of fins on heat transfer coefficient. Conclusion drawn shows that increase in the number of pieces and the gap between them, heat transfer coefficient increases and thus heat transfer rate increases. [2] M. J. Sable et. al. have done experimental investigation for the enhancement of natural convection heat transfer on vertical heated plate by multiple V fin array. The conclusion obtained shows increase in the heat transfer coefficient for V-type partition fins as compared to the rectangular fins having same surface area because of the formation of low pressure suction region on the downstream side of each V-fin. this helped to allow the inflow of low temperature fluid into the separation region. [3] Rameshwar B. Hagote et. al. have numerically analyzed natural convection heat transfer on horizontal, vertical and inclined heated plate by V-fin array. Conclusion depicts that maximum convective heat transfer coefficient is obtained for 60º V-fin array as compared to horizontal, vertical or other inclination heated plate. it is also observed that as the heat flux increases, heat transfer coefficient also increases with the increase in temperature difference. [4] S. S. Sane et. al. have done computational analysis of horizontal rectangular notched fin arrays dissipating heat by natural convection. The numerically obtained results have been compared with the experimentally obtained results. The results obtained shows that notched rectangular fin array gives better performance than un-notched rectangular fin array.[5] S. H. Barhatte et. al. have done experimental and computational for the optimization of heat transfer through fins with triangular notch. Different models having different aspect ratio of fins have been modeled and simulation is done on them using constant heat flux. The numerical and experimental results have been compared. The overall result suggest that the heat transfer coefficient is highest for the set of fins with triangular notch. [6] Edlabdkar et. al. have done computational analysis of natural convection with single V-type partition plate and compared the results with horizontal and vertical plates. The analysis is done using isothermal condition for base plate and fin. The numerical results have been compared with experimental results which confirms results with 10% variation. It was concluded that V-type fins give higher heat transfer coefficient than vertical and horizontal rectangular fins. [7] Pardeep Singh et. al. designed and analyzed fins with extensions using AutoCAD and Autodesk simulation multi physiscs software for determining heat transfer. Models of rectangular fins having rectangular, trapezium and circular

segmental extension on rectangular base plate have been designed and modeled. analysis have been done using 55º C and 30º C wall and ambient air temperature. Results obtained fins with extension provide more heat transfer rate than fins without extension. And in all the three extensions, rectangular extension fins show higher heat transfer rate. [8] S. Rangadinesh et. al. have experimentally and numerically analyzed the heat transfer characteristics of shoe brush shaped fins. Rectangular and cylindrical fins are also modelled for the comparison of results. The results obtained show an agreement between experimental and numerical results and it has been concluded that shoe brush shaped fins give better results than rectangular and cylindrical fins. [9] Ambeprasad S. Kushwaha et. al. have done comparative study of rectangular, trapezoidal and parabolic shaped finned heat sink using CFD commercial packages. The heatsink has been modeled by using optimal geometric parameters. Different heat inputs have been used with constant air inflow temperature. The analysis has been concluded for all the fin profiles for different heat inputs to capture the maximum fin temperature and Nusselt number. It has been concluded that trapezoidal heat sink attained maximum temperature as compared to rectangular and parabolic shaped finned heat sink for same heat input. Thus, trapezoidal fins have highest heat transfer rate and lowest thermal resistance.

In Thermal Engineering, increased heat transfer rate is very much essential factor for the better performance of heat exchanging devices. Removal of excessive heat accumulated in the heat exchanging devices avoids the problem of burning and damaging the devices and thus results in the increased life span and better performance of the equipment. In devices like heat sinks, the air circulating around the fins takes up the heat accumulated on the fins due to the change in the density. thus, natural convection current occurs in the field. The air sucks heat from the device and heated air goes up and cools the device. Hence, to increase the heat transfer rate for the better performance of the heat exchanging devices, researchers are working on different designs and geometrical configurations of fins. In this study, the work has been done on the shape and size of the fins. V shaped fins have been designed with different dimensions and are attached to the vertical base plate. And analysis has been done for natural convection laminar flow heat transfer using constant air velocity and varying heat inputs from 100 W to 250 W. Temperature at the fins has been noted and heat transfer coefficient has been calculated to compare the results.

