Investigation on Thermal Performance of Elliptical Piston Profile in Texvel Diesel Engine

Dr. S. Periyasamy[1] Mr. A. Vadivel[2]
[1,2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]Government College of Technology India

Abstract— Heat transfer is a predominant factor in diesel engines, and it plays a major role in engine performance. Heat transfer occurs in diesel engine from cylinder to its outer casing of the engine. The experiment is conducted in Texvel diesel engine with elliptical piston profile and heat transfer analysis is carried out. This project is carried out by two methods, theoretical approach and numerical simulation. Theoretical approach is done with the calculation of pressure, temperature, and volume at each angle of crank rotation. Finally, the rate of heat transfer is calculated by correlation. Numerical simulation is done by analyzing the elliptical piston profile using ANSYS software. Modeling and heat transfer analysis are performed. Finally, the numerical and theoretical results are compared. On comparison, numerical results are well agreed with the theoretical results.

Key words: Combustion Chamber, Heat Transfer, Temperature Distribution

I. Introduction

Proper design of the combustion chamber is at least as important in the CI engine as in the SI engine. In the SI engine a nearly homogeneous mixture inters the cylinder, is compressed, and the ignited by means of a spark plug. The fuel and air are mixed in the carburetor. In the CI engine, on the other hand, only the air is compressed in the cylinder, and the fuel is injected during a period of 30 to 35 degrees of crank angle. In this short period of time, the fuel and air must be mixed. In essence, the mixing portion of the SI engine. Consequently, the combustion chamber in a CI engine must design to provide for this mixing of fuel and air.

The introduction of turbulent air in the chamber tends to sweep away any stagnant layers of gas near the walls of the combustion chamber. Removing this insulator caused higher heat transfer from burning gases to the chamber walls, and tends to reduce the temperature within the chamber.

Another factor entering into the transfer of heat to the cylinder walls is the surface to volume ratio of the combustion chamber. As the surface area of the chamber increases, the gases are exposed to a greater cooling area. The larger S/V ratio is an indication of the cooling that might be expected from a given combustion chamber. The performance of a CI engine can be improved by removing water (or) air cooling, thus the combustion chamber surface temperature increases to a greater extend. This can be achieved by maintaining the combustion chamber surface completely adiabatic (or) insulating.

A. Heat Transfer Analysis

The experimentation is carried out on a Texvel engine single cylinder four stroke, water cooled engine in a rope brake, which is used for carrying out experimentation. Initially the engine is started by cranking in proper direction and the decompression lever is used for easy cranking. The engine is allowed to run to attain the steady state. At each load and at rated speed (1500 RPM) the time taken for 25cc of fuel consumption is noted. Then the load is applied in percentage of maximum load. Governor adjustments are made in order to maintain the constant speed of the engine at each load. The performance tests are carried in Texvel single cylinder diesel conventional engine. The engine details, apparatus required and experimental procedure are given below. The performance parameters are calculated for a combustion chamber with the help of required formulae and calculations are tabulated.

The standard test procedure with all precautions is used and performance test is carried out. The time taken for the consumption of 25cc of fuel and exhaust valves is noted.

The brake power, total fuel consumption, specific fuel consumption, indicated power, mechanical efficiency, brake thermal efficiency, indicated thermal efficiency, brake mean effective pressure and indicated mean effective pressure are all calculated for the observed values.

