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Fabrication and CFD analysis of cylindrical heat sink having longitudinal fins with rectangular notches

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Abstract – *By fabricating the cylindrical heat sink having rectangular notch fins the heat transfer is going to increase. The measuring parameter is convective heat transfer coefficient of fin with different notch size for the given fin spacing using free convection heat transfer. By Ansys Fluent software steady thermal analysis, Air Flow analysis, pressure drop analysis had performed. The notch size is varies from 10%, 20% and 30% the heat input is varies from 25 watt, 45 watt and 65 watt.*

Key Words: Thermal analysis, Pressure drop, heat input, parameter, heat sink, notch etc.

1. INTRODUCTION

Fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. Increasing the convection heat transfer coefficient or increasing the surface area of the object increases the heat transfer. Sometimes it is not feasible or economical to change the first two options.[5] Thus, adding a fin to an object increases the surface area and can sometimes be an economical solution to heat transfer problems

Over fins in plate heat sink stagnant zone created at centre of fin becomes less effective or sometimes ineffective for heat transfer, because no air stream passes over this region. [7] To optimize the fin geometry some portion of this stagnant zone is removed in various shapes and sizes and its effect on other parameters are studied in some experiments. Some of the material from that central portion is removed, and is added at the place where greater fresh air comes in the contact of the fin surface, it would increase overall heat transfer coefficient ‘h’. [15] Hence it can be studied with various modes of heat transfer. Since heat transfer by convection depends on fluid flow, so we change the fluid flow by providing a notch. [5] By variation of heat input we can analyse the optimum notch size of fins for maximum heat transfer and natural convection air flow pattern around cylinder. Following is the diagram which shows the fin having notch by compensating area and without compensating area. [12]

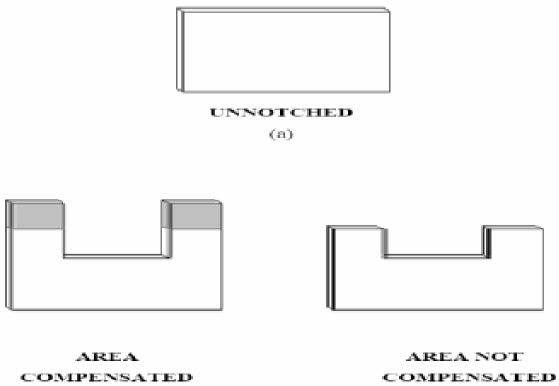

Fig -1: Idea of Area compensation

1.1 Literature Survey

Qie shen had done work on cylindrical heat sink with branch angle of 40° he put the relation for local Nusselt number distribution and thermal boundary layer at different height and number of fins.[1] Krishna Kumar had done the study of parametric effects on a heat sink with branched fins under natural convection. [2] Dr. M.K. Sinha determines of the optimum values of the design parameters in a cylindrical heat sink with branched fins. Investigations on the effect of the design parameters, such as the number of fins, length of fin, height of fin, and the outer diameter of the heat sink on heat transfer. [2] Vijay Kumar experimental study deals with natural convection through vertical cylinder .The experimental set up is designed and used to study the natural convection phenomenon from vertical cylinder in terms of average heat transfer coefficient. Also practical local heat transfer coefficient along the length of cylinder is determined experimentally and is compared with theoretical value obtained by using appropriate governing equations [4] Shivdas Studied the natural convection heat transfer from vertical rectangular fin arrays with and without notch at the center have been investigated experimentally and theoretically. Moreover notches of different geometrical shapes have also been analyzed for the purpose of comparison and optimization.[13]

2. AIM OF THISES

The main aim of the project is to perform experiment to investigate optimum notch size of the of fin having maximum heat transfer as well as to analyze convection air flow pattern over geometry by varying the heat input. For the purpose we had taken different notch sizes of fins having fix fin spacing using free convection heat transfer from the cylinder having longitudinal rectangular fin array. Longitudinal rectangular fin array with aluminium fin and aluminium cylinder is constructed. Fins with different rectangular notch size as 10%, 20%, 30% are used. We are varying the heat input as 25 watt, 45 watt and 70 watt. Three methods are adopted as software analysis, mathematical analysis and experimental performance. Finally we calculate convective heat transfer coefficient, Nusselt No. for all longitudinal rectangular notch fins taken of 3mm thickness by using software analysis, mathematical analysis and experimental performance. Then we compare the optimum notch size of fins by drawing graphs. The steady thermal analysis, pressure drop analysis, air density analysis, Air temperature analysis and air velocity analysis is done on computational fluid dynamics software to validate the result.

