OPTIMIZATION OF ENGINE CYLINDER COOLING BY USING TRIANGULAR FINS

Syed Khaderbasha[1], Dr.Syed Nawazish Mehdi[2], Dr.T.Kishen Kumar Reddy[3], Syed Danish mehdi[4]

[1]Assistant Professor, Mechanical Engineering Department, Muffakham jah College of Engineering and Technology.

[2]Professor & PhD Guide, Mechanical Engineering Department, Muffakham jah College of Engineering and Technology.

[3]Former Rector, JNTUH &Professor, Mech Engg Dept, Jawahar Lal Nehru Technological University, Hyderabad

[4]Research scholar, Mewar university, Rajasthan

Abstract

Engine life and performance can be improved with effective cooling. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. The heat is conducted through the engine parts and convected to air through the surfaces of the fins. Insufficient removal of heat from engine will lead to high thermal stresses, more wear & tear of engine components and lower engine efficiency and more exhaust emissions. As the air-cooled engine builds heat, the cooling fins allow the air to move the heat away from the engine. In the present work, numerical optimization of the fins array is carried out by using commercially available CFD tool Ansys – Fluent 15.0. The performance is analyzed by considering and varying the following parameters: 1. Fins geometry profile 2. Pitch of the fins 3. Wind speed. The results obtained from the numerical analysis are compared with the wind tunnel based experimental results.

Keywords- triangular fin array, Heat transfer, CFD analysis, Wind tunnel experiment.

I. INTRODUCTION

Most internal combustion engines [1] are fluid cooled using either air or a liquid coolant run through a heat exchanger (radiator) cooled by air. In air cooling system, heat is carried away by the air flowing over and around the cylinder. Here fins are cast on the cylinder head and cylinder barrel which provide additional conductive and convective surface. We know that in case of Internal Combustion engines, combustion of air and fuel takes place inside the engine cylinder and hot gases are generated. The temperature of gases will be around 2300-2500°C. This is a very high temperature and may result into burning of oil film between the moving parts and may result into seizing or welding of the same. So, this temperature must be reduced to about 150-200°C at which the engine will work most efficiently. Too much cooling is also not desirable since it reduces the thermal efficiency. So, the object of cooling system is to keep the engine running at its most operating temperature. It is to be noted that the engine is quite inefficient when it is cold and hence the cooling system is designed in such a way that it prevents cooling when the engine is warming up and till it attains to maximum efficient operating temperature, then it starts cooling.

Extended surfaces or fins [2] are widely used in many engineering applications which include, but are not limited to, air conditioning, refrigeration, automobile and chemical processing equipment. The primary objective of using fins is to enhance the heat transfer between the base surface and its convective environment.

As per the literature survey [3], it is established that Effectiveness of the circumferential fin with material aluminum alloy 6061 is better than the fin with material aluminum alloy A204,which is used as fin material for I.C. Engines.

Hence, circumferential fin of rectangular and triangular profiles with material aluminum alloy 6061 is used in the henceforth work.

II. ENGINE SPECIFICATION

Table 1: Engine Specification

No of cylinders	1
bore	57.3mm
stroke	57.8mm
Piston displacement	149.2 cm^3
Compression ratio	9.1:1
Fuel used	petrol
Engine position	vertical

III. EXPERIMENTAL APPARATUS AND METHODS

Fig 1: casting of experimental cylinder [10]

Fig1 shows the casting of experimental cylinder, which can be tightly fitted (interference fit) with circumferential fins of rectangular or triangular profile.

