INTERNATIONAL JOURNAL OF SCIENTIFIC PROGRESS AND RESEARCH (IJSPR) ISSN: 2349 - 4689
Volume-02, Number - 01, 2014

An Experimental Analysis of Transient Heat Transfer in Air Cooled IC Engine Fin using FEA

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Abstract - A fin is a surface which extends from a surface to increase the rate of heat transfer to the environment by increasing convection. The IC Engine fins are made from Aluminum alloy and it is provided for better cooling effect. The cooling mechanism of the air cooled IC engine is generally dependent on the fin design of the cylinder, cross-section area of fin, pitch of the fin, thickness of fin, air velocity, air exposed angle and weather conditions. In this research paper first experimental readings were taken in form of temperature of existing fin of air cooled IC engine. These readings were validated with ANSYS model. After validation fin was modified with same volume, again analysis of modified fin done by ANSYS software. By comparing the result, we can get the clear idea about the fin performance.

Keywords: IC engine, heat transfer, fin, FEA, ANSYS

I. INTRODUCTION

Heat transfer through a fin is the study of the transfer of heat from fins extending from a primary heat transfer surface. The effect of such fins is to increase the area over which heat is transferred to or from the surrounding fluid and to substantially increase the rate of heat between the primary surface and the surrounding fluid. There are different geometries for the primary surface: planar and radial also there are many different shapes of fin: pin, rectangular, trapezoidal, dovetail and parabolic, and annular. [1]

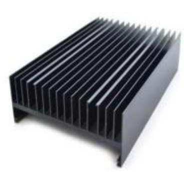

Fig.1.1 Rectangular fin

All internal combustion engines are fluid cooled using either air (a gaseous fluid) or a liquid, in which the coolant is run through a heat exchanger cooled by air. Marine engines and there are some stationary engines have ready access to a large volume of water at a appropriate temperature. The water can be used directly to cool the engine, but frequently it sediment, which can clog coolant passages, and chemicals, such as salt, that may chemically damage the engine.

II. SYSTEM MODEL

The finite element method is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations. The solution approach is base either on eliminating the differential equation entirely, or rendering the Partial differential equations into an approximating system of ordinary differential equations, these are then numerically, integrated using standard techniques such as Euler's method, or Runge-kutta method etc.

Following are the steps required for thermal analysis:

Steady State and Transient Thermal Study

- Defining the element
- Defining the material properties
- Building geometry
- Meshing
- Defining load
- Solution
- Result

III. PREVIOUS WORK

P.J. Heggs[5] presented a mathematical model for radial rectangular fin. Design charts were presented with example. The charts used to evaluate the fin performance with respect to certain heat transfer processes. They can be used to interpret the relationship between each parameters and the fin problem. PR, fin performance ratio is not a measurement of the fin thermal performance but its effectiveness.

Mostafa H. Sharqawy[6] carried out an analysis to study the efficiency of straight fins of different configurations when subjected to simultaneous heat and mass transfer mechanisms.

As the temperature and humidity ratio differences are the parameters for heat and mass transfer, correspondingly.

N. P. Raja Rao et. al[9] experimented the transient thermal analysis to analyse the thermal properties by varying material, thickness and geometry of cylinder fins. Whereas the analysis three material were used i.e. Aluminium Alloy A204, Aluminium alloy 6061 and Magnesium alloy. These different materials were experimented with rectangular, circular and curve shaped fins. Finally as result shows that by using circular fin with material Aluminium Alloy 6061 is better because heat transfer rate and Effectiveness of the fin is more. By using the circular fins weight of the fin body reduces compare to existing engine cylinder fins.

Tae Hoon Kim [18] performed both experimental and numerical studies and suggested a closed form correlations that allow for thermal optimization of vertical plate-fin heat sinks under natural convection in a fully-developed-flow regime. They gave a simple way to predict the optimal dimensions of plate-fin heat sinks. They offered analytical solutions using the volume averaging approach for velocity and temperature distributions for high channel aspect ratios, the high conductivity ratios, and the low Rayleigh numbers. As of the analytical solutions author proposed

IV. METHODOLOGY

The IC Engine fins are made from Aluminum alloy and it is provided for increase in contact area in convective heat transfer. By using of fins, the contact area of engine to air is increased therefore the heat transfers rate increase. Due to this fins are used for cooling of the engine.

