Journal of Applied Fluid Mechanics, Vol. 11, Special Issue, pp. 115-119, 2018.
Selected papers from *International Conference on Newer Techniques and Innovations in Mechanical Engineering* ***(ICONTIME 2K18)****, 2018*
Available online at www.jafmonline.net, ISSN 1735-3572, EISSN 1735-3645.
DOI: 10.36884/jafm.11.SI.29427

Analysis of Varying Geometri Structures of Fins using Radiators

K. Chinnarasu[1†], M. Ranjithkumar [2], P. Lakshmanan[2], K. B. Hariharan[2], N. K. Vigneshwaran[2] and S. Karan[2]

[1]*Department of Mechanical Engineering, United Institute of Technology, Tamil Nadu, India*
[2] *Department of Mechanical Engineering, K. Ramakrishnan College of Technology, Trichy, Tamil Nadu, India*

†*Corresponding Author Email:* chinnarasu132@gmail.com

(Received May 15, 2018; accepted July 18, 2018)

ABSTRACT

Radiators are heat exchangers used to transfer thermal energy from one medium to another medium. In the existing plain fins type radiator are commonly used, which are usually set up in a cross flow arrangement made up of aluminum and copper alloy. Powerful fan and water pump is accompanied in this to greatly improve heat dissipation rate. For higher cooling capacity of radiator, addition of fins is one of the approaches to increase the cooling rate of the radiator. This method follows the principle of increasing contact surface. Contact surface can also be increased by varying fin geometrical structure. In this project simple modification has been carried out in the existing fin geometry with a view to improve its heat dissipated rate. The varying fin structures are Box type, Sharp type, Round type. Sharp type radiator fins is fabricated to evaluate the effectiveness of the radiator. Also comparison of conventional coolant with SiC Nano fluid has been carried out by using Solid works and Ansys software. The result are compared with both analytical and experimental fin design is concluded.

Keywords: Fins; Heat transfer; Geometrical; Coolant; Nanofluid.

1. INTRODUCTION

In this radiators are brazing the thin aluminum fins to flattened tubes. The coolant flows from the inlet tubes to outlet tubes in a parallel order. Akhilnandh *et al* (2015) tested radiators are the heat exchanger that uses in many application like automobiles, refrigeration and some of water treatment plants. Experiments were done by utilizing □-NTU method and results were compare with theoretical values. The results were done using GARCH tool. Mohamed (2016) comparative results are given for various engine speeds during a cold start and engine fully warm up tests when the engine was equipped by conventional cooling system and MCS Operation. Srinivasan *et al* (2017) elucidates the outcomes of an experimental study validating a methodology for applying aerodynamic co efficients for a missile grid fins. Hardik Patel *et al* (2017) is carried out to evaluate heat transfer through the radiator for water based CuO nano fluid. Hardikkumar *et al* (2015) investigated by increasing the water in the mixture side outlet temperature will be decreasing in radiator 355.6 K to 349K, So higher mixing ratio of water is desirable for achieving better performance. By fixing the water proportion with different coolant at50% (like Methanol, Propanol, Ethanol), In that, Ethanol gives the highest outlet temperature of 351.3 K among all the mixture and Methanol gives the least outlet temperature as 350.1K . Ethanol is more desirable to use among all the coolants it gives the high temperature at the outlet. Tianwei Wang *et al* (2015) ensured the non linear controller provided superior performance in terms of power consumption and temperature tracking as evident by the reduced magnitude. Saif, Butt *et al* (2016) conducted experiment on a dedicated test rig highlight the effectiveness of the proposed nocel adaptive sliding mode control in terms of asymptotic tracking. Muruganandam *et al* (2017) found that the brake thermal efficiency increases by 10% to 15% exhaust temperatures decreases by 8%. Venkatesh *et al*. (2016) studied the flow of heat and fluid in solar air heater using Computational Fluid Dynamics (CFD). The predicted temperature results were observed within a deviation of ±10.64%. Krunal *et al* (2015) ensured soft running of an automotive vehicle under any variable load conditions, one of the major systems necessary is the cooling system.