Fig2: wind tunnel test rig at MJCET

Fig2 shows the subsonic low speed wind tunnel test rig, experimentation is carried out in the test section of this wind tunnel

Fig3: experimental setup

Figure 3 shows the experimental setup consists of the following components

1. Wind tunnel test rig
2. Casted experimental cylinder with circumferential fins
3. SAE40 lubricating oil
4. 500 watts electric heater
5. Ammeter
6. Voltmeter
7. Dimmer stat
8. Temperature indicator
9. K type thermo couples
10. Anemometer
11. Wooden cap

In the present experiment, temperature distribution and rate of heat transfer of experimental cylinder is evaluated at various fins pitch and wind speeds. The experimental cylinder is tightly fitted with the replaceable fins of rectangular and triangular profile. The pitch of the fins is adjustable. The cylinder is subjected to various wind speeds, in the range of 8-22 m/s at the test section of the wind tunnel. Initially the experimental cylinder is filled with oil SAE40 and tightly fitted with fins of rectangular profile is placed inside the test section of the wind tunnel. A 500 watt electric heater is immersed in the oil which is controlled by dimmer stat. After heating the oil, once the steady state is reached the cylinder is subjected to wind flow of 8m/s and temperature is measured.

To measure the temperature at various locations on experimental cylinder, K type thermo couples connected to temperature indicator is used. To measure the rate of heat transfer, ammeter and voltmeter is used. The wind speeds are measured using anemometer. Experiment is continued at various fins pitch and flow speeds. The above said experiment is also carried out with the experimental cylinder fitted with the fins of triangular profile. Results are tabulated and compared.

IV. CFD ANALYSIS IN ANSYS

In the present work solid model of engine cylinder with circumferential fins array of different fin geometries like rectangular and triangular are prepared by using Solid Works. After modeling it has been imported in a Ansys work bench with suitable extension for assigning boundary conditions. Below figure shows the geometry model of engine cylinder.

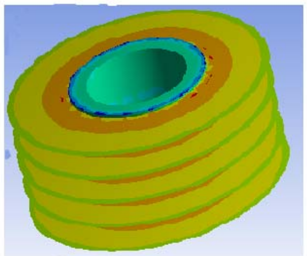

Fig4: Geometry model

V. RESULTS AND DISCUSSIONS

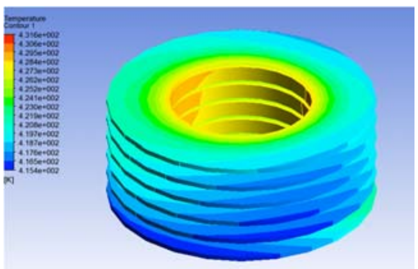

Fig:5 Temperature distribution of rectangular profile fins with 9mm pitch at wall temperature of T=160^0C and speed of 8 m/s

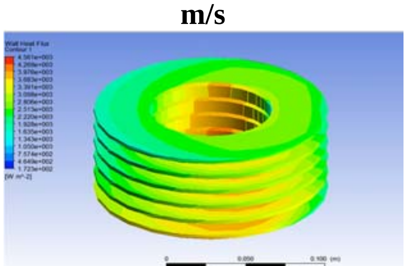

Fig:6 Heat flux distribution of rectangular profile fins with 9mm pitch at wall temperature of T=160^0C and speed of 8 m/s

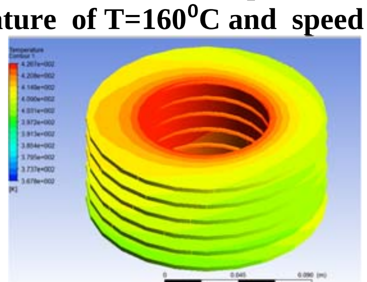

Fig:7 Temperature distribution of rectangular profile fins with 9mm pitch at wall temperature of T=160^0C and speed of 22 m/s

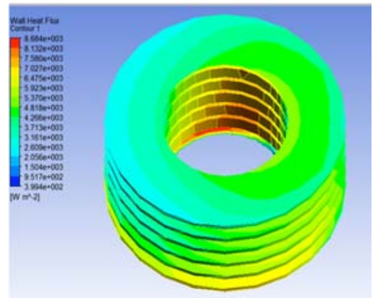

Fig:8 heat flux distribution of rectangular profile fins with 9mm pitch at wall temperature of T=160^0C and speed of 22m/s

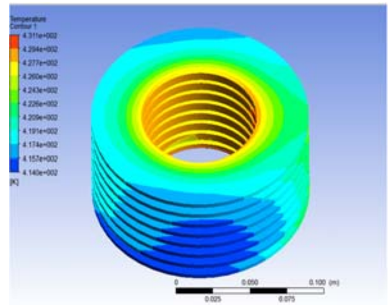

Fig:9 Temperature distribution of rectangular profile fins with 6mm pitch at wall temperature of T=160^0C and speed of 8 m/s

