INTERNATIONAL JOURNAL OF AUTOMOTIVE SCIENCE AND TECHNOLOGY
2017, Vol. 1, No: 3, 8-11
www.dergipark.gov.tr/ijastech

Temperature Distribution Measurement on Combustion Chamber Surface of Diesel Engine -Experimental Method

Shivakumar Nagareddy

Automobile Engineering Department, Karpaga Vinayaga College of Engineering and Technology, Chennai, India

Abstract

Combustion chamber modification in diesel engine is much important than petrol engine, because the combustion chamber profile imparts squish and swirl effects for better mixing of air and fuel. While modifying the profile of combustion chamber of diesel engine, it is important to relocate the hot spot regions on the combustion chamber surface which supports combustion initiation. With these hot spot regions on combustion chamber surface regulates/controls ignition delay period which results in controlled detonation. In diesel engines, controlled detonation which in turn improves engine performance and reduced emissions. Therefore, to include the hot spot regions at proper locations, it is required to measure the temperature values at different locations/coordinates with the help of thermocouples on the surface exposed to combustion chamber.

Keywords: *Temperature Distribution, Diesel engine combustion chamber, Temperature on cylinder head.*

* Corresponding author
Shivakumar Nagareddy
Shivaç.termal@gmail.com
Adress: Automobile Engineering Department, Karpaga Vinayaga College of Engineering and Technology, Chennai, India
Tel: +919042041088.

Manuscript Received 13.09.2017
Revised 28.12.2017
Accepted 28.12.2017

1. Introduction

Diesel engines are being extensively used for rail and road transportation, agriculture applications and power generation. Increasing demand and depleting fossil fuels have lead to research and development on production of energy efficient engines. Minimizing the energy losses in the engine definitely improves the power output and efficiency of the engine. In order to improve that performance of the engine, many experimental and theoretical investigations have been carried out elucidating the heat transfer characteristics of compression ignition engines. 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 enters 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 carburetor's duties is performed within the combustion chamber in a CI engine. Consequently, the combustion chamber in a CI engine must be designed to provide for this mixing of fuel and air.

NO_x emission increases with increase in in-cylinder temperature and the peak NO_x level occur at combustion peak temperatures which occur between start of combustion and in-cylinder peak pressure [1].

Burned zone temperature (localized in-cylinder temperature) is significantly higher than the global/average in-cylinder temperature during the combustion. The reason for this significant difference is due to localized phenomenon i.e., the in-cylinder temperature varies with respect to spatial coordinates in the combustion chamber [2].

The combustion temperature was not sufficiently high to make soot inception or to continue their growth in most regions, except for several high-temperature regions. This is analogous to the inverse diffusion flame, where the nascent soot particles can be transported away from the flame front by thermophoretic force toward lower temperature regions [3-6]. It is noted that an individual soot particle experiences the process of evolution and oxidation along the diesel spray flame axis and in the radial direction during conventional diesel combustion [7, 8], even though partially premixed combustion could be achieved in low temperature combustion.

NO_x forms in the lean mixture zone where flame temperature is above 2200 K, whereas soot forms in the rich mixture zone above 1800 K. Conventional combustion overleaps the formation zones of NO_x and soot, but LTC techniques like HCCI and PCCI avoid these zones and reduce NO_x and soot simultaneously [9-11]. Interestingly they observed that even on higher EGR, higher biodiesel content showed lowest ignition delay and they suggested that ignition delay relied more on chemical kinetics mechanism than the temperature reduction made by EGR. However, shorter ignition delay may also produce less NO_x if the ignition delay is short enough to make a weak mixture [12]. Exergy destruction rate increased with increasing the dead state temperature [13].

2. Temperature Measurement

Thermocouple used for the measurement of temperature on the cylinder head surface exposed to combustion chamber is based on its operating range and compression fitting. The Cromel/Alumel is the thermocouple material selected for the measurement of temperature and its maximum operating range is 1300˚C. The description of the Cromel/Alumel2 thermocouple is as follows:

Type : Transition K-type
Gas Model : HT-04
Protective Tube : MI SS316
Dimension in mm : OD-4mm, L-150mm
Cable : Braided, Size-7*36, L-1m
Compression Fitting : Adjustable SS Ferrule Lockable
having thread M10*1
Termination Style : Pin type lugs
Accuracy Standard : IS2054
Operating Temperature : 0 to 1300˚C

Fig. 1. K-type, Compression Fitting Alumel-Cromel Thermocouple.