2.1 Specifications of Apparatus

Longitudinal Rectangular fin of size (L x W x t) = ((30,33,36,39) x 100 x 3) In mm, No. of fin: 24, Thickness of fins: 3mm., Angle between fins: 15^o, Modification in Geometry of longitudinal rectangular fins: Fins without notch, Fins with 10% of notch without compensation of area and with compensation of area of fin., Fins with 20% of notch without compensation of area and with compensation of area of fin., Fins with 30% of notch without compensation of area and with compensation of area of fin. Heat inputs: 25 Watt, 45 Watt, 65 Watt.

2.2 Project Methodology

Solid modeling, Steady thermal analysis by Ansys, Interpretation of air flow pattern from cylindrical fin array, Experimental validation by apparatus, pressure drop analysis, Air density analysis, air temperature analysis and Air velocity analysis on CFD.

2.3 Load Applied

The loads applied on Selected inside area 25 Watt, 45 Watt and 65Watt. Ambient Temperature 306 K. The given loads are applied on meshed models of aluminum 6061 grade. Heat load is applied to each of 7 cylinders to attain a steady state 90mins area required. The load is varied by the dimmerstat.

3. EXPERIMENTAL SET UP

Our experimental set up consists of cylinder placed on the concrete block. We use 7 types cylindrical heat sink having without notch, 10% notch, 20% notch, 30% notch with and without area compensated. With the help of cartridge heater. We provide heat the inner surface of cylinder. 8 K- Type thermocouple wires are used to measure the temperature of the fins. Heater is connected through voltmeter and ammeter and dimmerstat to mains. Dimmer stat is used to give desired input to the heater. We had selected a room with no fans and windows or any other ventilation to avoid forced convection.

Fig -2: Circuit diagram of Testing Kit

Power from the main circuit is given to MCB which act as the main switch the power is given to the on/off button. From that power is circulated in dimmer stat which act as a single phase auto transformer Voltmeter and ammeter are connected in series circuit then the power is given cartridge heater. Maximum wattage for heater is 275 watt and maximum range in dimmerstat operates is 5 ampere.

Fig -3: Experimental set up

5. SOFTWERE ANALYSIS AND VALIDATION

5.1 Three dimensional and thermal analysis of cylindrical heat sink with 20% notch

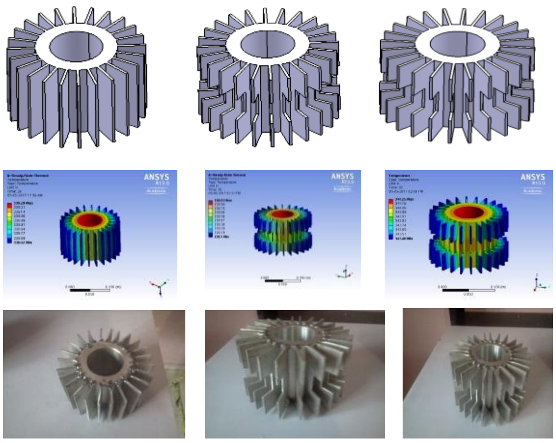

Fig -4: 3D and Thermal Analysis of Cylindrical heat sink.

5.2 Experimental and Analytical Results

According to the Newton's law of cooling we get coefficient of convective heat transfer and Nusselt number experimentally.