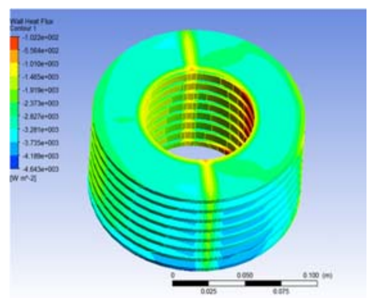

Fig:10 heat flux distribution of rectangular profile fins with 6mm pitch at wall temperature of T=160^0C and speed of 8m/s

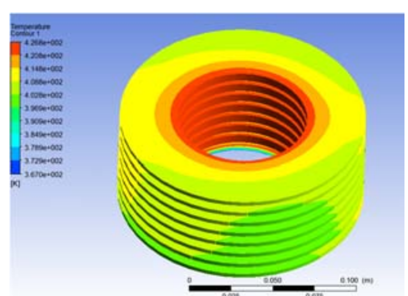

Fig:11 Temperature distribution of rectangular profile fins with 6mm pitch at wall temperature of T=160^0C and speed of 22 m/s

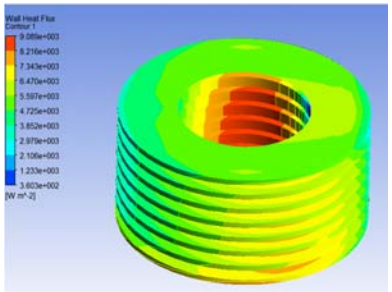

Fig:12 Heat flux distribution of rectangular profile fins with 6mm pitch at wall temperature of T=160^{0}C and speed of 22m/s

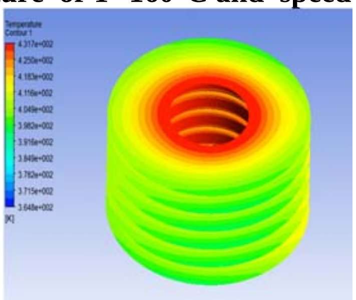

Fig:13 Temperature distribution of triangular profile fins with 9mm pitch at wall temperature of T=160^{0}C and speed of 8m/s

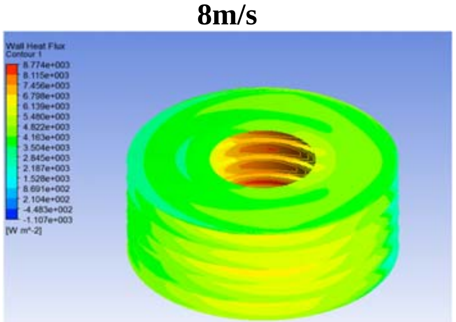

Fig:14 heat flux distribution of triangular profile fins with 9mm pitch at wall temperature of T=160^{0}C and speed of 8 m/s

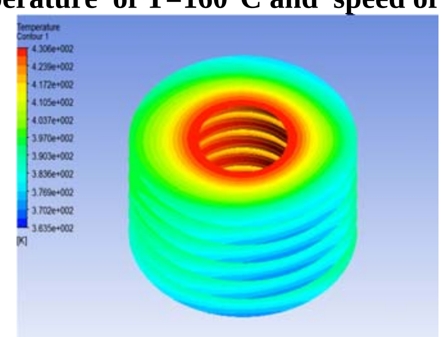

Fig:15 Temperature distribution of triangular profile fins with 9mm pitch at wall temperature of T=160^{0}C and speed of 22m/s

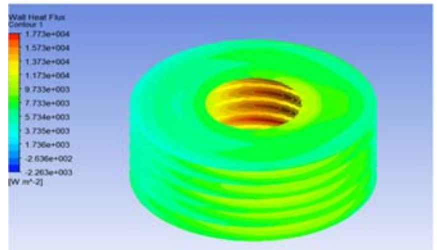

Fig:16 Heat flux distribution of triangular profile fins with 9mm pitch at wall temperature of T=160^{0}C and speed of 22m/s

