Materials and its Characterization

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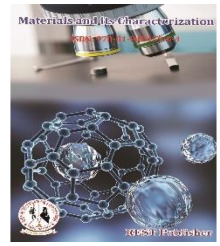


Combustion and Emission Characteristics of a Redesigned Piston in an Ethanol-Fueled IDI Diesel Engine

D. S. Manoj Abraham

Associate Professor, PSN Engineering College, Tirunelveli, Tamilnadu, India.

*Corresponding Author E-Mail: manoth_333@rediffmail.com

Abstract: *Compression ignition engines with ethyl alcohol as a fuel are associated with some problems. Because of ethyl alcohol has high self ignition temperature. It can be used in compression engine by hot surface ignition method which is used to resolve the ignition of the fuel. The modification of the engine is carried out in such a way that a pre combustion chamber is designed in engine head with a provision for heat plug is made on the pre combustion chamber. A piston with squish plate is designed and thermally analyzed. The squish piston helps for attaining better homogeneous mixture than conventional piston. Thus the better combustion is obtained with the squish piston resulting with higher adiabatic flame temperature than the conventional piston. When air is inducted into the combustion chamber it is exposed to high temperature. Modifications for pure ethyl alcohol made significant improvement in thermal efficiency, torque and reduction in specific fuel consumption of an engine. The results exhibit a path toward ethyl alcohol has an effective alternative to conventional diesel engines.*

Keywords: *Ethyl alcohol, Squish, Emissions, Combustion.*

1. INTRODUCTION

In recent days it was shown that the fast growing need of investigations and technical and development to use alternative fuels in the present power system. Both in vehicular and stationary application a substantial number of different approaches can be seen in many places in the world [1]. The single most important force propelling system fuels development is the rapid escalation of prices of oil on the international crude market and continued uncertainty regarding future prices in addition to the rapid drain by way of consumption [2]. Therefore the whole world has little choice but to pursue alternative fuel. Clearly the need in most countries is to develop substitutes for oil or oil-derived products. However what form of fuel substitute is most appropriate will depend on several factors specific to a given country [3, 4]. Alcohols are the most preferred alternative fuels, because that can be produced from various resources [5]. There are several methods by which alcohols can be used in diesel engines. Ethyl alcohol is one of the best fuels to replace the diesel in C.I engines. Sugar corn barley are raw materials of the ethyl alcohol. Since 1970's the usage of ethyl alcohol in the diesel engines have been studied [6-8]. The early experimentations were focused on reduction of CO_2 life cycle and particle levels. Ethyl alcohol is an assured oxygenated fuel. In compression ignition engines the ethyl alcohol can be used in the form of alcohols-diesel blend (mixture of the fuels prior to injection) fumigation of alcohols (injection of alcohols into the intake air charge), alcohols-diesel emulsion (emulsifier can be used to mix the fuels) and dual injection (each fuel has separate injection systems) [9-11].The cold starting problems avoided by the hot surface assisted ignition concept. This concept has been introduced particularly for the low cetane fuels like ethyl alcohol. The hot surface provides sufficient local ignition condition and establishes a stable diffusion flame [12, 13]. The geometry of the piston is an act important role on heat transfer of diesel engine. These types of pistons are generally used in direct injection engines. The air and fuel mixes very well in a squish model piston than a conventional type of piston. The main function of squish in a piston is creating turbulence [14].

TABLE 1. Comparison of ethyl alcohol properties with Diesel

Properties	**Diesel**	**Ethyl alcohol**
Air fuel ratio, by weight	14.5	**9.0**
Calorific Value (MJ/kg)	45	**27**
Cetane number	52	8
Viscosity at 40°C (centipoises)	1.45	0.83
Self-ignition temperature(K)	665	695
Octa ne num ber	-	110

The key function of the squish piston is to enhance the turbulence in the combustion chamber. This increase the gas to surface heat transfer rate. The producing of turbulence depends on the piston movement. The squish motion makes the air and fuel mixture to move towards the cylindrical axis [15].