II. Result and Discussion

A. Experimental Results – Graphs

1) Elliptical Piston Profile

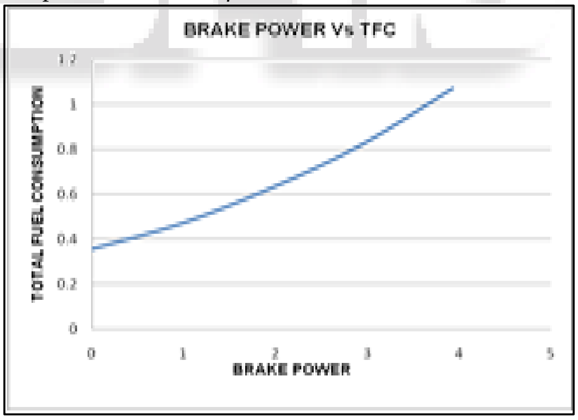

Fig. 1: Variation of BP Vs TFC

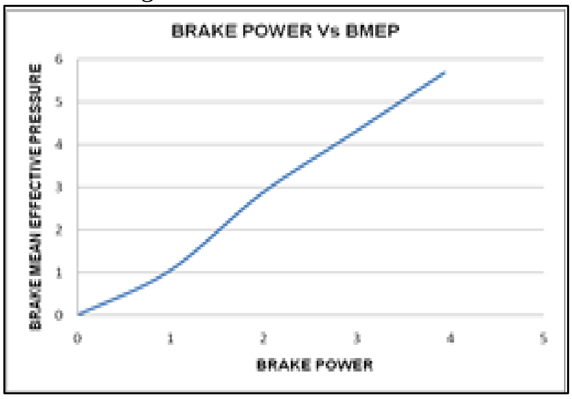

Fig. 2: Variation of BP VS BMEP

B. Theoretical Results – Graphs

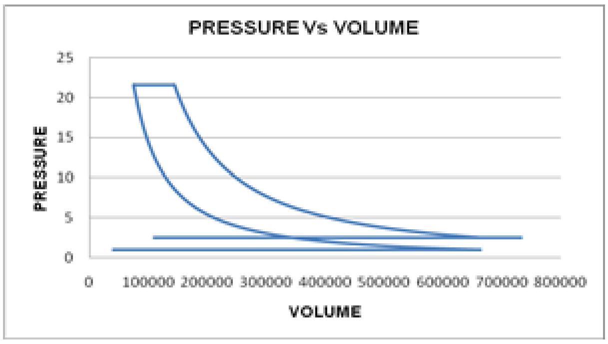

Fig. 3: Variation of Volume Vs Pressure

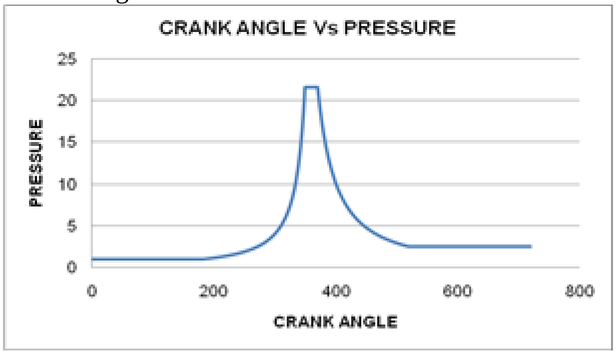

Fig. 4: Variation of Crank Angle Vs Pressure

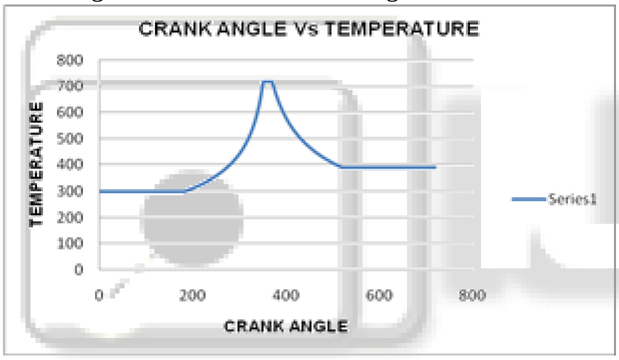

Fig. 5: Variation of Crank Angle Vs Temperature

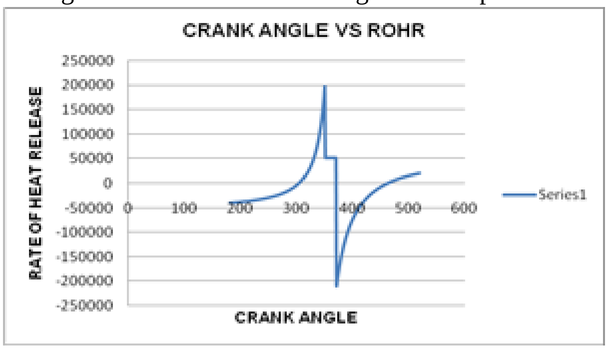

Fig. 6: Variation of CRANK ANGLE Vs ROHR

C. Combustion chemical formula for diesel engine

The stoichiometric equation with 100% theoretical air:

$$C_{10.8}H_{18.7} + 27.96\,(O_2+3.76N_2) \rightarrow 10.8CO_2+9.35H_2O+12.48O_2+105.12N_2$$