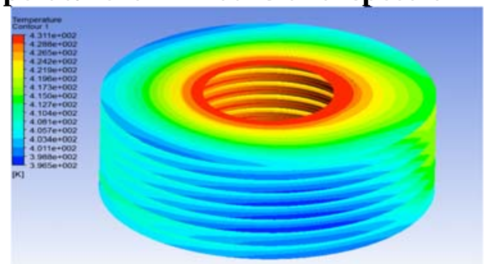

Fig:17 Temperature distribution of triangular profile fins with 6mm pitch at wall temperature of T=160^{0}C and speed of 8m/s

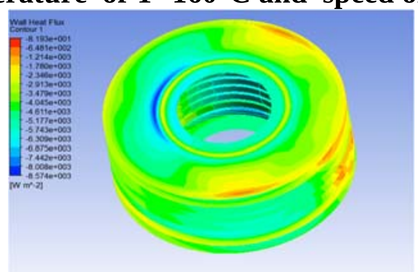

Fig:18 heat flux distribution of triangular profile fins with 6mm pitch at wall temperature of T=160^{0}C and speed of 8m/s

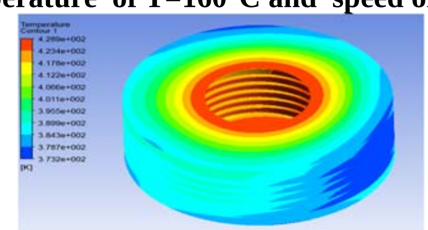

Fig:19 Temperature distribution of triangular profile fins with 6mm pitch at wall temperature of T=160^{0}C and speed of 22m/s

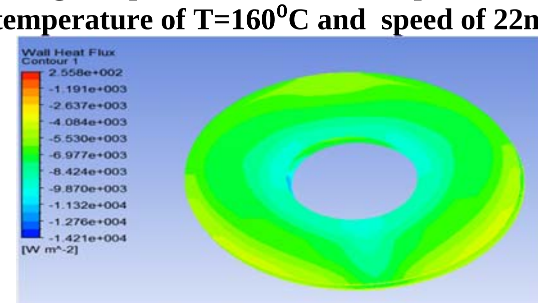

Fig:20 heat flux distribution of triangular profile fins with 6mm pitch at wall temperature of T=160^{0}C and speed of 22m/s

Table2:CFD ANALYSIS RESULTS

DESCRIPTION					CFD-ANSYS RESULTS			
S.NO	Fins array with fin profile	Air flow speed	Pitch (mm)	No of fins	Temperature at the base	Temperature at the tip of	Temperatu	Heat flux (watts/m²)
1	Rectangular profile	8	9	6	160	141	19	4561
2	Triangular profile	8	9	6	160	91	69	8774
3	Rectangular profile	8	6	8	160	141	19	4643
4	Triangular profile	8	6	8	160	123	37	8574
5	Rectangular profile	22	9	6	160	94	66	8684
6	Triangular profile	22	9	6	160	90	70	17730
7	Rectangular profile	22	6	8	160	94	66	9089
8	Triangular profile	22	6	8	160	91	69	14210

Table 3: Experimental Results

DESCRIPTION					EXPERIMENTAL RESULTS			
S.NO	Fins array with fin profile	Air flow speed (m/s)	Pitch (mm)	No of fins	Temperature at the base of the fin(ºC)	Temperature at the tip of the fin (ºC)	Temperature difference (ºC)	Heat flux (watts/m²)
1	Rectangular profile	8	9	6	160	139	21	4682
2	Triangular profile	8	9	6	160	87	73	8876
3	Rectangular profile	8	6	8	160	139	21	4836
4	Triangular profile	8	6	8	160	119	41	8754
5	Rectangular profile	22	9	6	160	91	69	8860
6	Triangular profile	22	9	6	160	88	72	17921
7	Rectangular profile	22	6	8	160	92	68	9216
8	Triangular profile	22	6	8	160	90	70	14324

