ETHANOL-DIESEL BLEND STABILITY AND PERFORMANCE OF HHO ON DIESEL ENGINE

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ABSTRACT:

Globally, due to the realization that, crude oil stocks are limited, and hence the swing towards more renewable sources of energy are studied. Since, in diesel engine, ethanol cannot be directly used; therefore, the attention is given to its blending component. It is observed that 5% ethanol-diesel blends have comparable properties to that of diesel fuel. The concentration of ethanol can be improved by an addition of alcohol base additive i.e. hexanol in the blends to increase the phase stability. It is observed that, Optimum stable blends of Ethanol-Diesel (15%-83%) are obtained for longer duration of 90 days with addition of 2% hexanol as an additive.

Moreover, this paper focuses on the performance and emission of diesel engine by an addition of hydrogen gas. Thus, a mixture of HHO, air and diesel burns completely and reduces an emission. The experimental work was carried out with varying load (5kg, 10kg, 15kg & 20kg) under constant speed of 1500 rpm. It is observed that, fuel efficiency increases by using different blends of ethanol-diesel (5%, 10%, 15% and 20%) with HHO gas and the emissions of CO and Smoke density also decreases.

KEYWORDS:

Ethanol–Diesel blends, HHO gas, Engine Performance, Exhaust emission

INTRODUCTION:

Rudolf Diesel invented and patented the diesel engine in 1892. This invention presented superior fuel efficiency, higher thermal efficiency, greater power output, better fuel saving, longer durability and better emission. The diesel engines can either be two-stroke or four-stroke. It is also called compression-ignition (CI) engine [7]. On the other hand, it is estimated that the use of ethanol can decrease the amount of petroleum-fuel imports up to 15-20%. It is found that ethanol has lower heating value than that of regular diesel and the use of pure ethanol increases efficiency of engines. Also, Ethanol has limited solubility in diesel fuel; therefore, phase separation can occurs at lower temperature and water content in ethanol–diesel blend fuel [5]. It is reported that, 5% ethanol-diesel blends are very promising and the concentration of ethanol in ethanol-diesel blends can be improved by an addition of alcohol base additives in the blends.

The use of ethanol in diesel fuel can yield a significant reduction of exhaust emissions in terms of CO and Smoke density [5].

The Conceptual technique has been introduced in IC engine using hydrogen as a secondary fuel. The production of hydrogen gas by cheaper method which is an electrolysis process. The HHO gas or Brown's gas or hydroxy gas was produced by the process of water electrolysis. However, hydrogen is not ignitable merely by means of compression in modern diesel engines, and therefore it requires an ignition source [3]. Hydrogen cannot be used directly in a diesel engine because its auto ignition temperature is higher than that of diesel fuel [1]. The HHO gas is taken for experimental but it is a secondary fuel, which could help in increase the performance of CI engine along with ethanol-diesel blends and reduce the emission. The main concept of HHO technique is to check engine performance by various engine parameters and exhaust emission at different varying load of diesel and ethanol-diesel blends with HHO and without HHO.

The important properties of Hydrogen gas such as Auto ignition temperature, Minimum ignition energy, Flammability limit, Explosive limit, Flame velocity etc, which seems to be the supporting properties or the properties required for combustion are given in table 1. The objective of the work is to introduce hydrogen along with the normal diesel fuel and ethanol-diesel blends in the engine which will lead to complete combustion and hence less consumption of fuel with no harmful gases in the exhaust.

EXPERIMENTAL SECTION:

Blend Stability:

The solubility of ethanol and diesel is mainly affected by two reasons i.e. water content and temperature of the blend [1]. At mild ambient temperatures dry ethanol blends readily with diesel fuel. However, fuels are separated below about 10^{o}C temperature. This separation can be prevented effectively in one way: By adding additives such as higher alcohol, like Butanol, Propanol, Hexanol, and Octanol could solve the problem of fuel instability at low temperature and thus phase stability increases. The ethanol-diesel blends were prepared using splash blending method in magnetic stirrer. The table 2 & 3 shows the long term stability test of Ethanol-Diesel blends by using without and with additive (hexanol).