The combustion equation with percentage of excess air:

$$C_{10.8}H_{18.7} + (27.96 \text{ x } Air_{ex})\,(O_2+3.76N_2) \rightarrow 10.8CO_2+9.35H_2O+(Y)\,O_2+(Z)\,N_2$$

D. Adiabatic Flame Temperature for Applied Load of 5 Kg

By interpolation, the adiabatic flame temperature is 1150K.

E. ANSYS Results

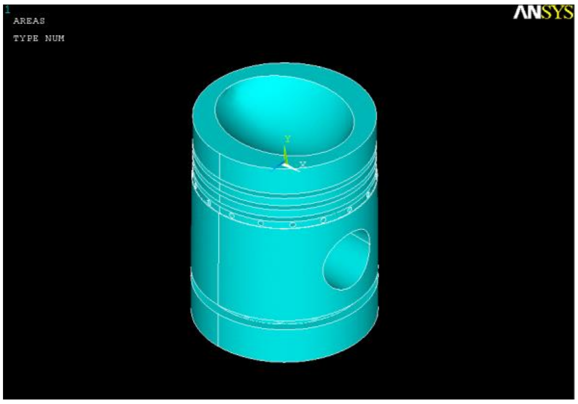

Fig. 7: Modeling View of an Elliptical Piston Profile

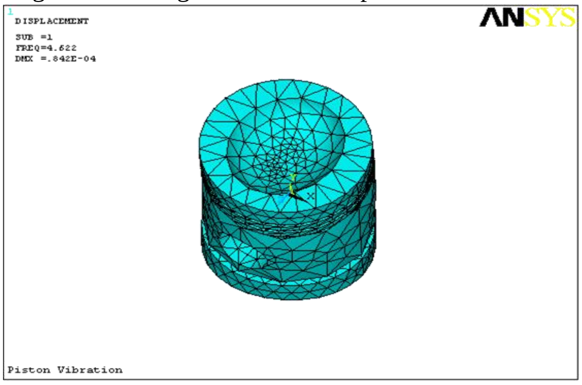

Fig. 10: Meshing View of an Elliptical Piston Profile

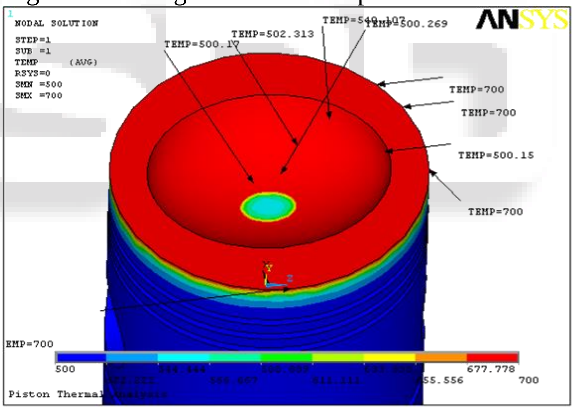

Fig. 11: Thermal Temperature Analysis View of an Elliptical Piston Profile

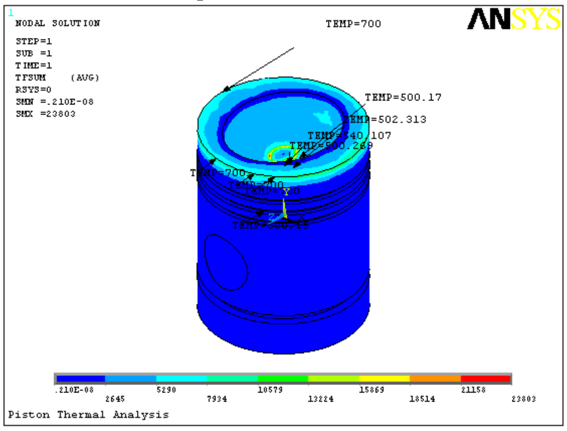

Fig. 12: Temperature Gradient Analysis View of an Elliptical Piston Profile

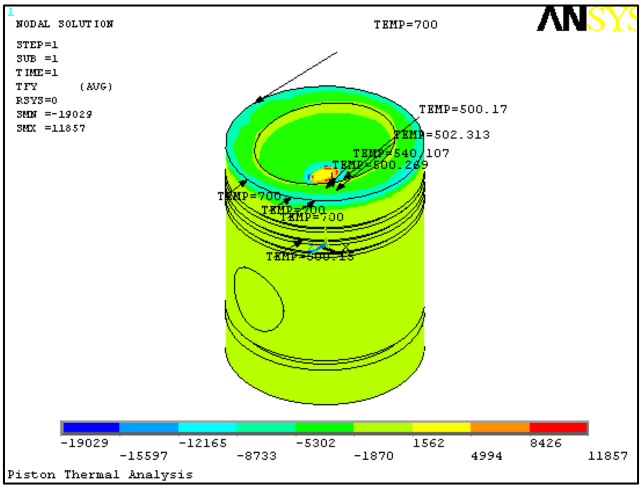

Fig. 13: Heat Flux Analysis View of an Elliptical Piston Profile

	Temperature (K)
Minimum	500
Maximum	700

Table 1: Elliptical Piston Profile – Temperature Distribution: Temperature

	X	Y	Z	Vector Sum
Minimum	-65.59	-55.24	-50.62	1.052e-011
Maximum	55.3	100.2	66.88	125.3

Table 2: Elliptical Piston Profile – Temperature Gradient

	X	Y	Z	Vector Sum
Minimum	-1.051e+004	-1.903e+004	-1.271e+004	2e-009
Maximum	1.246e+004	1.05e+004	9619	2.38e+004

Table 3: Elliptical Piston Profile – Heat Flux:

III. Conclusion

In this project, heat transfer in an elliptical piston is analyzed. Here two methods are used for finding the temperature distribution. Theoretically, calculation of pressure, temperature and volume at each crank angle of rotation is done. Experiment is conducted on Texvel Engine to acquire the necessary data. From this adiabatic flame temperature is calculated.