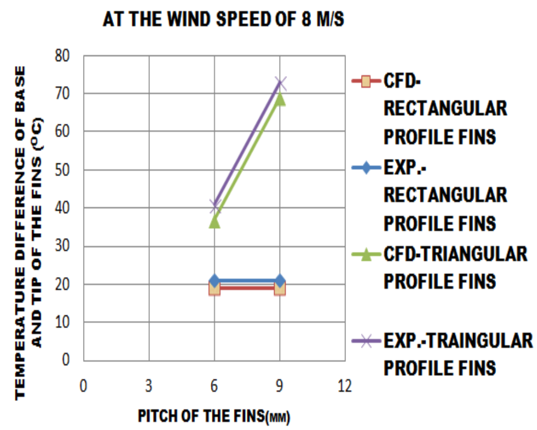

Fig: 21 Graph at the wind speed of 8 m/s.

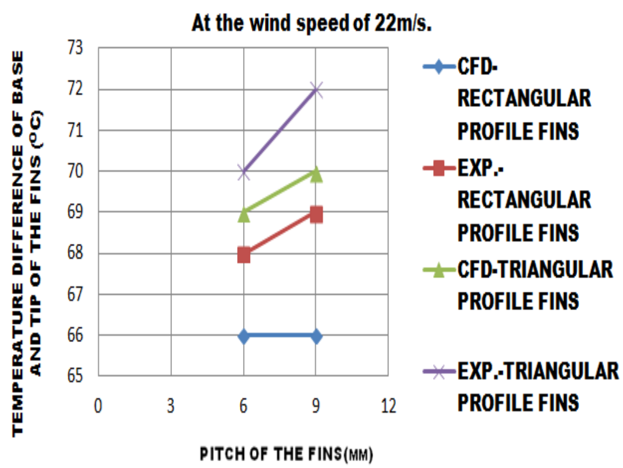

Fig: 22 Graph at the wind speed of 22m/s.

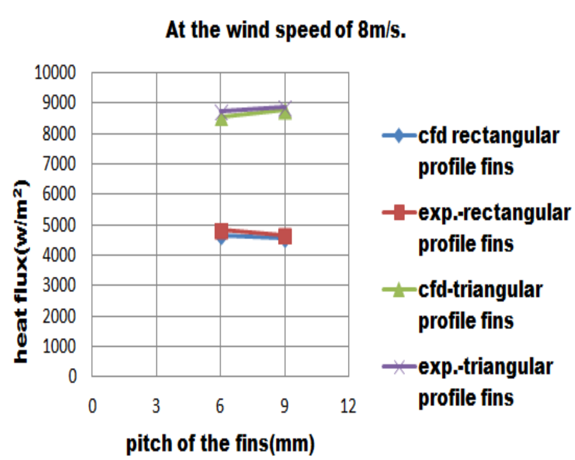

Fig:23 Graph at the wind speed of 8 m/s.

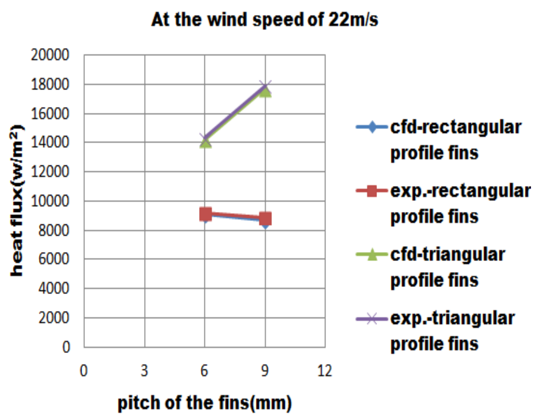

Fig: 24 Graph at the wind speed of 22m/s.

On comparing rectangular and triangular profile fins at the same wind speed and pitch, temperature difference and rate of heat transfer is higher for triangular array of fins. Moreover, triangular profile fins array at same wind speed and different pitch it is observed that the 9mm pitch is optimum compared to 6mm pitch. Finally the CFD analysis results are compared with experimental results obtained by testing the engine cylinder in the test section of the wind tunnel for a wind speed range of 8-22m/s. From the CFD analysis, heat flux is found to be maximum for the triangular profile fins at the wind speed of 22m/s with pitch of 9mm.