The dimensions of extended surface or fin provided in IC engine of *HEROHONDA SPLENDOR* were measured and temperature also measured by thermocouple after stopping the engine at every 5 minute interval.

Fig. 4.1 fin provided in IC engine

V. SIMULATION/EXPERIMENTAL RESULTS

V.I FEA of existing fin

- Element type- solid87
- Analysis Type- Thermal
- Material Properties
- Thermal Conductivity= 190 watt/mºC
- Density= 2650Kg/m3
- Specific Heat= 900J/Kg.K

After measuring the dimensions of fin, generate the model of that fin in FEA software the length of fin is 65 mm and height is one side 9.2mm and another side is 17.5mm. the thickness of fin is 3mm.

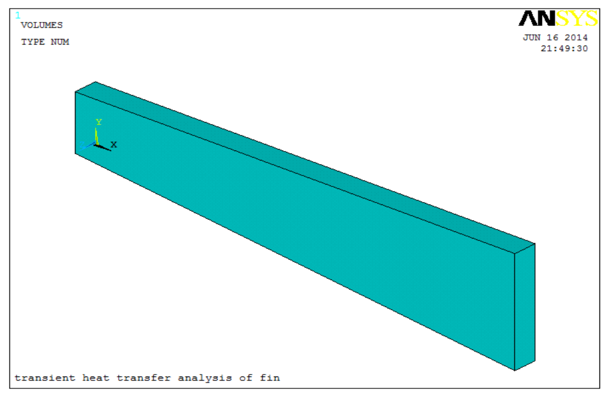

Fig. 5.1 3D model of fin

By using messing tool the fin is dived in the 9393 elements and Fin is divides in 13249 nodes

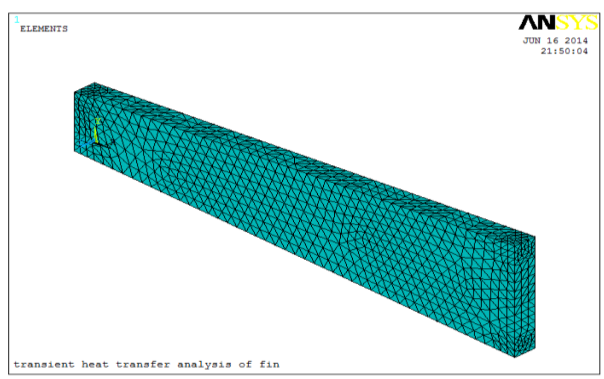

Fig. 5.2 messing of fin

By taking data for boundary condition

- Initial Temperature =200°C
- Film Co- efficient=15w/m^{2}K
- Bulk Temperature= 25°C

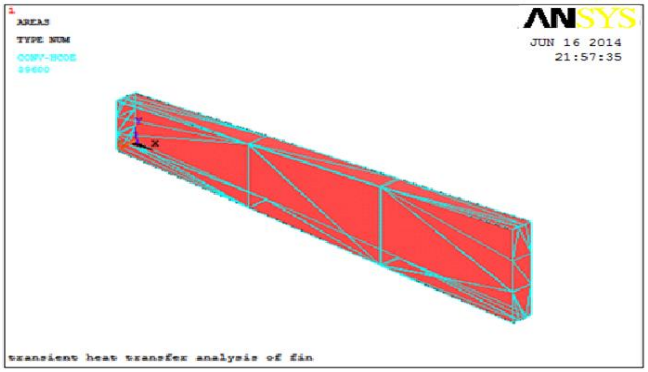

Fig. 5.3 boundary conditions

After 5 minutes maximum temperature is 183.334° C and minimum temperature is 182.02° C.

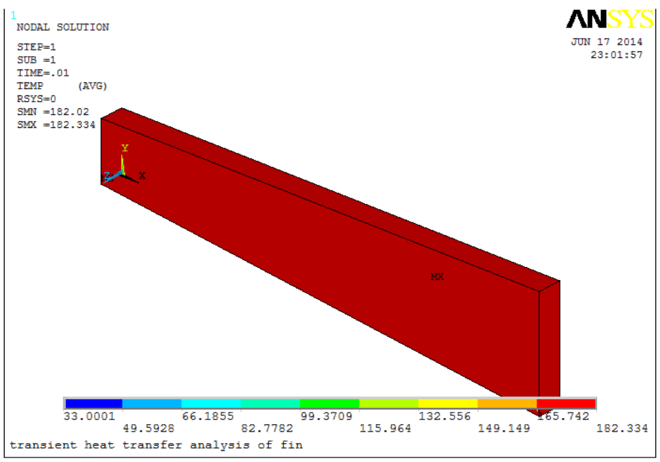

Fig. 5.4 result after 5 minutes

After 10 minutes maximum temperature is 114.389° C and minimum temperature is 114.203° C.