3. Experimental Work

Kirloskar Diesel Engine is chosen for combustion chamber modification/temperature distribution measurement on cylinder head surface.

Engine Specifications:

B.H.P : 5 hp
Speed : 1500 rpm
Bore : 80 mm
Stroke: 110 mm
Type : Single Cylinder 4S Diesel Engine
Fuel : Diesel
Loading Type : Rope Brake Loading
Cooling Type : Water Cooling

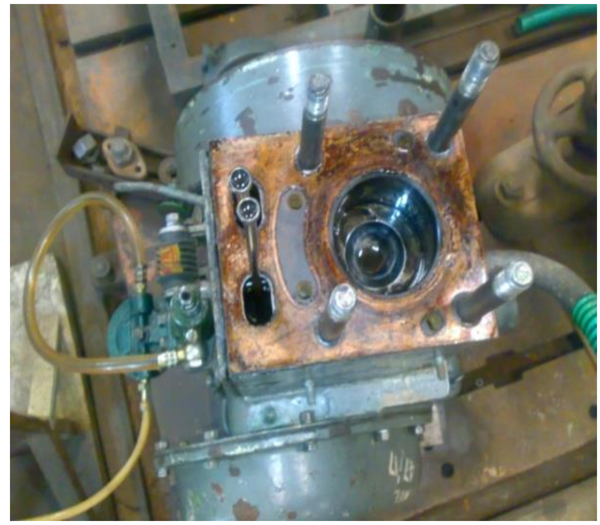


Fig. 2. Kirloskar Diesel Engine.

To install/fit the thermocouples through cylinder head which is incorporated with water jacket, provisions for inlet and exhaust manifolds, valves, push rods, fuel injector and foundation bolts, CAD model was done in which the paths were found for fixing thermocouples with any restrictions with respect to compression leakage from engine cylinder and water leakage from water jacket. The CAD model of piston, cylinder liner and cylinder head with fuel injector and valves assembly as shown in figure-3 below.

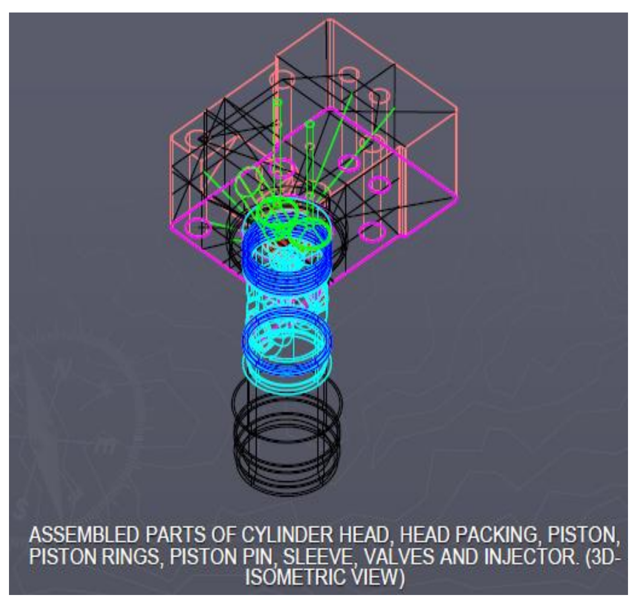


Fig. 3. CAD Model (Wireframe) of piston, cylinder head and cylinder sleeve assembly.

The cylinder head with fabricated sleeves for fixing thermocouples is as shown in fig-4.

Fig. 4. Cylinder Head with fabricated sleeves for fixing thermocouples.

Figures 5 and 6 show the cylinder head fitted with thermocouples through sleeves fabricated.