Heat transfer analysis is carried out in ANSYS. Adiabatic flame temperature obtained from the theoretical calculation is used for analysis. In ANSYS, the temperature distribution along the elliptical piston is found. It has been noted that the theoretical values are well agreed with the ANSYS results.

References

[1] W.H.Kurniawan, S.Abbullah, A.Shamsudeen, 2007, "Turbulence and Heat Transfer Analysis of Intake and Compression Stroke in Automotive 4-stroke Direct Injection Engine", Algerian Journal of Applied Fluid Mechanics, Vol 1.

[2] J.Galinda, J.M. Lujan, J.R.Serrano, V.Dolz, S. Guilain, 2006, "Description of a heat transfer model suitable to calculate transient processes of turbocharged diesel engines with one-dimensional gas-dynamic codes", Applied Thermal Engineering 26 , page no:66-76..

[3] Pin Zeng and Dennis N. Assanis, March 8-11, 2004, "Cylinder Pressure Reconstruction and its Application to Heat Transfer Analysis", 2004 SAE World Congress, Detroit, Michigan.

[4] C.D.Rakopoulos, K.A.Antonopoulos, D.C. Rakopoulos, E.G.Giakoumis, 26 2006, "Study of combustion in a divided chamber turbocharged diesel engine by experimental heat release analysis in its chambers", Applied Thermal Engineering, page no: 1611-1620.

[5] Internal Combustion Engines, Paul W. Gill, Commander, United States Navy.

[6] Internal Combustion Engines, J.B. Heywood.

[7] Ing. Marcel Divis, Department of Automotive and Aerospace Engineering, Josef Bozek Research Center, Czech Technical University in Pague.

[8] Christopher M.Atkinson, Sorin Petreanu, N.Clark, 1999, "Numerical Simulation of a Two-Stroke Linear Engine-Alternator Combination" SAE Technical paper series.

[9] T.Morel, R.Keribar, 1990, "Detailed Analysis of Heat Flow Pattern in a Piston", International Symposium Comodia.