2. CFD ANALYSIS OF THE HEAT SINKS

2.1 Building the model

The models are designed using CAD tool SOLIDWORKS and saved in STEP/IGES format in order to make it compatible with the ANSYS software. Only half the original model has been taken in order to reduce the computational time. The designed CAD models are then imported to Computational Fluid Dynamics software ICEM ANSYS which are readable in STEP/IGES format.

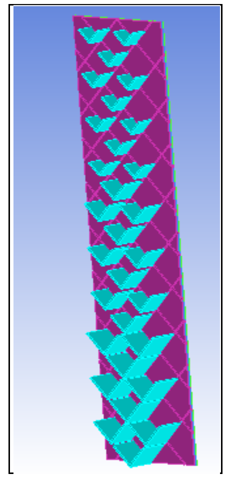


Fig. 1 : Descending Model with 30-40-50 mm

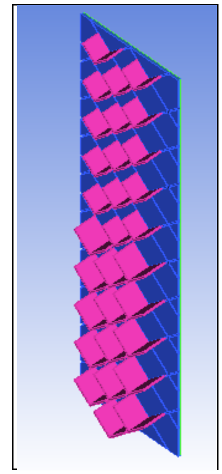


Fig. 2.: Descending Model with 35-45 mm fins

The models have been cleaned in ICEM. Part naming has been done to distinguish each part to set the boundary conditions. Having done with the naming, body points are created to set material points. A domain has been created to enclose the model to study mass flow and thus the heat flow from the fin to the ambient air. The main purpose of having an enclosure around the model is to obtain a good natural convection condition. The model is surrounded with ambient air. As the model is held in vertical position, the inflow of air is from the bottom of the domain so it is named as the inlet. The opposite side of the domain is set as outlet. The remaining sides of the domain are named as wall. A body point has been created inside the domain for the air flow. Having done with all the procedure, meshing parameters have been set. The maximum size given to the entire model is 60. The size set for base plate and fins are 4 and 2 respectively because the main motive is to capture temperature distribution on fins. Unstructured mesh has been generated on the model with the Delaunay approach. The mesh quality is checked and it came up to 0.4 which is assumed as a good quality. Grid Independence test has been taken using mesh count 13840932 and 3367082. But, the results are coming same for both the mesh counts. So, meshed model with less mesh count has been taken for analysis in order to reduce the analysis time. The meshed model then given an output solver Fluent_V6 so that the mesh could be read in CFD simulation software ANSYS FLUENT.

Table 1: Effective surface area of models

Surface Area of Models (m2)		
	Vertical Plate with V Fins (W=H=30-40-50 mm) descending arrangement	**Vertical Plate with V Fins (W=H=35-45 mm) descending arrangement**
Height of Fins (m)	0.03, 0.04, 0.05	0.035, 0.045
Base Plate Area (m2)	0.16	0.16

Fin Area (m2)	0.1775	0.1775
Total Area (m2)	0.3375	0.3375

The mesh is then read in ANSYS FLUENT software to run the simulation. In FLUENT, the governing equations are solved using Finite Volume Approach. The models are set to viscous laminar because the working fluid is under natural convection. Energy equation is used to acquire thermal conditions. Materials for working fluid, base plate and fins are air, mild steel and aluminum resp. Density of air is set to Boussinesq scheme. The thermo-physical properties of fluid and materialare calculated at 300 K temperature. The pressure based solver is used. Coupling between the velocity and pressure is made with SIMPLE algorithm. The resultant system of discretized linear algebraic equation is solved with an alternating direction implicit scheme. Boundary conditions have been set. Varying heat flux is used for different heat input keeping the velocity of air as 0.5 m/s constant for each heat input in both the models. Simulation is then run till the residuals of energy come to 1e-6. As the simulation has stopped, mass balance has been checked. And temperature contour plots have been taken to compare the results.

