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EXPERIMENTAL INVESTIGATIONS OF VARIOUS MODES OF CHARGING ON HCCI ENGINE

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Abstract

Homogeneous Charged Compression Ignition technology is most favourable or suitable for Internal Combustion engines for reducing the exhaust emissions and enhances the Thermal efficiency, improve the fuel consumption, and increase the rate of combustion. This article represents the various charging methods on HCCI technology engine; it improves the engine performance and determines the emission characteristics of HCCI technology engine. The homogeneous mixture prepared with different methods. In –cylinder internal homogeneous mixture preparation method applied in this present work. It reduces the exhaust emissions released from the combustion chamber. However, oxides of nitrogen and soot emissions are significantly reduce, because combustion starts at lower temperatures and various points in combustion chamber.

The HCCI technology generates small amount of exhaust emissions and it improves the performance of the engine. In addition, performance and released emissions depends on the quality and quantity of homogeneous mixture.

Keywords: *HCCI technology, homogeneous mixture, thermal efficiency, combustion rate, emissions*

1. Introduction

Most of the Automobiles and Industries depend on the fossil fuels. Actually, engine is a device; it transforms energy from one form to another form. The thermal energy is converted into mechanical energy, it is known as Heat Engine. Basically, heat engines are classified as Internal Combustion engines and External Combustion engines. Compared to External combustion engines, Internal combustion engines performs the better thermal efficiency, less amount of fuel consumption and reduces the exhaust emissions [1]. Therefore, Internal Combustion engines are preferred. These are classified as Rotary type and Reciprocating type engines. The open cycle gas turbine and wankel engines are the examples of rotary type engines. The Gasoline and diesel engines are the examples of reciprocating type engines. The higher thermal efficiency can be obtained at moderate working pressures in IC engines. The capacity of internal combustion may be defined as the displacement volume multiplied by the number of cylinders. The compression ratio of IC engines varies from 16 to 20. In internal combustion engines air is inducted in suction, by the piston movement air is compressed in cylinder [2-3]. At the end of compression stroke, the fuel starts combustion in combustion chamber. With the high-pressure fuel pump and injector, automatically starts combustion in engine. It generates the large amount exhaust emissions are oxides of nitrogen and particulate matters, large fuel consumption and lower thermal efficiency.

To overcome the difficulties (or) drawbacks of internal combustion engines, Homogenous Charged Compression Ignition technology efficiently used. It generates fewer amounts of exhaust emissions and improves the performance of the engine. It is the most promising technology for internal combustion engines and spark-ignition engines and also efficiently control of emissions and environmental pollution in next generations. In this technique, both fuel and air injected during suction [4]. Therefore, starts combustion at lower temperatures and mixture ignites number of unknown places volumetrically entire engine cylinder. When, the combustion starts at lower temperatures, the small amount of exhaust emissions are generated. The fuel ignites more than one area in cylinder, the formation of Particulate Matters are reduces. It is significantly reduces the Oxides of Nitrogen and PM matters. It is efficiently suitable for small size to large size applications. Homogeneous Charged Compression Ignition also applied on Spark Ignition engines [5].

2. Homogeneous Mixture Preparation

The Homogeneous mixture can be prepared either internally and externally. In internal preparation method, the homogeneous mixture (fuel and air) prepared with in the engine cylinder and external preparation method homogeneous mixture prepared outside the engine cylinder. Internal preparation method a modification needed at engine inlet. In external preparation method, arrange the fuel injector at head instead of direct ignition concept [6-8]. In external preparation method large amount of mixture easily prepared before combustion in cylinder compared with the internal preparation method. It is most suitable for gasoline fuels. Port fuel injection method is example of external preparation method.