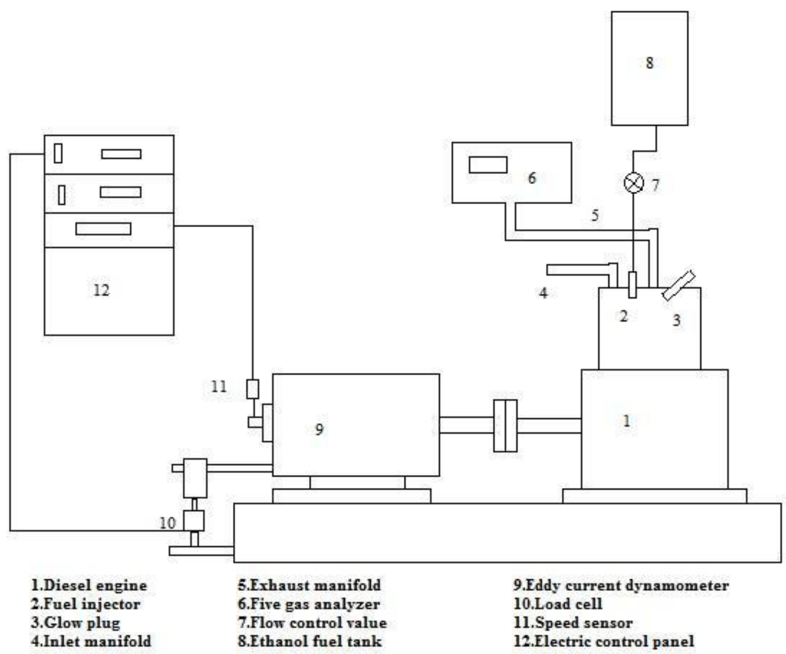


FIGURE 1. Schematic diagram of experimental setup

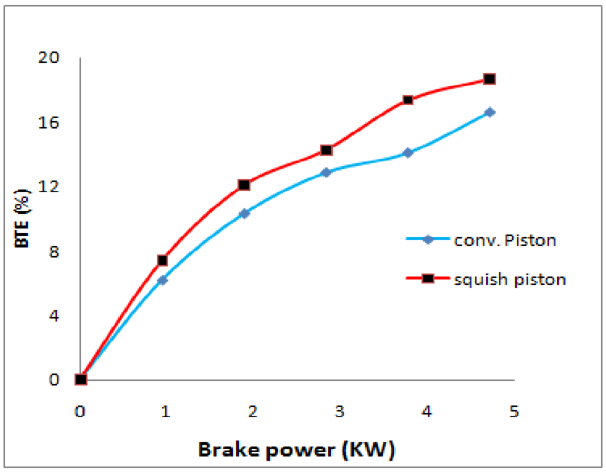
EXPERIMENTAL SETUP

Experiments were conducted on a single cylinder, direct injection compression ignition engine. The bore, stroke and displacement volume of the engine are 95mm, 110mm and 780cc respectively. Fig.1. showed the schematic representation of the experimental setup. The rated output of the engine is 5.9 kW at 1500 rpm and its compression ratio is 14:1. This engine has a 3-hole injection nozzle and its opening pressure is 20 MPa at 27° before top death centre. A heat plug was installed in the pre-combustion chamber which is used to ignite the fuel and it gets power from a 12 V battery. An eddy current dynamometer and electrical control panel were coupled with the engine. The load cell is used to sense the applied load to the engine. Speed of the engine measured by speed sensor. The fuel consumption of the engine was calculated with the aid of stop watch and burette. The emissions were started to measure from equilibrium state of coolant and exhaust temperature. Emissions were measured by crypton five gas analyzer in which flame ionization detector (FID) is used to measure the hydrocarbon, CO and CO2 were measured by non-dispersive infra-red analyzer (NDIR) and nitrogen oxides were analyzed by Chemi-luminescent detector (CLD).

3. RESULTS & DISCUSSION

A. Performance Characteristics

Figure 2 shows the brake thermal efficiency variation with respect to load for conventional piston and squish piston. Brake thermal efficiency determines the performance of the engine for the specific fuel. It actually means conversion efficiency of chemical energy into heat energy by the engine and to recover all the heat, without