Table -1: Experimental Result for convective heat transfer coefficients and Nusselt number

Notch variation	25 W h	45 W h	25 W Nu	45 W Nu
Plane Fin	7.14391	8.041641	7.908388	8.902185
10% AC	6.528056	7.679201	6.528056	8.50096
10% ANC	7.245656	8.160272	8.021022	9.033512
20% AC	7.281293	8.186535	8.060472	9.062585
20% ANC	7.397336	8.338815	8.188932	9.23116
30% AC	6.336858	7.530708	7.014972	8.336577
30% ANC	6.953556	7.995571	7.697663	8.851185

By using the Ansys result and mathematical correlations we get following results

Table -2: Analytical Result for convective heat transfer coefficients and Nusselt Number

notch variation	25 W h	45 W h	25 W Nu	45 W Nu
Plane Fin	8.260629	9.367157	9.144607	10.36955
10% AC	8.228981	9.332945	9.109574	10.33167
10% ANC	8.390394	9.509008	9.288259	10.52658
20% AC	8.439747	9.553133	9.342893	10.57542
20% ANC	8.563208	9.698606	9.479565	10.73646
20% AC	8.220757	9.383127	9.100469	10.31051
30% ANC	8.232942	9.351468	9.113958	10.35218

By comparing the Notched fin array with the plane fin array through experimentally and theoretically at different heat inputs the convective heat transfer coefficient in increased.

Table -3: Percentage increase of heat transfer comparing to plane fin heat sink

Notch variation	25 W	45 W	65 W
10% ANC Experiment	1.4648	1.4752	1.6956
10% ANC Theoretical	1.5708	1.5143	1.7545
20% AC Experiment	1.9638	1.8018	2.2959
20% AC Theoretical	2.1683	1.9662	2.3259
20% ANC Experiment	3.5889	3.6954	3.7895
20% ANC Theoretical	3.6629	3.5384	3.6625

According to chart 1 and chart 2 it is found that the convective heat transfer coefficient and Nusselt number is increasing comparing to the plane fins without notch for 10% Area not compensated fin array, 20% Area compensated fin array and 20% Area not compensated fin array. According to observation it is found that 10% area compensated fin array heat transfer coefficient and Nusselt number both area decreasing. Similarly for 30% area compensated fin array the convective heat transfer coefficient and Nusselt number both area deceasing comparing to plane fin. The decease of convective heat transfer value and Nusselt number value is lowest out of 7 cylindrical fin arrays. Again for 30% area not compensated cylindrical fin array the value of convective heat transfer coefficient is increasing but the increase in value is less than that of plane fin heat sink fin array.

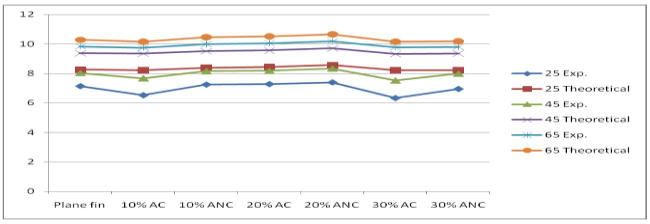

Chart -1: Heat Input V/S Variation of Notch in terms of Average convective heat transfer coefficients.

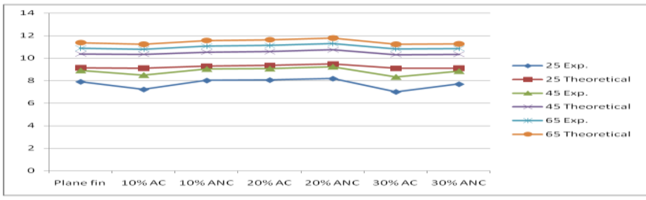

Chart -2: Heat Input V/S Variation of Notch in terms of Average Nusselt Number.

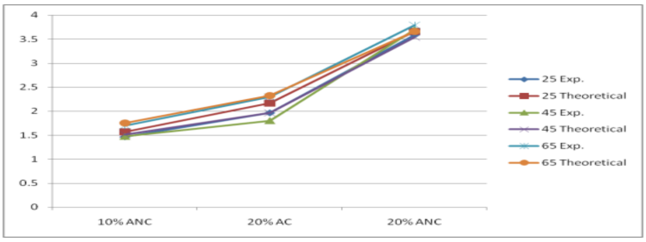

Chart -3: Percentage increase of convective heat transfer coefficient comparing to plane fin.