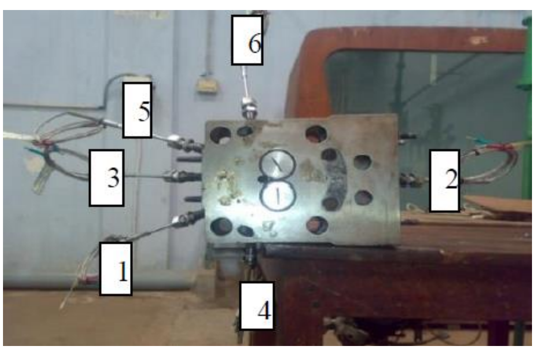


Fig.5. Cylinder Head with Fitted Thermocouples.

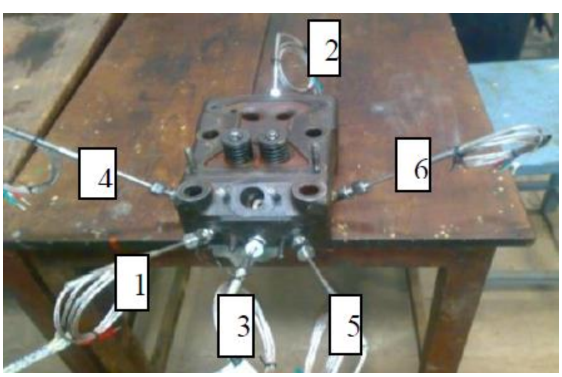


Fig. 6. Cylinder Head with Fitted Thermocouples.

Finally, the installed thermocouples with Kirloskar diesel engine is tested for temperature measurement over cylin der head surface exposed to combustion chamber. The engine with installed thermocouples is as shown in figure-7 below.

Fig. 7. Kirloskar Diesel Engine with installed Thermocouples.

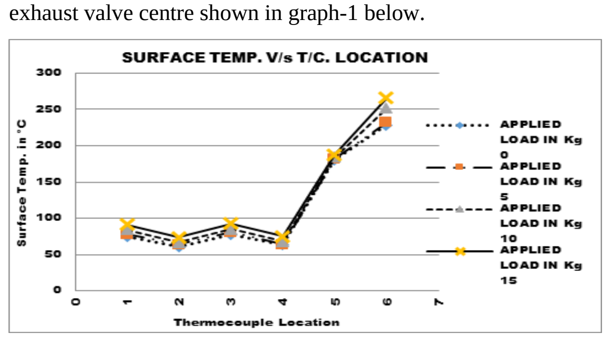
4. Results and Discussion

The measured values of temperatures on cylinder head surface at different loads of 0 kg, 5 kg, 10 kg and 15 kg using thermocouples with their locations from the exhaust valve centre were tabulated as shown below.

Table 1. Measured values of Temperatures at different loads using thermocouples and their locations from exhaust vale centre.

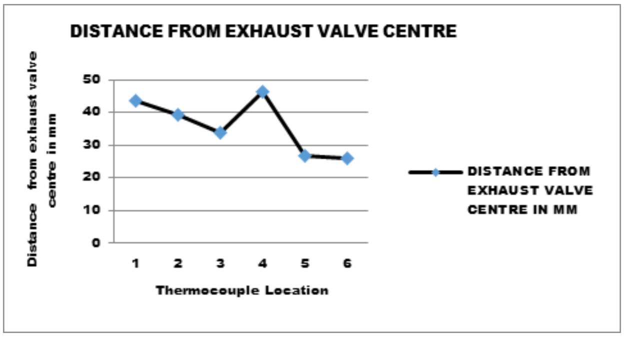
Applied Load in kg	T/C. Location-1	T/C. Location-2	T/C. Location-3	T/C. Location- 4	T/C. Location-5	T/C. Location-6
0	75	61	78	63	181	228
5	78	64	81	64	182	232
10	84	67	85	68	184	252
15	91	74	93	75	188	266
Distance From Exhaust Valve Centre in mm	43.7925	39.4924	33.6987	46.5321	26.6946	25.9921

The measured values of temperature at different loads of 0 kg, 5 kg, 10 kg and 15 kg are plotted with respect to their positions from the exhaust valve centre shown in graph-1 below.