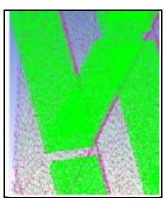
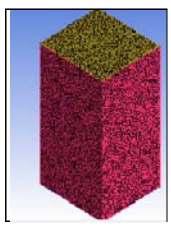



Fig. 3: Geometry of Fig.4.: Geometry of meshed fin meshed Domain

The governing equations which are used, in this study are as follows:

Conservation of mass:

$$\frac{\partial(\rho u)}{\partial x}+\frac{\partial(\rho v)}{\partial y}+\frac{\partial(\rho w)}{\partial z}=0$$

Conservation of momentum:

$$\frac{\partial(\rho u^2)}{\partial x}+\frac{\partial(\rho uv)}{\partial y}+\frac{\partial(\rho uw)}{\partial z}=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)\ \frac{\partial(\rho vu)}{\partial x}+$$

$$\frac{\partial(\rho v^2)}{\partial y}+\frac{\partial(\rho vw)}{\partial z}=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)+g(\rho-\rho_\infty)$$

$$\frac{\partial(\rho wu)}{\partial x}+\frac{\partial(\rho wv)}{\partial y}+w\frac{\partial(\rho w^2)}{\partial z}=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)$$

Conservation of energy:

$$\frac{\partial(\rho uT)}{\partial x}+\frac{\partial(\rho vT)}{\partial y}+w\frac{\partial(\rho wT)}{\partial z}=\frac{\mu}{Pr}\left(\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right)$$

Formulas Used:

The average convection heat transfer coefficient "h" is calculated by

$$h=\frac{Q}{As(Ts-T\infty)}$$

The average Nusselt number is calculated by

$$Nu=\frac{hL}{k}$$

where, k is the thermal conductivity of air.

3. RESULTS AND DISCUSSION

CFD Results:

Table 2: Descending Model with 30-40-50 mm Fins: Total Surface Area = 0.3375 m^2

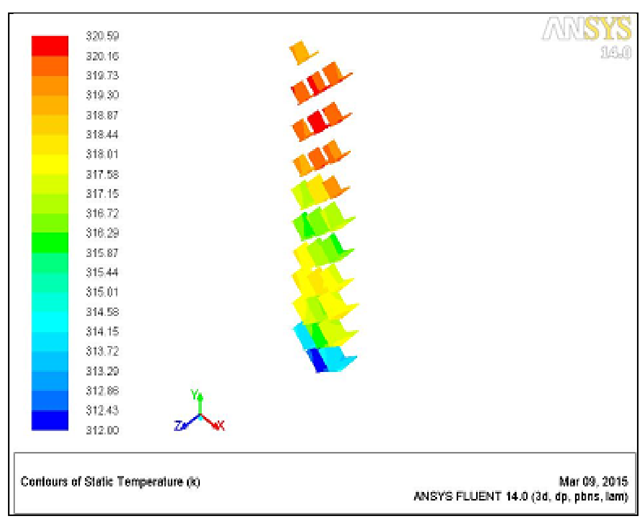
Heat Input, (W)	Temp. of fins, (K)	Ambient Temp (K)	Convective Heat Transfer Coefficient, W/ m2K	Nusselt Number
100	317.14	300	17.28	521.66
150	323.59	300	18.84	568.75
200	330.16	300	19.64	592.91
250	335.89	300	20.63	622.79

Table 3: Descending Model with 35-45 mm Fins: Total Surface Area = 0.3375 m^2

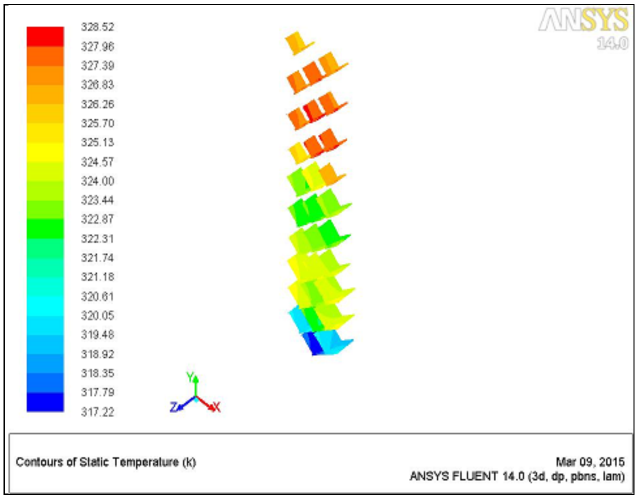
Heat Input, (W)	Temp. of fins, (K)	Ambient Temp (K)	Convective Heat Transfer Coefficient, W/ m2K	Nusselt Number
100	316.44	300	18.02	544
150	322.92	300	19.39	585.36
200	328.83	300	20.55	620.38
250	335.55	300	20.83	628.83