VI. CONCLUSIONS

The following conclusions are made after comparative study.

1. The temperature difference and rate of heat transfer is higher for triangular profile fins array compared to rectangular fins array.
2. The triangular profile fins array having pitch of 9mm is found to be optimum.
3. By using triangular fins array the weight of the fins body reduces, and hence the overall load on the engine is also reduced, which contributes to the increase in the efficiency of the system.
4. Hence for the cooling of cylinder block of I.C.engine, circumferential fins array of triangular profile with pitch of 9mm and material aluminum alloy 6061is preferred and recommended based on this research work.
5. The rate of heat transfer is observed to be maximum for the triangular profile fins at the wind speed of 22m/s with pitch 9mm.

REFERENCES

[1]. Deepak Gupta, Wankhade S.R "Design and analysis of cooling fins" (IJMER), ISSN (Print): 2321-5747, Vol 3, Issue 2, 2015, PP:1-4

[2]. Mohsen Torabi, Hessameddin Yaghoobi, Mohammad Reza Kiani "Thermal Analysis of the convective – radiative fin with a step change in thickness and temperature dependent thermal conductivity" Journal of theoretical and applied mechanics 51, 3, PP: 593-602, warsaw 2013

[3]. N. Phani Raja Rao, T. Vishnu Vardhan, "Thermal Analysis of Engine Cylinder Fins by Varying its Geometry and Material", (IJERT), ISSN:2278-0181, Vol. 2, Issue 8, August 2013, PP: 404-412.

[4]. Prabhmeet Singh, K.K. Jain, R.K Dave, Pooja Tiwari, "Comparison of Performance of Different Profiles of Fins using Thermal Analysis", (IJRTE), ISSN: 2277-3878, Volume 4, Issue 1, March 2015, PP: 47-48

[5]. R. Arularasan, P. Hemanandhan, T.Thamizhselvan, B. Arun Kumar, S.Senthilnathan, S, Prathap, "Modeling and Simulation of Engine Cylinder Fins by using FEA", (IJRASET), ISSN: 2321-9653, Vol 2, Issue IV, April 2014, PP:403-408

[6]. P. Sai Chailtanya, B. Suneela Rani, K. Vijaya Kumar, "Thermal Analysis of Engine Cylinder Fin by Varing its Geometry and Material" (IOSR-JMCE), e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 6 ver. I (Nov-Dec 2014) PP: 37-44.

[7]. Esmail M.A Mokheimer, "Performance of Annular Fins with Different Profiles Subject to Variable Heat Transfer Coefficient", International Journal of Heat and Mass Transfer (2002) 3631-3642 (www.elsevier.com/locate/ijhmt)

[8]. Cihat Arslanturk, "Analysis of Thermal Performance of Annular Fins with Variable Thermal Conductivity by Homotopy Analysis Method", Int. Journal

of Thermal Science and Technology, ISSN:1300-3615, © 2010, TIBTD Printed in Turkey.

[9]. Kohei Nakashima, Sumio Teramolo, Yoshio Murakami, Soichi Ishihara and Masago Yamamato, Masao Yoshid, “Improving Cylinder Cooling using Tapered Fins and Baffles Plates between Fins in Air-cooled Engines”, SAE International 2010-01-0323, Published 04/12/2010.

[10]. Syed Khader Basha, Dr. Syed Nawazish Mehdi, Dr. T.K.K. Reddy, “Performance Analysis of Cylinder Cooling of an Air Cooled Engine”, IJLTEMAS, ISSN: 2278-2540, Volume IV, Issue XII, December 2015, PP: 38-40.

[11]. Syed Khader Basha, Dr. Syed Nawazish Mehdi, Dr. T.K.K. Reddy, Analytical comparison of cylinder cooling using rectangular and triangular fins” , IJLTEMAS, ISSN: 2278-2540, Volume V, Issue V, May 2016, PP: 30-32.