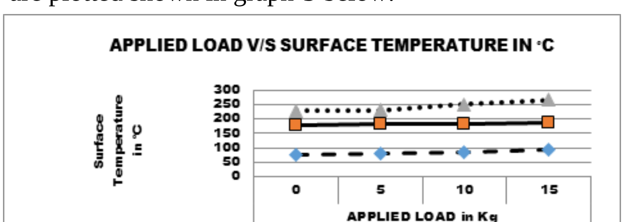
Graph. 1. Measured Temperature Values at different loads 0 kg, 5 kg, 10 kg and 15 kg.

The positions of various thermocouples from exhaust valve centre are plotted with graph-2 as shown below.



Graph 2. Distance of Thermocouple points from Exhaust Valve Centre.

From the above graph, it is clear that the thermocouple locations 3, 5 and 6 are nearest to the exhaust valve centre and the measured values of temperature at these locations for different loads of 0 kg, 5 kg, 10 kg and 15 kg are plotted shown in graph-3 below.



	0	5	10	15
T/C. LOCATION-3	78	81	85	93
T/C. LOCATION-5	181	182	184	188
T/C. LOCATION-6	228	232	252	266

Graph 3. Measured Temperature Values from Thermocouple locations-3,5 and 6 for different applied loads of 0 kg, 5 kg, 10 kg and 15 kg.

4. Conclusions

From the obtained values of temperature on cylinder head surface exposed to combustion chamber of diesel engine, it is possible to modify the surface profile of combustion chamber by imparting the hot spot regions at proper locations which support complete combustion in order to improve its performance and also to control/reduce the harmful emissions from diesel fuel combustion. Also the modified profile of combustion chamber impart swirl and squish effects by keeping in mind the hot spot regions, results in better performance and reduction in harmful emissions.

References

[1] Heywood JB. Internal combustion engines fundamentals. New York: McGraw-Hill, Inc; 1988.

[2] Venkateswarlu Chintala, K.A. Subramanian, CFD analysis on effect of localized in-cylinder temperature on nitric oxide (NO) emission in a compression ignition engine under hydrogen-diesel dual-fuel mode, Energy 116 (2016) 470e488.

[3] Blevins LG, Fletcher RA, Benner Jr BA, Steel EB, Mulholland GW. The existence of young soot in the exhaust of inverse diffusion flames. Proc Combust Inst 2002; 29:2325–33.

[4] Lee EJ, Oh KC, Shin HD. Soot formation in inverse diffusion flames of diluted ethene. Fuel 2005; 84:543–50.

[5] Oh KC, Lee UD, Shin HD, Lee EJ. The evolution of incipient soot particles in an inverse diffusion flame of ethene. Combust Flame 2005; 140:249–54.

[6] Jung Y, Oh KC, Bae C, Shin HD. The effect of oxygen enrichment on incipient soot particles in inverse diffusion flames. Fuel 2012; 102:199–207.

[7] Dec JE. A Conceptual model of diesel combustion. SAE technical paper 970873; 1997.

[8] Kosaka H, Aizawa T, Kamimoto T. Two-dimensional imaging of ignition and soot formation processes in a diesel flame. Int J Engine Res 2005; 6:21–42.

[9] Nieman DE, Dempsey AB, Reitz RD. Heavy-duty RCCI operation using natural gas and diesel. SAE International Journal of Engines 2012; 5:270–85.

[10] Splitter DA. High efficiency RCCI combustion. United States – Wisconsin: The University of Wisconsin – Madison; 2012. p. 320.

[11] Splitter D, Hanson R, Kokjohn S, Reitz R. Reactivity controlled compression ignition (RCCI) heavy-duty engine operation at mid-and high-loads with conventional and alternative fuels. SAE technical Paper 2011–01-0363; 2011.

[12] Zheng M, Mulenga MC, Reader GT, Wang M, Ting DSK, Tjong J. Biodiesel engine performance and emissions in low temperature combustion. Fuel 2008; 87:714–22.

[13] Hakan Caliskan , Mustafa Ertunc Tat , Arif Hepbasli, Performance assessment of an internal combustion engine at varying dead (reference) state temperatures, Applied Thermal Engineering 29 (2009) 3431–34.