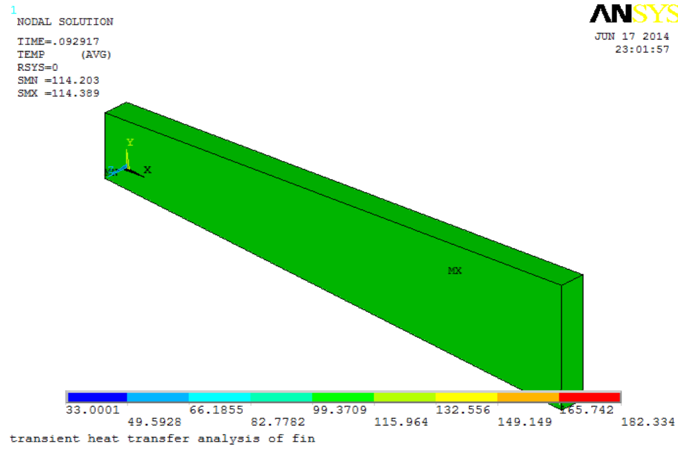

Fig. 5.5 result after 10 minutes

After 30 minutes maximum temperature is 40.7484° C and minimum temperature is 40.7307° C.

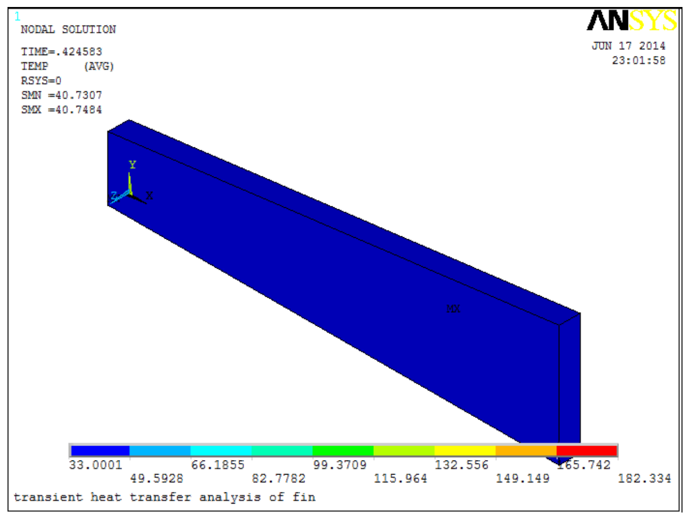

Fig. 5.6result after 30 minutes

Table 5.1 Results of FEA of existing fin

Time (after stop engine)	FEA result readings
Initial temp.	195°C
5 minute	182.33°C
10 minute	114.39°C
15 minute	78.46°C
20 minute	58.02°C
25 minute	46.88°C
30 minute	40.74°C
35 minute	37.26°C
40 minute	35.36°C
45 minute	34.32°C
50 minute	33.72°C

V.II Experimental validation of fin

Reading has been taken by attach thermocouple on the fin. K type thermocouple is used for experimental reading.

Table 5.2 Results of FEA of existing fin

Time (after stop engine)	Temperature
Initial temp.	193°C
5 minute	185°C
10 minute	117°C
15 minute	79°C
20 minute	57°C
25 minute	47°C
30 minute	41°C
35 minute	38°C
40 minute	36°C
45 minute	34°C
50 minute	32°C

V.III FEA of modified fin

Existing fin dimensions b= 65mm,y= 3mm , L= 13.35mm was replaced by taking b= 65mm, y= 2mm, L= 20mm. so volume remains constant.