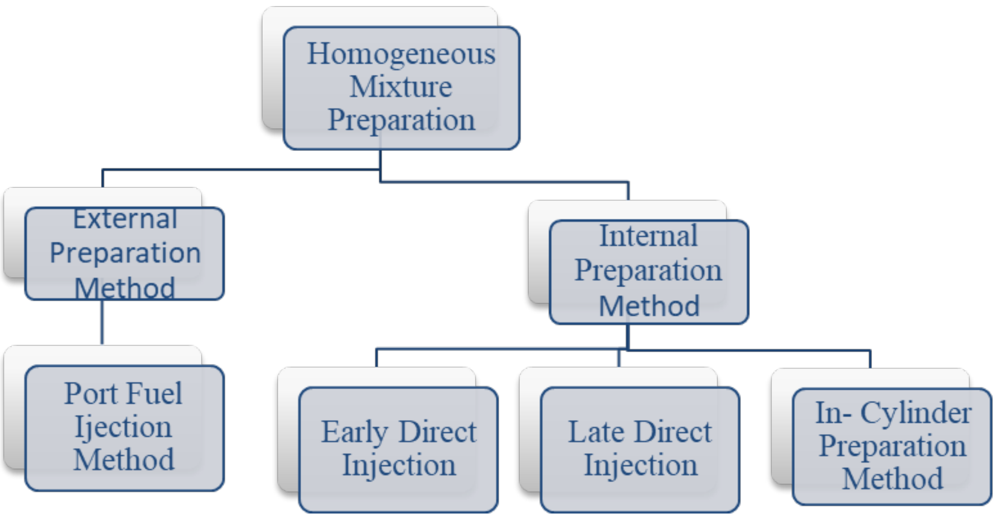

Fig. 1. Homogeneous Preparation Methods

In-cylinder internal preparation method enhances the engine performance and reduces the exhaust emissions released from the engine. The fuel economy and vibrations are efficiently controlled by this method. At high pressures, homogeneous mixture can be easily prepared. Fuel combustion at all times depends on the injection time. Early injection method shows better performance compare to late direct injection method. Because of late injection, fuel densities and temperature values are decreases. The fuel enters during suction, it can be divided into number of parts, and starts combustion in cylinder is known as premixed lean combustion. The exhaust emissions are controlled by quality of homogeneous mixture. In-cylinder internal preparation techniques to overcome the drawbacks in Port fuel injection method.

3. Exhaust Emissions

The exhaust emissions hydrocarbons, oxides of nitrogen, oxides of carbon, sulphur dioxide, carbon dioxide, and carbon monoxide and carbon particles are released from exhaust pipe [10-14]. They are polluting the atmosphere, and they generate global warming, acid rain, odours, and smog in environment. In 1940, first identify the air pollution as a problem in California. Because of huge amount of smoke and other pollutants generates with factories and automobiles. In 1950 increases the smog, by increasing population and automobile density. At this time, realized or identified automobiles are one of the major causes for environment pollution.

3.1. Carbon monoxide (CO) emissions

It is an odourless, colourless, and poisonous gas. The amount of CO emissions depends on the percentage of fuel air ratio [15]. In combustion, insufficient amount of oxygen in combustion chamber all carbon particles converts into CO_2, if small amount of fuel not ignited, it can be formed as carbon monoxide emission. The engine 0.2 to 5 percentages of carbon monoxide emissions are released. Due to improper mixing and low combustion rate are main causes producing CO emissions.

3.2. Hydrocarbon

The combustion chamber of IC engine consists 4000ppm of hydrocarbon components. It is equivalent percentage of 1-1.5% of fuel. During combustion small non-equilibrium components and large fuel molecules breaks up it formed as hydrocarbons. It damages the engine operating parameters and combustion chamber geometry. HC emissions are enters into atmosphere, they react with irritants and odorants. The reasons for HC emissions incomplete combustion, fuel deposits on walls and wall overlap. Because of some fuel, particles do not find and react with oxygen, improper mixing of fuel and air causes incomplete combustion [16]. However, complete combustion is not possible in combustion chamber. With the Homogenous Charged Compression Ignition Technology, engines enhance the performance and lesser amount of exhaust emissions is released.