Automobile radiators are becoming highly power-packed with increasing power to weight or volume ratio.D. Ganga Charryulua *et al* (1999) has examined the effects of different materials of construction of fins and tubes. Computational Fluid Dynamics (CFD) is one of the important software tools to access preliminary design and the performance of the radiator. The experiment is done Pro-E software and analysis by ANSYS-12. Helical tubes are considered for the radiator with two different diameter like 15mm & 20mm. It is found that there is more heat dissipation rate in 15mm pitch helical tubes compared to 20mm pitch helical tubes. Maximum temperature drop and minimum pressure drop occurs in case of 0.5 kg/sec of mass flow rate. It is observed that with increased mass flow rate, there is decrease in temperature drop & increase in pressure drop.

2. EXPERIMENTAL SETUP

The figure 1 shows the Experimental setup of Proposed Model. In this model the actual analysis is carried to evaluate the performance of the sharp type radiator fins. Two thermocouple are introduced in the inlet and the outlet temperature of the coolant is measured using J-Type thermocouple. The heater is used to heat the coolant. The temperature readings are noted in the display provided in the above setup. The mass flow rate of water is measured by using the measuring jar. The time taken to fill one liter of water is noted using stopwatch.

Fig. 1 Experimental Setup

The table 1 shows the observed values of water and air during the experimental analysis. These values are essential for the calculation of effectiveness of the fins.

Heat Exchanger (Radiator) to be counter flow we get,

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}$$

$$LMTD = \frac{\theta_1 - \theta_2}{\ln \frac{\theta_1}{\theta_2}}$$

Table 1 Observed values

OBSERVATION	WATER	AIR
Inlet Temperature (°C)	52	27
Outlet Temperature (°C)	44	32.43
Mass flow rate (kg/s)	0.0238	0.1459
Specific Heat (kJ/kg °C)	4.187	1.005
Thermal Conductivity (W/mK)	0.66	0.024
Density (kg/m3)	1000	1.1

For correction factor required dimension parameters are,

$$P = \frac{t_2 - t_1}{T_1 - t_1}$$

$$R = \frac{T_1 - T_2}{t_2 - t_1}$$

That area of the heat transfer after considering correction factor is given as,

$$A = \frac{q}{U \times F \times \theta_m}$$

Effectiveness of Heat Exchanger

Ch=(Mw ×CPw)

CC = (Ma ×CPa)

Capacity Ratio(C):

$$C = \frac{C_{\min}}{C_{\max}}$$

$$NTU = \frac{U \times A}{C_{\min}}$$

Using NTU-□ correlation for cross flow HE with both fluids unmixed, we have

$$\varepsilon = 1 - \exp\left[\left(\frac{1}{C}\right)\left(NTU^{0.22}\right)\left\{\exp\left[-C\left(NTU^{0.78}\right)\right]-1\right\}\right]$$

Table 2 Calculated Values (units to be change)

Type of fin	Nodes	Element
Normal	94556	50485
Box	125140	63493
Sharp	13562084	68453
Round	141676	71789

The Table 2 the calculated values for the proposed model is shown. By using the above formulas the effectiveness of the fins are calculated. The effectiveness values mentioned above are calculated for sharp type fins.

3. RESULTS AND DISCUSSION

Table 3 Calculated Values (units to be change)

Observation	Value
Heat transfer coefficient (U)	350 W/m^2K
Log Mean Temperature Difference(LMTD)	18.25 °C
Amount of heat transferred(Q)	2869.93 W
Capacity Ratio(C)	0.679
NTU	1.68
Effectiveness(ε)	0.65

3.1 Mesh Generation

Solid mesh has been generated using Ansys 16.0 with configuration as relevance center as fine, smoothing as high.