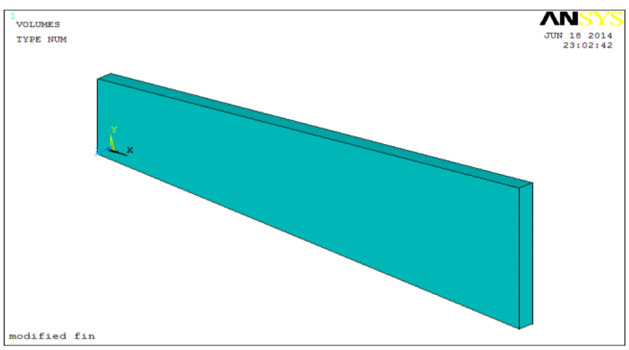

Figure 5.7 3D model of modified fin

By using messing tool the fin is dived in the 30941 elements and Fin is divides in 29231 nodes.

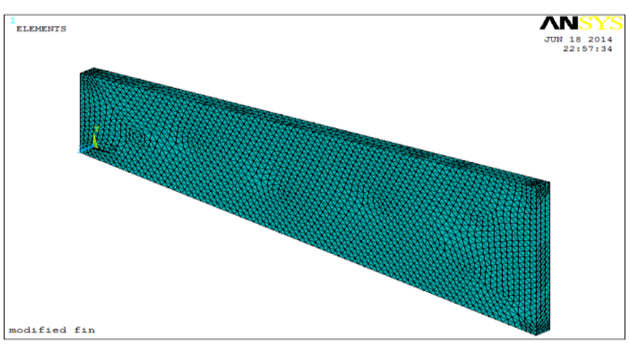

Figure 5.8 messing of modified fin

Conduction and convection will occurred in fins during heat transfer. Heat transfer phenomena start when engine stops. 5 sides of fins are in contact of air and one side is contact of cylinder. So in 5 sides there will heat convection will done and in bottom side heat conduction process done. So apply boundary condition in 5 sides which are in contact of air.

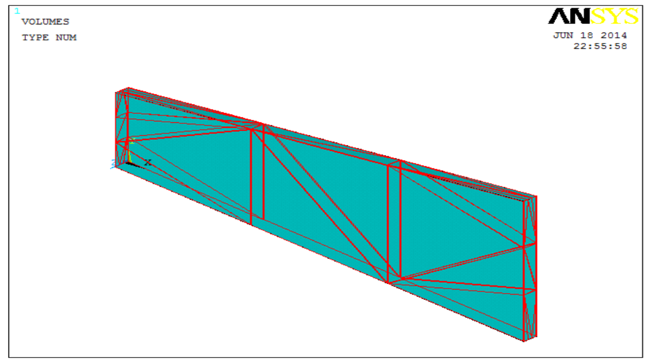

Figure 5.9 boundary conditions

After 5 minutes maximum temperature is 170.411° C and minimum temperature is 170.171° C

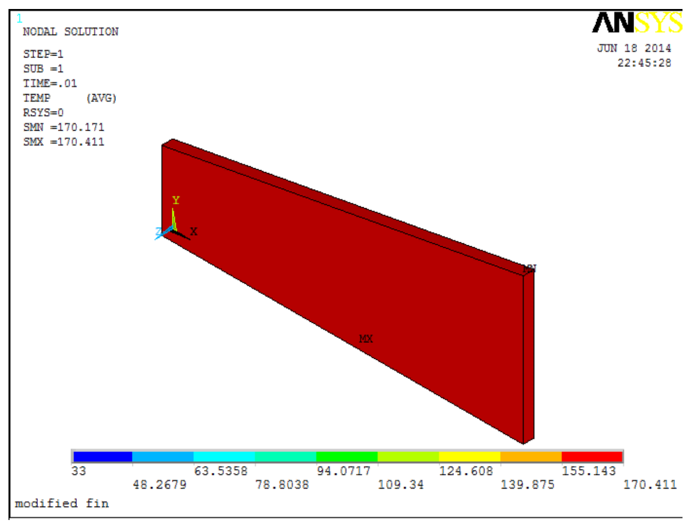

Fig. 5.10result of modified fin after 5 minutes

After 15 minutes maximum temperature is 45.2949° C and minimum temperature is 45.2728° C.