6. CFD ANALYSIS OF VARIOUS PARAMETERS

6.1 Pressure drop over cylindrical heat sink

As air flows across the channel having fix spacing it creates the pressure drop which affects the flow of natural air over cylindrical heat sink. By following correlation pressure drop can be calculated

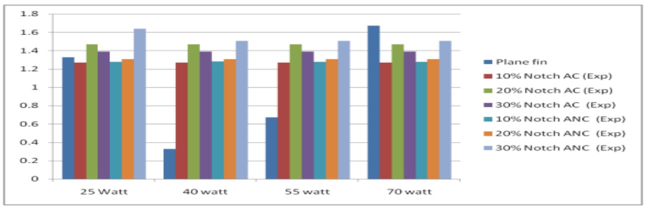

Chart -4: Graph of Pressure drop variation by CFD

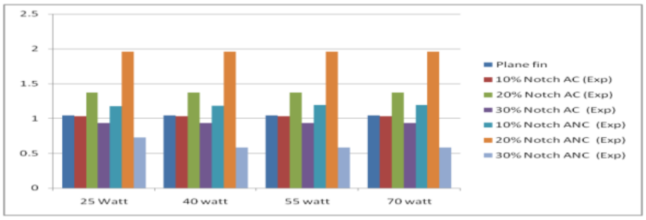

Chart -5: Graph of pressure drop variation by mathematical correlation

According to the Chart -1 and Chart -2 it is found that the value of pressure drop is increased for 10% Area not compensated, 20% Area compensated and 20% Area not compensated respectively. With increased in the value of pressure drop for above selected fins the rate of air flow is also increase its leads to high heat transfer. Fig. 5 shows the pressure variation over the cylindrical heat sink. It is found that the pressure near notch is increases slightly which attracts the drag of air over the notch surfaces and Air flows from base fin to top of fin and also air flows from bottom to top of cylindrical fin array.

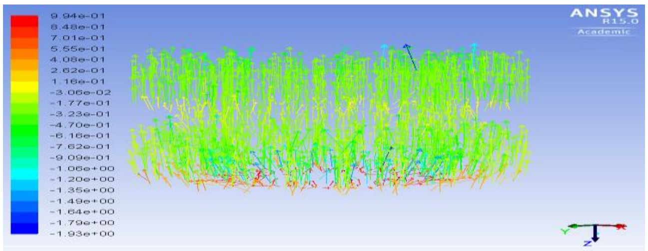

Fig -5: Pressure range over cylindrical heat sink at 20% AC fin array.

6.2 Air flow analysis by CFD

According to the inlet boundary condition with the speed of 1m/sec the air is flowing from bottom to top. When air is flowing across the channel the profile of notch creates the disturbance to the air flow thus the slight turbulence is created near the notch profile. According to the Fig. 5 pressure is higher near the notch profile and pressure is lower at the tip of the fin. Thus the air flows from the lower notch profile to the tip of the fin as the air always flow from high pressure to low pressure. Maximum value of increase in air velocity is 1.76 m/sec at the top of the fin.

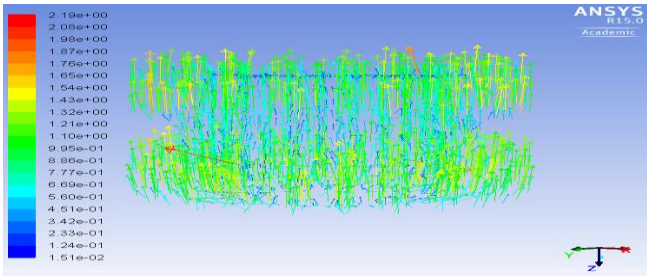

Fig -6: Air velocity variation over cylindrical heat sink at 20% fin array.

6.3 Air density analysis by CFD

As the heat is give to inner surface of cylinder that heat is travels across the fin surfaces, when the air is enters from the sides and bottom into the heat sink, air touches the surface of the cylindrical heat sink get heated first and density of that air is increase that air is travels from the bottom of the fin to top of the fin and also from bottom of the cylinder to top of the cylinder. The value of density increases from 1.125 Kg/m^3 to 1.23 Kg/m^3

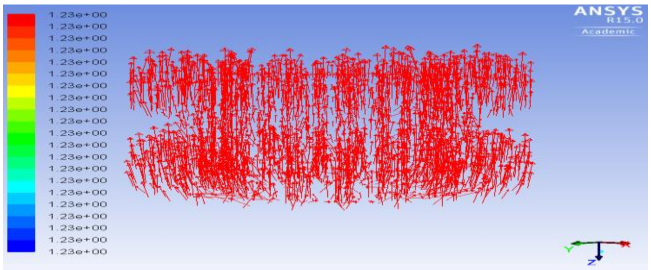

Fig -7: 11 Air density variation over cylindrical heat sink at 20% AC fin array.