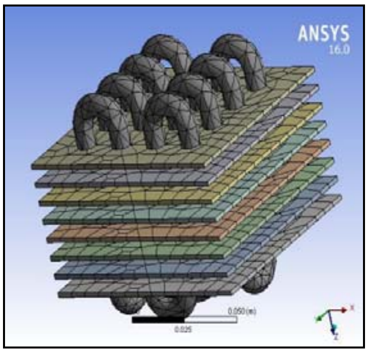

Fig. 2. Meshing of a segment of Radiator on ANSYS

3.2 Steady State Analysis

Steady State Analysis has been done using a high configuration desktop computer. The four proposed model is analyzed and the result is calculated using the CFD (Computational Fluid Dynamics).

3.3 Analysis with Water as Coolant

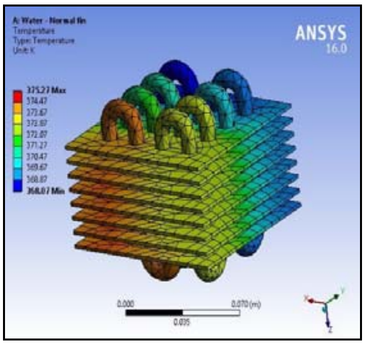

Fig. 3. Variation of Coolant (Water) Temperature in Normal Type Fin

The figure 3, it can interpreted that there is temperature drop from 375K to 368.07K i.e. 6.93K in the existing model fin. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely.

The figure 4, it can be interpreted that there is temperature drop from 375K to 364.01K i.e., 10.99K in proposed model 1(Box type fin). This model has more contact surface as compared to previous existing type as the result there is a significant temperature drop seen.

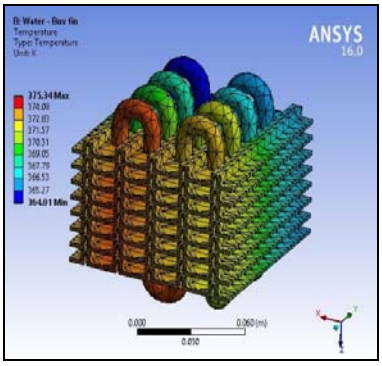

Fig. 4. Variation of Coolant (Water) Temperature in Box Type Fin

The figure 5 , it can be interpreted that there is temperature drop from 375K to 365.51K i.e., 9.5K in proposed model 2(Sharp type fin).Proposed model 2 as less contact surface than proposed model 1 but more space for air flow due to its geometrical structure. But the simulation result reports that temperature drop is slightly less when compared to proposed model 1.

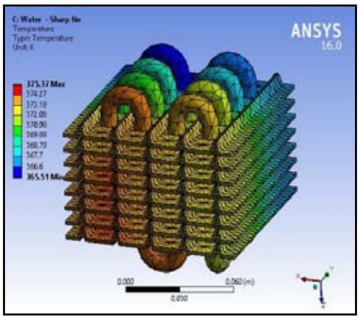

Fig. 5. Variation of Coolant (Water) Temperature in Sharp Type Fin

The figure 6, it can be interpreted that there is temperature drop from 375K to 362.1K i.e., 12.9K in proposed model 3(Round type fin).Proposed model 3 has large contact surface than the existing and previous two proposed model as the result temperature is drop is high in proposed model 3.

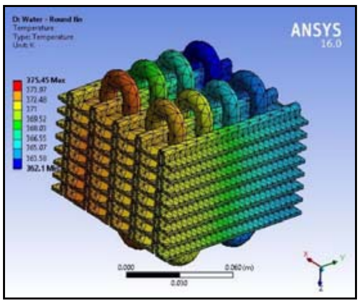

Fig. 6. Variation of Coolant (Water) Temperature in Round Type Fin

3.4 Analysis with SiC Nano fluid As Coolant

The figure 7, it can interpreted that there is heat dissipation from 375K to 360.67K i.e., 14.33K in the existing model fin. This model has less contact surface as compared to other proposed model but has more space in between for air to flow freely. And use of Nano fluid increased heat dissipation rate when compared to existing model using water as coolant.