Comparison with Contour Plots

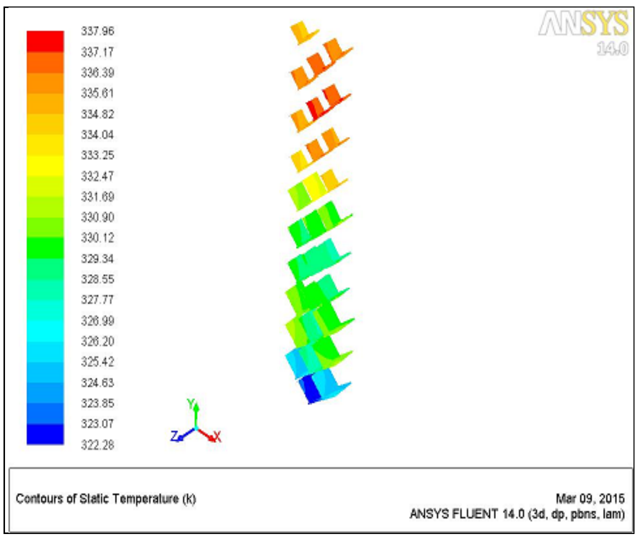
30-40-50 Descending Model



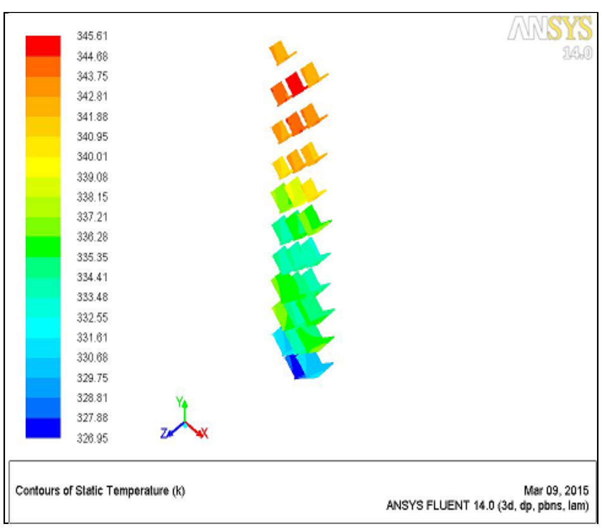
For 100 W



For 150 watts

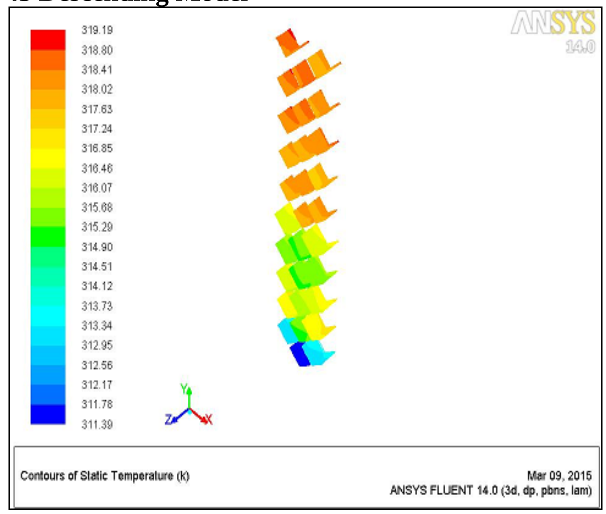


For 200 watts

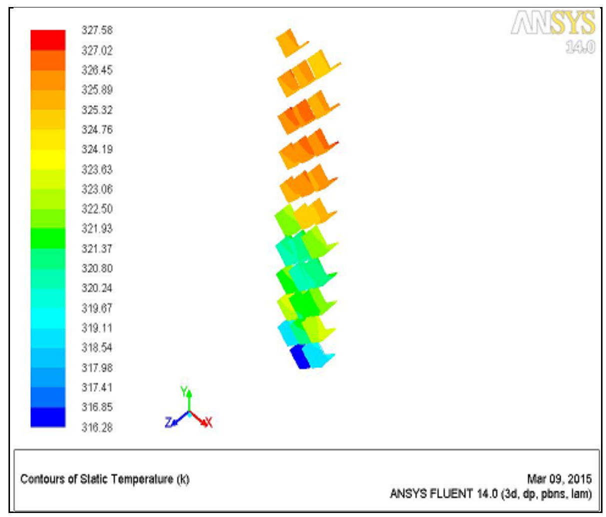


For 250 watts

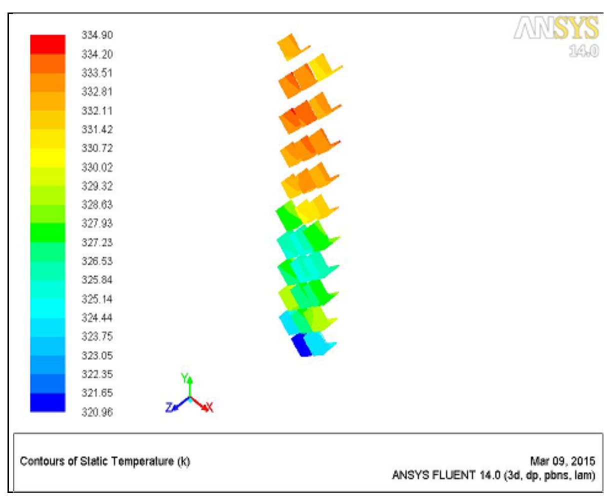
35-45 Descending Model



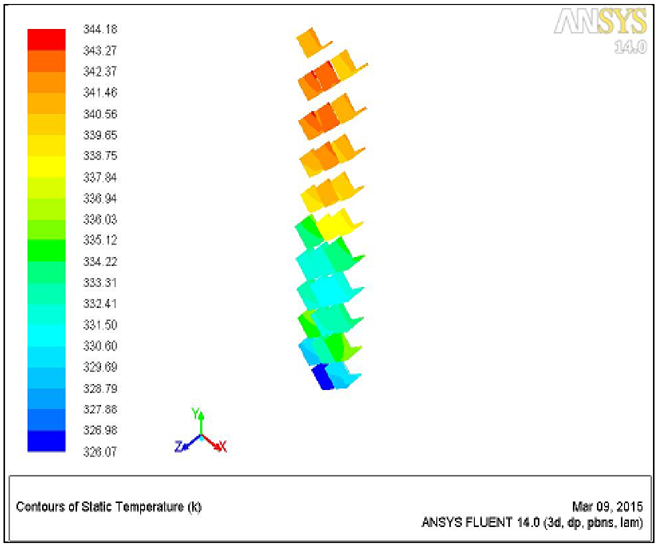
For 100 watts



For 150 watts

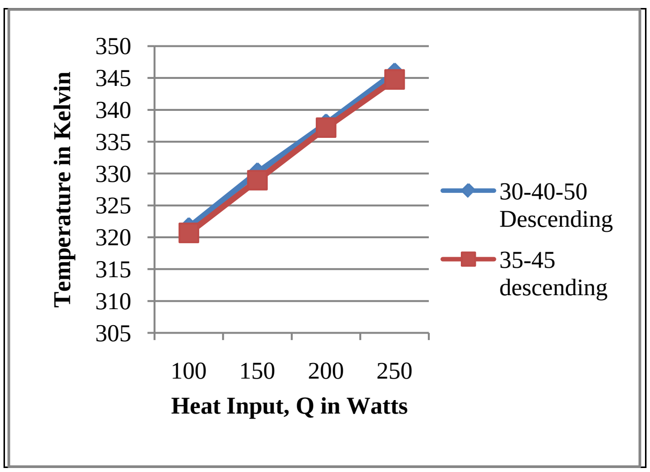


For 200 watts

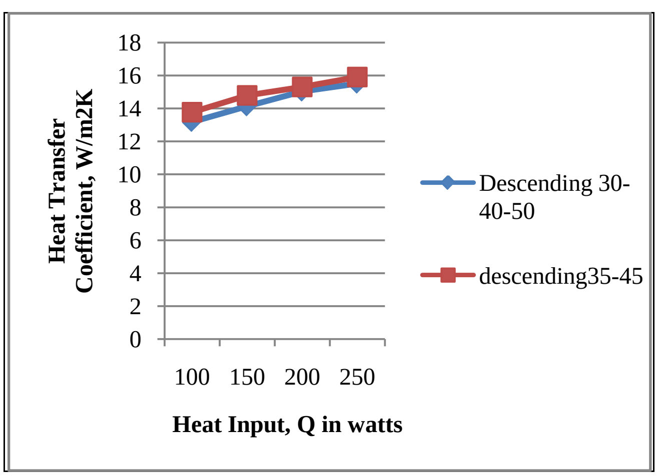


For 250 watts

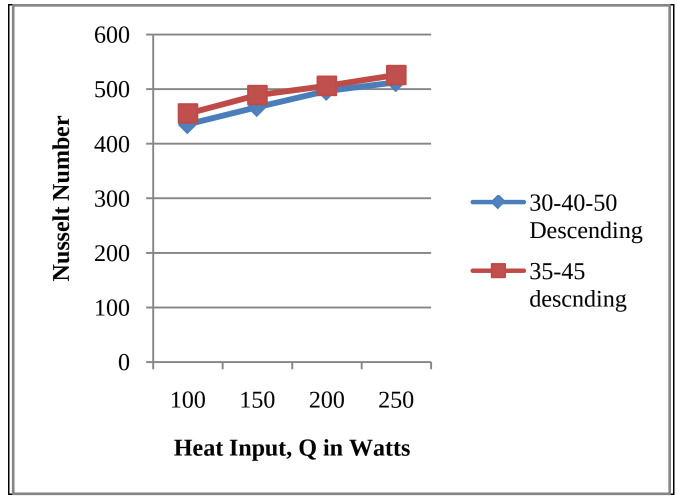
Graphical Comparison:



Comparison of temperature values for both the models



Comparison of Heat Transfer Coefficient values for both the models



Comparison of Nusselt Number values for both the models

4. CONCLUSION

CFD analysis of geometries having V shaped fin arrays with different geometrical configurations with staggered arrangement has been carried out. Grid independency test has been carried. After simulating the models, with the increase in temperature difference, heat transfer rate increases. Results obtained show that the models having same heater input and having