6.4 Air temperature variation analysis by CFD across cylindrical heat sink.

As the air enters from the side and bottom of the cylindrical heat sink as soon as air enters across the channel between two fins of fix spacing it starts absorbing the heat and get heated. The air very close to the cylinder base and surface of the fins has higher temperature and air somewhat above the metal surface has lower temperature. This change of temperature forms the boundary layer near the base surface of cylinder and side walls of cylinder. As the notch size is varies corresponding temperature distribution is also varies thus affect the formation of thermal boundary layer. The air temperature varies from 307.60 K to 320.20 K.

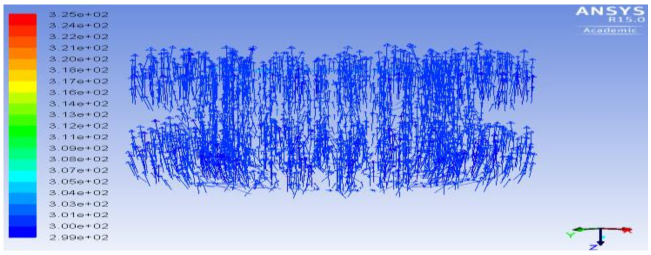

Fig -8: Air temperature variation over cylindrical heat sink at 20% AC.

7. HEAT LOSSES IN CYLINDRICAL HEAT SINK.

As when heat is given to cartridge type of heater that heat is absorb by the cylindrical heat sink though heat is get transfer across the fin surfaces by conduction from fin surface to air by convection. But some of the heat is also get lost because of radiation, though other losses are presents but radiation losses are more. According to the graph of heat input V/S Notch variation in terms of radiation losses it is observe that radiation losses are higher in 10% Area compensation fin array, 10% Area not compensated fin array, 20% area not compensated fin array and 30% area not compensated fin array. Average radiation losses area 10.8 Watt.

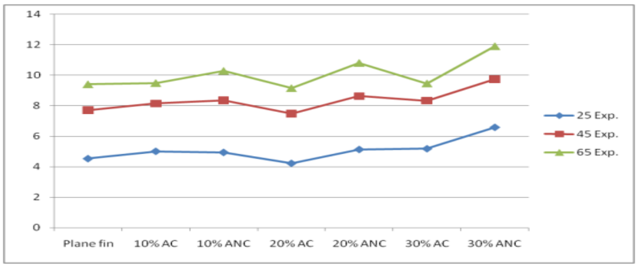

Chart -6: Heat input V/S Notch Variation in terms of radiation losses

7. FUTURE SCOPE

By changing the position of the notch at different location of the fin surface have different identity of heat transfer. As heat transfer is also get affected by the optimum fin spacing so by changing the fin spacing and changing the Branched angle of fin heat transfer may increase in certain proportion.

8. CONCLUSIONS

After design and fabrication of cylindrical fin array and validation of results it is observe that convective heat transfer coefficient and Nusselt no. is increased comparing to fin without notches.

1) In area not compensated fin array though area of fin will decrease still heat transfer increase.

2) Second case with compensation fin array the central material of fin is exposed to fresh cold air again it is found that heat transfer is increasing.
3) 10% of notch size Area without compensation and 20% of Notch size area with or without compensation has higher convective heat transfer coefficient that leads to increase in heat transfer of cylindrical heat sink from 1.5% to 3.65% comparing to the fin array without notches.
4) After provision of notch at the central portion of fin leads to change of flow pattern of natural air, increase in the air velocity across channel, Variation of air pressure across channel and increase of air temperature in cylindrical heat sink.
5) By experimental and CFD result it found that 20% of Rectangular Notch size of longitudinal fin is the optimum notch size which has the higher heat transfer comparing to the other fin array.