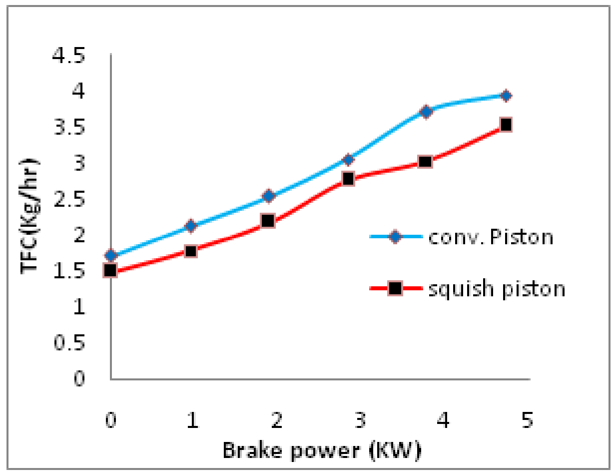
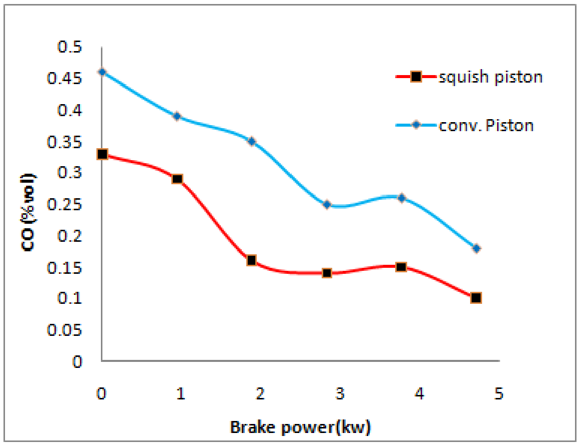


FIGURE 2. Variation of brake thermal efficiency with BP **FIGURE 3.** Variation of total fuel consumption with BP

wasting it to surroundings. The brake thermal efficiency of the squish piston is higher than the conventional piston due to the improved power output due to better combustion. From figure 3 indicates the quantity of fuel consumed for a particular period of time and for a particular load. The total fuel consumption increase with increase in brake power, because we know that calorific value of ethyl alcohol is low. The total fuel consumption of the squish piston is lower than the conventional piston due to the proper utilization of fuel by better combustion.*B. Emission Characteristics*

Exhaust emission characteristic of the engine for various loads were analyzed using a CRYPTON Exhaust Gas Analyzer. To measure emissions a probe inserted into the exhaust pipe of the engine and another end of the probe is connected into the exhaust gas analyzer. Various exhaust emissions HC, CO, CO2, and also O2 can be measured by the analyzer and results are plotted as graph.

Carbon monoxide emission is potentially hazardous; it should be reduced by using the fuels having oxygen content to oxide the carbon monoxide into carbon-di-oxide. The carbon monoxide emission is lower for squish piston this is due to the promotion of combustion process and more conversion of carbon to carbon di oxide. HC emissions decreased with increasing engine load. Above 65% load emissions continue to decrease for both squish and conventional piston. On comparison squish piston shows lower hydrocarbon emissions due to the better mixing of fuel with air leads to comparatively higher homogenous mixture. This figure shows the nitrous oxide emission variation with brake power of the engine. Since squish piston provides better combustion, this leads to higher peak temperature. Thus squish piston shows more nitrous oxide emissions comparing to conventional piston.



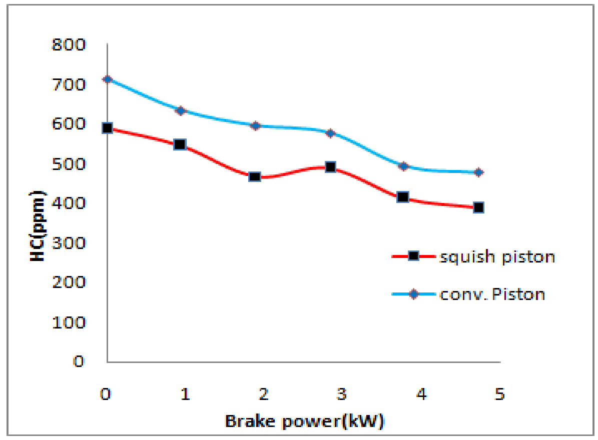
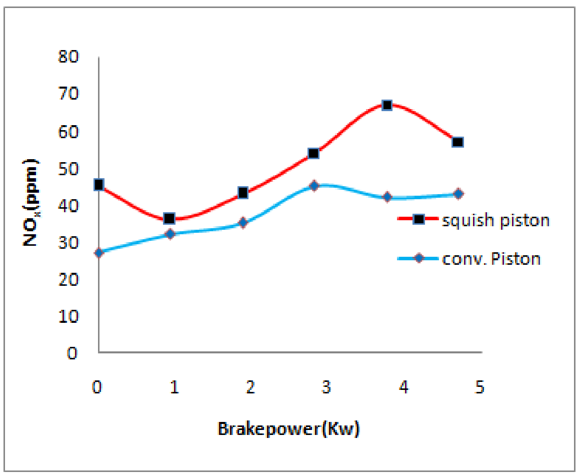


FIGURE 4. Variation of CO with increase in BP **FIGURE 5.** Variation of HC with increase in BP.