same ambient air velocity and constant other parameters like surface area and material, 35-45 mm V fin gives maximum heat transfer coefficient thus gives maximum heat transfer rate.

REFERENCES

[1] Mohammad Mahdi Naserian, Mahidi Fahiminia, Hamid Reza Goshayeshi, Experimental and numerical analysis of natural convection heat transfer coefficient of V-type fin configurations, Journal of Mechanical Science and Technology 27(7)(2013)2191-2197

[2] M.J. Sable, S. J. Jagtap, P. S. Patil, P. R. Baviskar, S. B. Barve, Enhancement of natural convection heat transfer on vertcal heated plate by multiple V-fin array, IJRRAS 5(2) November 2010

[3] Rameshwar B. Hagote, Sachin K. Dahake, Study of natural convection heat transfer on horizontal, inclined and vertical heated plate by V fin array, International Journal of scientific and Engineering Research, Volume 5, Issue 6, June-2014

[4] S. S. Sane, N. K. Sane, G. V. Parishwad, Computational analysis of horizontal rectangular notched fin arrays dissipating heat by natural convection, 5th European Thermal-Sciences Conference , The Netherlands, 2008

[5] S. H. Barhatte, M. R. Chopade, Experimental and computational analysis and optimization of heat transfer through fins with triangular notch, International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, volume 2, Issue 7, July 2012)

[6] R. L. Edlabadkar, N. K. Sane, G.V. Parishwad, Computational analysis of natural convection with single V-type partition plate, 5th European Thermal-Sciences Conference, The Netherlands, 2008

[7] Pardeep Singh, Harvinder lal, Baljit Singh Ubhi, Design and analysis for heat transfer through fin with extensions, International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organisation) Vol. 3, Issue 5, May 2014, ISSN:2319-8753
[8] S. Rangadinesh, M. Rajasekar, S. Arunkumar, M. Venkatesan, Experimental and numerical analysis on heat transfer characteristics of shoe brush-shaped fins, Current Science, Vol. 106, No.10, 25 May 2014
[9] Ambeprasad S. Kushwaha, Ravindra Kirar, Comparative study of rectangular, trapezoidal and parabolic shaped finned heat sink, IOSR Journal of Mechanical and Civil Engineering.e-ISSN: 2278-1684 Volume 5, Issue 6 (Mar- Apr 2013), PP 01-07
[10] John D. Anderson,JR, McGraw-Hill International Edition,a textbook of Computational Fluid Dynamics