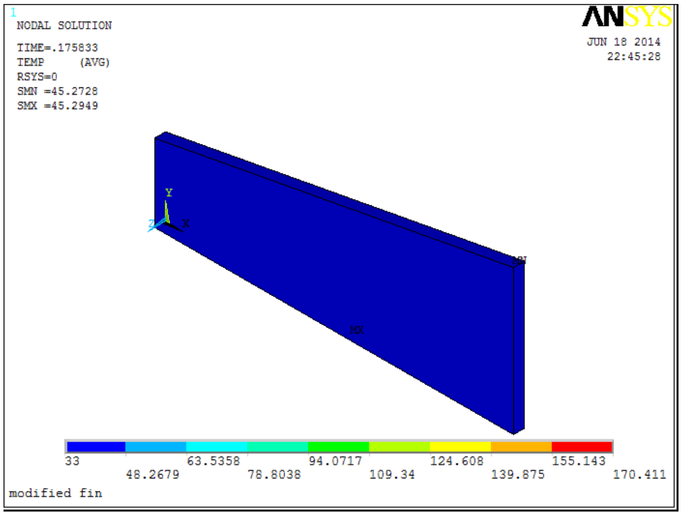

Fig. 5.11 result of modified fin after 15 minutes

After 30 minutes maximum temperature is 33.0014° C and minimum temperature is 33.0014° C

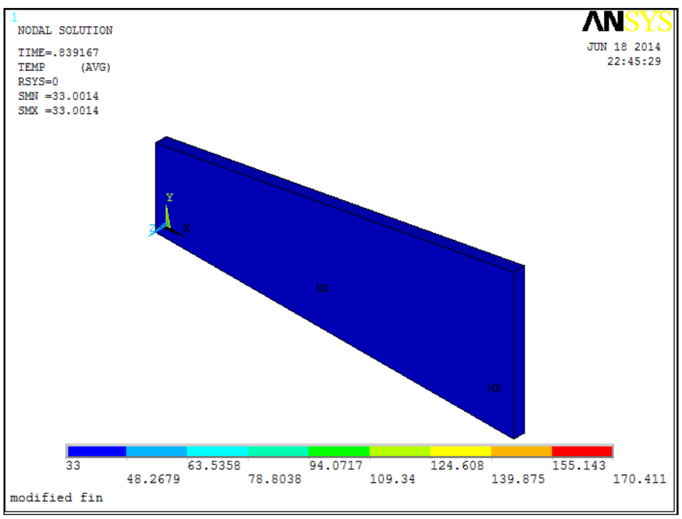

Fig. 5.12 result of modified fin after 30 minutes

Table 5.3 Results of FEA of existing fin

Time (after stop engine)	Temperature
Initial temp.	195°C
5 minute	170.41°C
10 minute	74.10°C
15 minute	45.29°C
20 minute	36.67°C
25 minute	34.09°C
30 minute	33.00°C

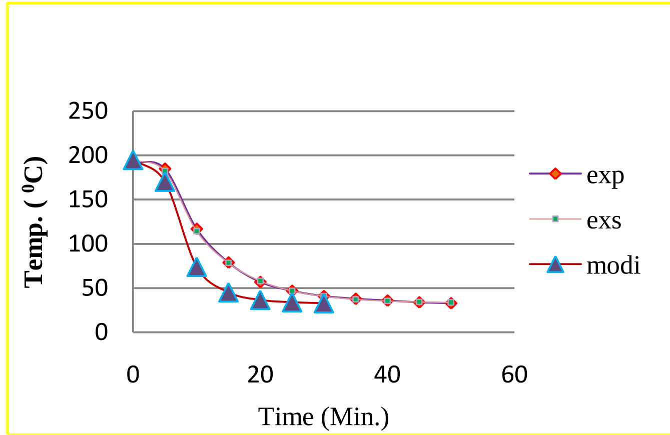

Fig. 5.13 comparison of experimental, FEA of existing fin and FEA of modified fin data

VI. CONCLUSION

By experimental data and FEA data for fin of air cooled IC engine is compared and validated. Also comparing the modified fin FEA data with existing fin data, this research paper give clear idea about fin performance. After the modification of fin with constant volume, effectiveness was increased with minor change in efficiency. So modified fin gives best cooling rate than the existing fin.

VII. FUTURE SCOPES

- Different materials can be used for FEA analysis
- Optimization of fin can be possible.
- Usage of composite materials
- Change the angles of fin
- Different dimensions and geometry of fin
- Usage of advance manufacturing process for better thickness
- Better messing is possible with use of hyper mess to get better accuracy

REFERENCES

[1] C.F. Taylor, T.Y. Toong, Heat transfer in internal-combustion engines, ASME paper 57-HT-17, 1957.