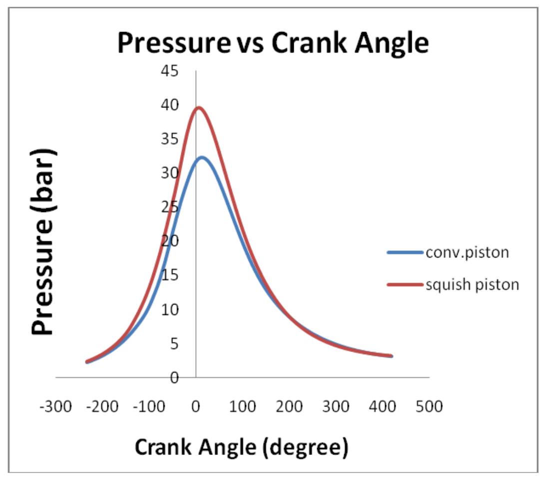
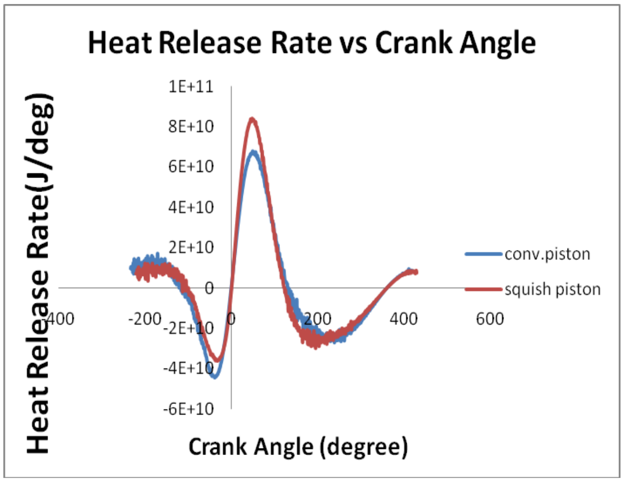


FIGURE 6. Variation of Nitrous oxide with increase in BP. **FIGURE 7.** Variation of cylinder pressure with increase crank angle.

Combustion Characteristics The variation of combustion pressure with respect to crank angle for different piston geometries are shown in fig.7. It has been observed from the figure that the variation of cylinder pressure differs between squish and conventional piston. This due to the faster and complete combustion of fuel inside in the combustion chamber in case of squish piston. The variation of heat release rate with respect to crank angle for different piston geomentries are shown in fig.8 & 9. It has been observed that the heat release rate increases with squish piston and slightly decreased in case of conventional piston. This may be due to the good air-fuel mixture and increase in the combustion temperature with squish piston.



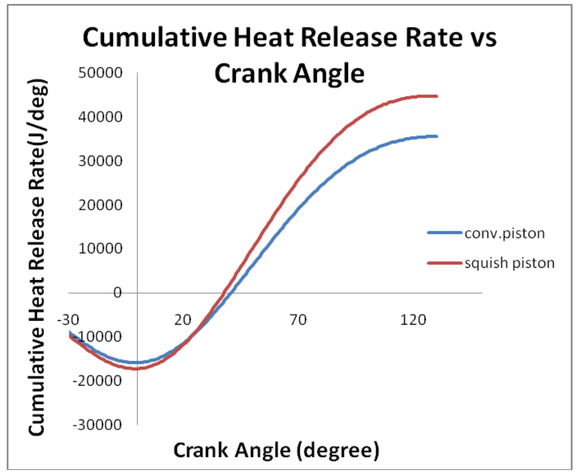


FIGURE 8. Variation of heat release rate with increase crank angle. **FIGURE 9.** Variation of cumulative heat release rate with increase crank angle.

4. CONCLUSION

The following results were obtained at from the experimental investigations carried out for the various modes of operation using ethyl alcohol. Heatplug assisted prechamber with squish piston ethyl engine gave the high brake thermal efficiency attains 18% at 75% load. The total fuel consumption with ethyl alcohol in squish piston was the lowest. Squish piston shows a higher exhaust temperature than the conventional piston. Hydrocarbon emission is reduced by 10% in case of squish piston than the conventional piston Among the various types of operation, it is inferred that, ethyl alcohol with heatplug assistance in prechamber squish piston has better performance characteristics.

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