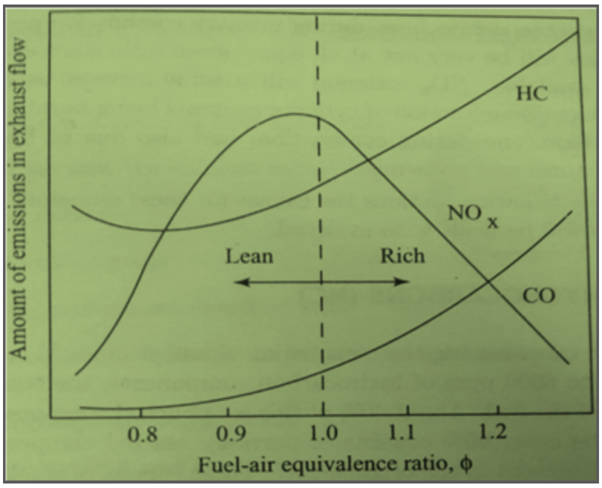

Fig. 2. Exhaust emissions

3.3. Oxides of Nitrogen

In exhaust emissions consists of 2000ppm oxides of nitrogen. It contains a nitrogen oxide and nitrogen dioxide. These are traces of other nitrogen-oxygen combinations. These are all formed

NOx, the x is represents the some suitable number. The NOx reacts with atmosphere, damage the ozone layer, and formed smog. The amount of NOx depends on the amount of nitrogen in the air [17]. The amount of N is highly depends on the temperature range from 2500-3000K. At lower temperatures small amount of NOx is formed. It also depends on the air-fuel mixture and pressure in the cylinder. Combustion time is acting very important role in NOx formation. The advanced HCCI technology reduces the NOx formation and small amount of NOx released in atmosphere.

The Smog creates major problems in many cities in the world. The exhaust emissions are reacts with atmospheric air in the presence of sunlight, so the smog is generated [18]. It damages the large amount of Crops, plants and creates harmful health problems for humans.

$$NO_2 + \text{Sunlight} \longrightarrow NO + O + \text{smog}.$$

3.4. Particulates

The exhaust emission contains solid carbon soot particulates produces in cylinder during combustion. They are in sphere shape; size varies from 9nm to 90nm. Mostly 15-30nm size releases from engine. The single soot contains up to 5000 carbon spheres. These are generated at fuel rich zones in the combustion chamber. The carbon particles 90-95% originally generated from engine, it converted to CO_2. The particulates generation reduces with engine design and controls the operating conditions of the engine [19-20]. The combustion time increases, formation of particulates are reduces. HCCI technology method efficiently reduces the formation of Particulates. The high injection pressures generate a fine size and reduce HC and particulate emissions.

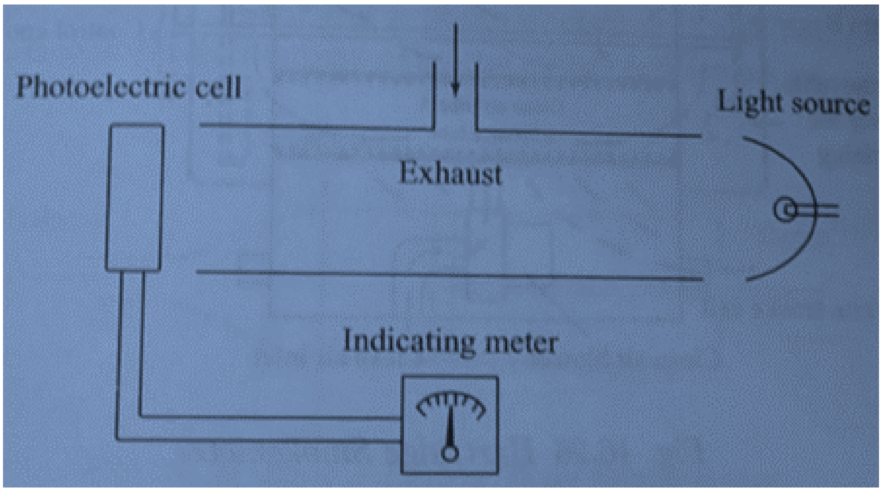

Fig. 3. Measurement of smoke

4. Experimental set-up

The 5H.P. Kirloskar engine modified to work Homogeneous Charged Compression Ignition (HCC) technology engine. The homogeneous mixture can be prepared In-cylinder preparation method. The engine specifications are water-cooled, stroke is 110 mm, bore of 87.5 mm, and compression ratio is 17.50. Take the readings every 10cc of fuel consumption and manometer readings. The performance parameters thermal efficiency, specific fuel consumption is determined. To measure the speed and control the loads with rope brake dynamometer. The various charging operations are Turbo charging (ET), HCCI mode (EH) and determine the performance parameters both Turbo charging and HCCI technique (ETH) applied on HCCI engine. Fig. 4 shows the experimental setup.