[2] Masao YOSHIDA et al, “Air-Cooling Effect of Fins on a Motorcycle Engine”, JSME International journal, Series B, Vol.49, No.3, 869-875, 2006.

[3] Bassam A/K Abu-Hijleh, “Enhanced forced convection heat transfer from a cylinder using permeable fins”, Journal of heat transfer, Vol. 125, 804-811, 2003

[4] Ashok tukaram pise et al, “Investigation of enhancement of natural convection heat transfer from engine cylinder with permeable fins”, International Journal of Mechanical Engineering and Technology, Vol.1, No. 1, 238-247, 2010

[5] P.J. Heggs * , T.H. Ooi, “ Design charts for radial rectangular fins in terms of performance ratio and maximum effectiveness”, Applied Thermal Engineering 24 (2004) 1341–1351

[6] Mostafa H. Sharqawy, Syed M. Zubair* “Efficiency and optimization of straight fins with combined heat and mass transfer – An analytical solution”, Applied Thermal Engineering 28 (2008) 2279–2288

[7] Wladyslaw Mitianiec, Konrad Buczek, Analysis of thermal loads on air cooled engine, Journal of KONES “ Powertrain and Transport, Vol.14, No. 3 2007

[8] L. Dialameh, M. Yaghoubi, O. Abouali (2008), “Natural convection from an array of horizontal rectangular thick fins with short length”, Applied Thermal Engineering 28 (2008) 2371–2379 – 2008

[9] N.P.R. Rao and T. V. Vardhan, Thermal Analysis of Engine Cylinder Fins By Varying Its Geometry and Material, International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 8, August – 2013, ISSN: 2278-0181

[10] N.Nagarani and K. Mayilsamy, Experimental heat transfer analysis on annular circular and elliptical fins, International Journal of Engineering Science and Technology 2(7): 2839-2845

[11] Pulkit Agarwal, et al, “Heat Transfer Simulation by CFD from Fins of an Air Cooled Motorcycle Engine under Varying Climatic Conditions”, Proceedings of the World Congress on Engineering 2011 Vol. III WCE 2011, July 6 - 8, ISBN: 978-988-19251-5-2, 2011, London, U.K

[12] K. shahril et al, “Heat transfer simulation of motorcycle fins under varying velocity using CFD method”, 2nd International Conference on Mechanical Engineering Research (ICMER2013), doi:10.1088/1757-899X/50/1/012043,pp-1-6, 2013

[13] A.-R.A. Khaled “Heat transfer enhancement in hairy fin systems” Applied Thermal Engineering 27 (2007) 250–257

[14] J.Ajay Paul,Sagar Chavan Vijay, U.Magarajan & R.Thundil Karuppa Raj (2012), “Experimental and Parametric Study of Extended Fins In The Optimization of Internal Combustion Engine Cooling Using CFD”, International Journal of Applied Research in Mechanical Engineering ISSN: 2231 –5950, Vol-2, Issue-1, 2012

[15] M. Sudheer, G. Vignesh Shanbhag, Prashanth Kumar and Shashiraj Somayaji, “Finite Element Analysis of Thermal Characteristics of Annular Fins with Different Profiles” ARPN Journal of Engineering and Applied Sciences, VOL. 7, NO. 6, JUNE 2012, ISSN 1819-6608

[16] S.H. Barhatte, M. R. Chopade, 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. JERS/Vol.II/ Issue I/January-March 2011/133-138 E-ISSN 0976-7916

[17] Tae Hoon Kim , Kyu Hyung Do , Dong-Kwon Kim , Closed form correlations for thermal optimization of plate-fin heat sinks under natural convection, International Journal of Heat and Mass Transfer 54 (2011) 1210–1216

[18] Shwin-Chung Wong, Guei-Jang Huang, “Parametric study on the dynamic behavior of natural convection from horizontal rectangular fin arrays” International Journal of Heat and Mass Transfer. 60 (2013) 334–342.

[19] Magarajan U et al., “Numerical Study on Heat Transfer of Internal Combustion Engine Cooling by Extended Fins Using CFD”, Research Journal of recent sciences, Vol. 1(6), 32-37, 2012.

[20] Yunus A Cengel, “ Heat and Mass Transfer” third edition (2011) 159 - 170

[21] J P Holman, “Heat Transfer” ninth edition (2010) 43-52