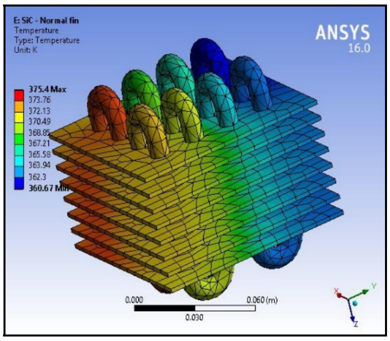

Fig. 7. Variation of Coolant (Nano fluid) Temperature in Normal Type Fin

The figure 8, it can be interpreted that there is heat dissipation from 375K to 353.64K i.e., 21.36K in proposed model 1(Box type fin). This model has more contact surface as compared to previous existing type and by use of Nano fluid as coolant there is a significant temperature drop seen.

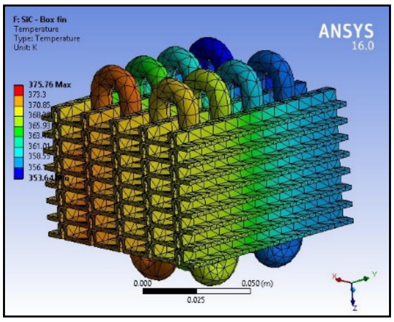

Fig. 8. Variation of Coolant (Nano fluid) Temperature in Box Type Fin

The figure 9, it can be interpreted that there is heat dissipation from 375K to 353.64K i.e., 21.36K in proposed model 2(Sharp type fin). Proposed model 2 as less contact surface than proposed model 1 but more space for air flow due to its geometrical structure and Nano fluid helps in having more heat drop than the previous two model.

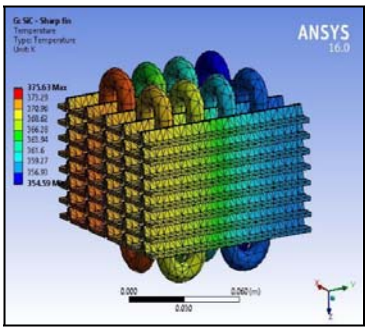

Fig. 9. Variation of Coolant (Nano fluid) Temperature in Sharp Type Fin

The figure 10, it can be interpreted that there is temperature drop from 375K to 349.44K i.e., 25.56K in proposed model 3(Round type fin).Proposed model 3 has large contact surface than the existing and previous two proposed model and with high heat transfer effect of Nano fluid there is a high temperature drop in proposed model 3

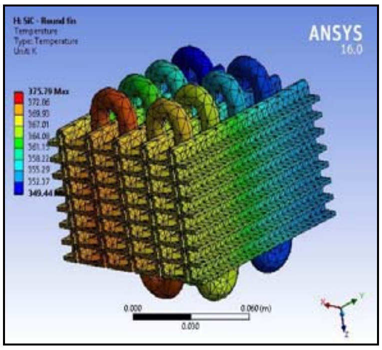

Fig. 10. Variation of Coolant (Nano fluid) Temperature in Round Type Fin

4. COMPARISON OF ANALYSIS RESULTS

4.1 Temperature Variation of Radiator with Water as Coolant

The fig. 11, it is concluded that the simulation with different geometrical fin along with conventional coolant (water) shows that the structure with larger surface area has more heat dissipation rate than the other. Round type fin has 3.47% heat drop followed by box type fin with 2.94%, sharp type fin with 2.54% and normal type fin with 1.85%. Temperature drop in round type fin is 1.62% more than existing plain fin type.