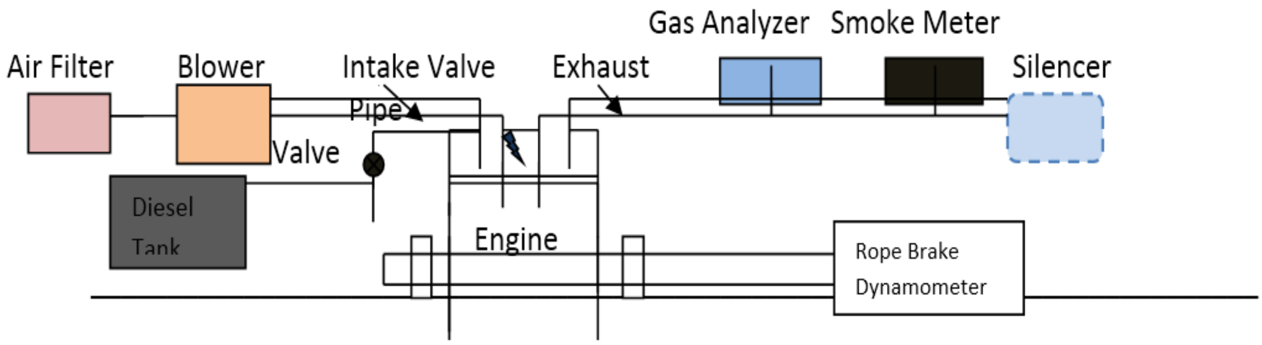

Fig. 4. Experimental Set-up

5. Results & Discussions

The different modes of charging operations conducted on Homogeneous Charged Compression Ignition technology engine. The performance parameters specific fuel consumption and brake thermal efficiency and emission parameters oxides of nitrogen, hydrocarbons and opacity (or) smoke are investigated. The effects of different modes of charging as discussed below.

Effects of different charging on HCCI engine

Figure 5 shows the load verses fuel consumption. It shows that fuel the brake specific fuel consumption reduces with varying the load. The effect of Turbo charging mode reduces the rate of fuel consumption.

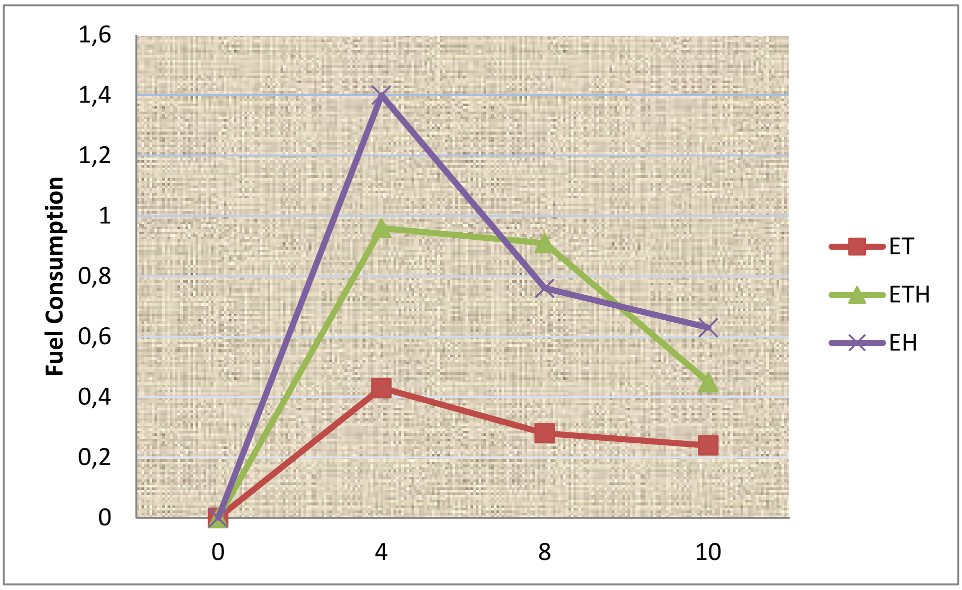

Fig. 5. Load v/s Brake specific fuel consumption

Figure 6 shows the graph of break thermal efficiency verses load. It shows that effect of HCCI mode of charging produces higher thermal efficiency. The Brake thermal efficiency always depends on the value of fuel consumption. The Fig. 7 shows the graph between oxides of nitrogen verses load. It shows that oxides of nitrogen emissions are significantly reduced with HCCI mode charging.