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REFERENCES

[1] Qie Shen, Daming Sun, Ya Xu, Tao Jin, Xu Zhao, Ning Zhang, Ke Wu, Zhiyi Huang, “Natural convection heat transfer along vertical cylinder heat sinks with longitudinal fins” , International Journal of Thermal Sciences. 1-8, 2015.
[2] Krishna Kumar Singh, Dr.M.K. Sinha, “Parametric Effects on a Heat Sink with Branched Fins under Natural Convection”, International Journal of Scientific & Engineering Research. Volume 7, 229 ,ISSN 2229-5518, 2016.
[3] Ayla Dogan, Sinan Akkus and Şenol Baskaya, “numerical analysis of natural convection heat transfer from annular fins on a horizontal cylinder”, Journal of Thermal Science and Technology ISSN 1300-3615, 2014.
[4] Nilesh B.Totala, Mayur V.Shimpi, Nanasaheb L.Shete, Vijay S.Bhopate, “Natural Convection Characteristics in Vertical Cylinder”, International Journal Of Engineering And Science. Vol.3, PP 27-31 Issn(e): 2278-4721, Issn(p):2319-6483, 2016.
[5] S. V. Kadbhane and D. D. Palande , “Experimental Study of Natural Convective Heat Transfer from Vertical Rectangular Fin Array at Different Angle of Inclination”, International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161, 2016.
[6] S.D.Ratnakar, D.D.Palande, “Enhancement of heat transfer from plate fine heat sink”, International Journal of Advance Research In Science And Engineering IJARSE, Vol. No.4, Issue 04, April 2015.
[7] P. Lohar, Dr. S. G. Taji, “Experimental Investigation for Optimizing Fin Spacing in Horizontal Rectangular Fin Array for Maximizing the Heat Transfer under a Natural and Forced Convection”, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 7, July – 2014.
[8] S. D. Wankhede, S. G. Taji, V. M. Suryawanshi, “Experimental Investigation of Heat Transfer from Inverted Notch Fin Arrays (INFA) Under Natural and Forced Convection”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN(e) : 2278-1684, ISSN(p) : 2320–334X, PP : 14-22, 2014.
[9] Aniket H. Kawade, “Experimental and numerical analysis of convective heat transfer from notched fin arrays with pin fins”, ASME International Mechanical Engineering Congress and Exposition November 15-21, 2013.
[10] Vishal Hegana, P.R. Kulkarn, “Experimental Analysis of Natural Convection Heat Transfer from Horizontal Rectangular Fin Arrays with a Semi Circular Profiled Notch at the Center”, International Research Journal of Engineering and Technology (IRJET). Vol.3, 2014.
[11] V.Sivaprakasam, J. Kalil Basha, R.Udhayarasu, D. Siva, “Experimental investigation on the performance of longitudinal fins with different notches using mixed convection heat transfer” , IJRAME, ISSN: 2321-3051 Vol.3 Issue.6, Pgs: 12-20, June 2015.
[12] S.C. Haldar, G.S. Kochhar and K. Manohar, “Numerical Study of Laminar Free Convection About a Horizontal Cylinder with Longitudinal Fins of Finite Thickness” International Journal of Thermal Sciences.volume.3, 2015.
[13] Shivdas S. Kharche, Hemant S. Farkade, “Heat Transfer Analysis through Fin Array by Using Natural Convection” International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, Volume 2, 2014.
[14] D GKumbhar , “Analysis of Heat Transfer From Horizontal Rectangular (Square Notched) Fin Arrays by Natural Convection”, International Journal of Engineering Innovation & Research, ISSN: 2277 – 5668, Volume 4, 2014.
[15] Mr. Ram Bakale, Mr. Kaushik Baheti, “ Experimental Analysis of Natural Convection Heat Transfer from Notched Fin” , Imperial Journal of Interdisciplinary Research (IJIR) Vol-2, Issue-6, 2016,ISSN: 2454-1362, 2015..
[16] V.sivaprakasam, j. kalil basha , r.udhayarasu, d. siva, “experimental investigation on the performance of longitudinal fins with different notches using mixed

convection heat transfer", International journal of research in aeronautical and mechanical engineering issn (online): 2321-3051, Vol.3, 2014.

[17] S.H. Barhatte1, M. R. Chopade2, V. N. Kapatkar, "experimental and computational analysis and optimization for heat transfer through fins with different types of notch" , Journal of Engineering Research and Studies E-ISSN 0976-7916, 2014.

[18] V.Achuth kumar reddy,SK subhani basha , "Effective cooling of ic engine by using various fin configurations and materials", International journal of professional engineering studies ,Volume 6, 2014.