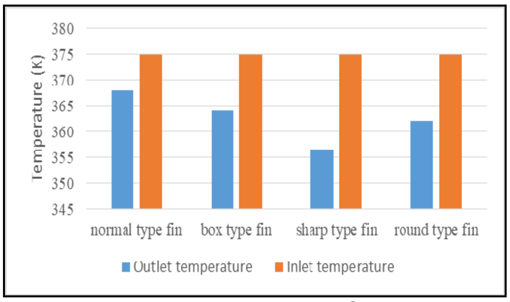

Fig. 11. Temperature Variation of Radiator with Water as Coolant

The fig.12, it is concluded that the simulation with different geometrical fin along with Nano fluid coolant shows that the structure with larger surface area has more heat dissipation rate than the other. Round type fin has 6.82% heat drop followed by box type fin with 5.7%, sharp type fin with 5.44% and normal type fin with 3.83%. Temperature drop in round type fin is 2.99% more than existing plain fin type.

4.3 Loss in Temperature of Coolant with Nano fluid And Water

The loss in temperature for coolant of the water and Nano fluid are shown in graph 3. Where the drop in temperature with water as coolant is from 375K to

362.1K i.e. 12.9K and with Nano fluid as coolant, it is 375 to 349.44 i.e. 25.56K. So by this it has been shown that heat transfer of Nano fluid is better than that of water as coolant in packed together radiator.

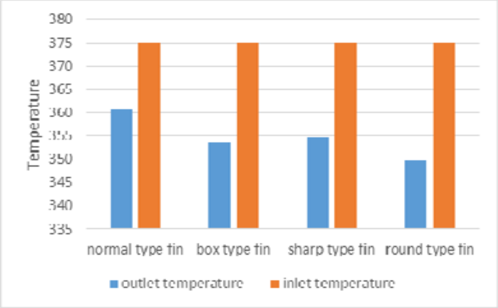

Fig. 12. Temperature Variation of Radiator with Nano fluid as Coolant

As heat transfer rate is more in tubes when coolant just enter. As the air flow rate is very less in between the tubes, heat transfer rate is less in the center tubes when compared to that of end tubes. Due to resistance in the tubes, there will be loss of pressure across the tubes. As there are number of tubes and in each tube input pressure and output pressure vary from each other, we get a graph of pressure variation along the tube length.

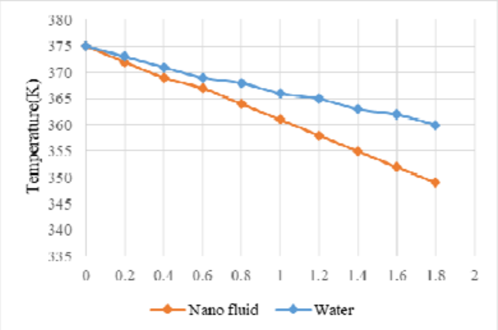

Fig. 13. Loss in Temperature of Coolant with Nano fluid And Water

5. CONCLUSION

The investigation of the automotive radiator with Nano fluid and water as a coolant in dissimilar geometrical structure of fin is effectively carried. The variations in the pressure, temperature are analyzed. From simulation of the radiator fins with conventional coolant (water) as coolant it is found that heat drop from 375K to 362.1K i.e. 3.47% for round type fin followed by box type fin from 375K to 364.01K i.e. 2.94%, sharp type fin from 375K to 365.51K i.e. 2.54% and normal type fin from 375K to 368.07K i.e. 1.85%. Round type fin show high temperature drops in the simulation. From simulation of the radiator fins with SiC Nanofluid as coolant it is found that heat drop from 375K to 349.44K i.e. 6.82% for round type fin followed by box type fin from 375K to 35364K i.e. 5.7%, sharp type fin from 375K to 354.59K 5.44% and normal type fin from 375K to 360.67K i.e. 3.83%. Round type fin show high temperature drops in the simulation.

From both the above simulation it is found out that temperature drop is high in radiator with large contact surface that is round type fin and further this heat dissipation can be increased by application of Nanofluid as coolant.

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