Figure 8 shows the graph of hydrocarbons verses load. It shows that hydrocarbons reduce with charging mode of Turbo charging. Fig. 9 shows the graph of opacity verses load. It shows that opacity decreases with the charging mode of HCCI.

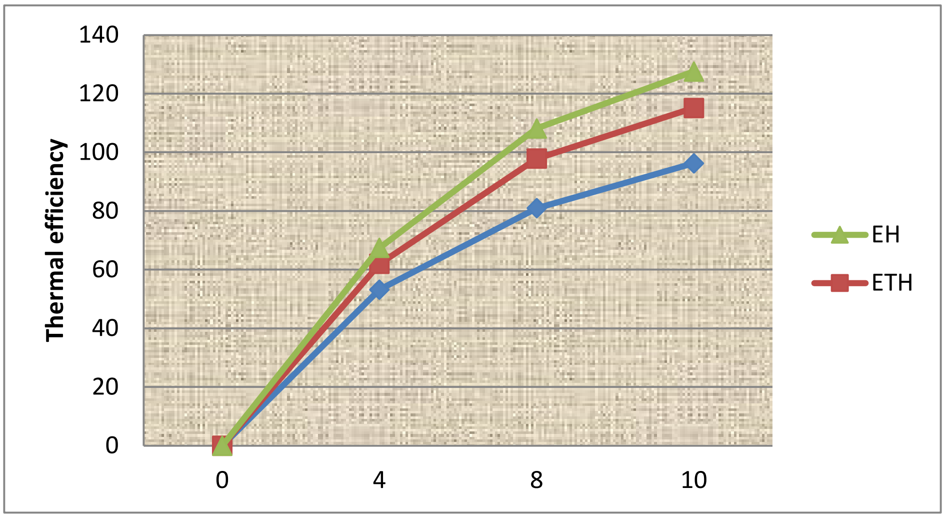

Fig. 6. Load v/s Brake thermal efficiency

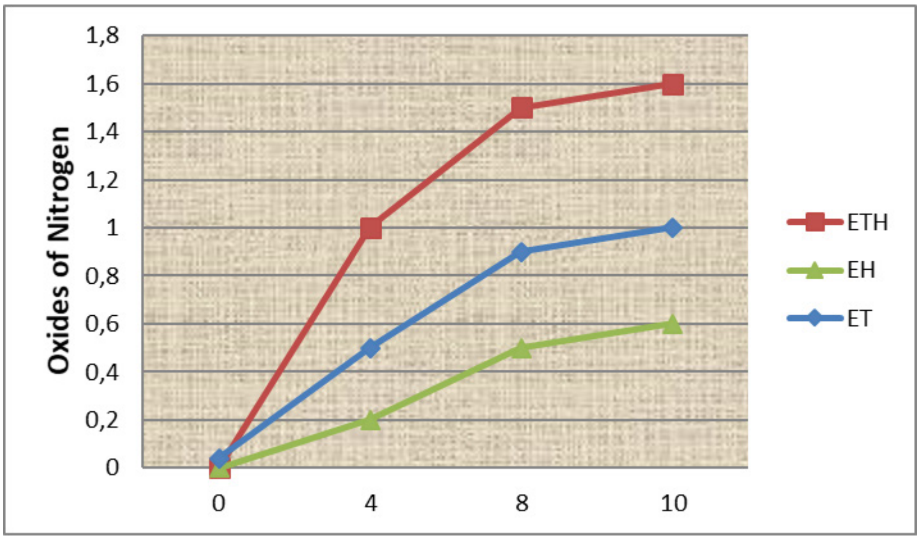

Fig. 7. Load v/s Nitrogen of oxide

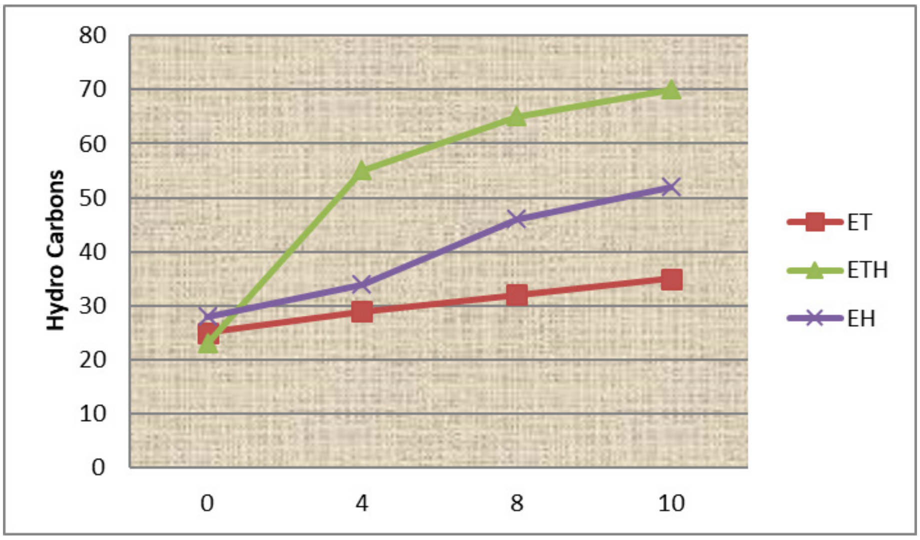

Fig. 8. Load v/s Hydrocarbons

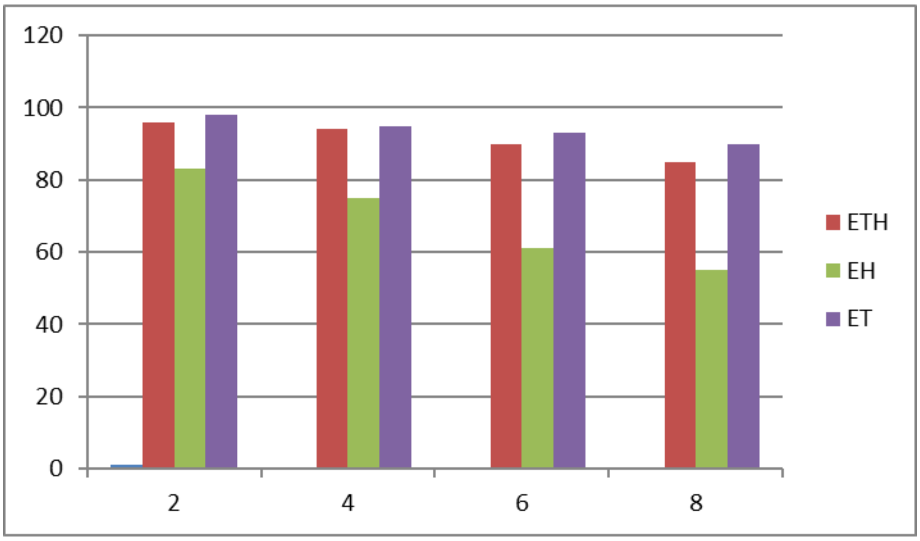

Fig. 9. Load v/s Opacity

6. Conclusion

The different charging modes of operations conducted on 4-stroke Homogeneous Charged Compression Ignition (HCCI) technology engine. The following points are observed. The HCCI technology generates small amount of exhaust emissions and it improves the performance of the engine. In addition, performance and released emissions depends on the quality and quantity of homogeneous mixture. The performance parameters fuel consumption reduces with the charging mode of Turbo charging, the brake thermal efficiency slight increases with the charging mode of Homogeneous Charged Compression Ignition (HCCI). The emissions parameters oxides of nitrogen reduce with the charging mode of HCCI only and unburned hydro carbons are reduces with the charging mode of Turbo charging. In addition, opacity or smoke emissions reduce with the HCCI mode of charging.

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