It is observed that, Optimum stable blends of Ethanol-Diesel (15%-83%) are obtained for longer duration of 90 days with addition of 2% hexanol as an additive.

Blend Properties:

There are various fuel properties that are necessary to the appropriate operation of a diesel engine (CI). Various IP test were carried out to compare physio-chemical properties of commercial diesel with various ethanol-diesel blends. An alcohol base additive like Hexanol is used to increase the concentration of ethanol and to avoid phase separation. Thus, by using hexanol as an additive higher stability is obtained which is kept under observation.

The important Properties like density, flash point, specific and API gravity; kinematic viscosity and ASTM distillation was carried out using density bottle, Pensky Martin flash point apparatus, A-type Oswald U-tube viscometer and ASTM Distillation D-89 unit. Materials compatibility and corrosiveness are important factors that needed to be considered. Properties of fuel that affect safety should be leading in any fuel evaluation. These include flashpoint and flammability [1].

The table 4 shows Physio- chemical properties of diesel compared with ethanol-diesel blends. It is observed that, the value of Density, Kinematic Viscosity, Specific gravity, API gravity, calorific value and Flash point for ethanol blends decreases as the percentage of ethanol increases comparably with normal diesel fuel.

Energy content:

The energy content of a fuel has a direct influence on the power output of the engine. It is reported that the ethanol-diesel blends to have high energy content to deliver sufficient power for the loads for which the vehicle is designed. The energy content of ethanol diesel blends reduce by about 1.5 % for each 5% addition of ethanol by volume [2]. As the concentration of ethanol increases the energy content decreases or the energy content reduction is proportional to the ethanol content.

Electrolyser Cell:

An 'electrolyser' is a cell which breaks water down into hydrogen and oxygen gases by passing an electric current through the water. The resulting gas is called 'hydroxy' gas, as it is a mixture of hydrogen and oxygen. Hydroxy gas is highly explosive and more dangerous than Fuel (Petrol, Diesel). The slightest spark will set it off and exploding as little as a single cupful of hydroxy gas produces a bang so loud that it can cause permanent hearing damage [3].

Reactions:

$2H_2O \xrightarrow{\text{Electricity}} 2H_2 + O_2$ .... (I)

(Electrolysis)

$2H_2O \xrightarrow{2500\,^{o}K} 2H_2 + O_2$ .... (II)

(Thermolysis)

$H2 + O2 \xrightarrow{2807\,^{o}C} 2H_2O$ .... (III)

(Combustion)

Safety:

Consequently, the most important information about electrolysers concerns the safety devices and techniques which must be used with them. The objectives are to keep the amount of hydroxy gas actually present in the system, to an absolute minimum, and to prevent any spark reaching the gas [3]. The most important properties of hydrogen are Auto ignition temperature, Minimum ignition energy, Flammability limit, Explosive limit and Flame velocity.

Design:

For the designing of electrolyser cell for diesel engine kit (1000 cc), the important materials used are CPVC pipe, CPVC cap , Stainless steel plate, HHO outlet hose, wires and calculated parameters observed effectively are Internal diameter of pipe, length of pipe, size of plate, No of SS plate used, Distance between two plates, HHO outlet hose dimension, Volume of kit, Connection of black & red wire, Diameter of pipe, Diameter of bubble, power supply, current supply, concentration of solution, volume of distilled water, Amount of KOH used, Volume of solution used, Average no of bubbles form per minute, Volume of flow-rate, Time required for rate of H_2 production, Rate of H_2 production in LPM. It should be noted that the material dimensions and calculated parameters must be change with the capacity required for an engine. This concept is mainly referred as the production of hydrogen gas known as HHO gas.

Four - Stroke Single Cylinder Diesel Engine:

A four- stroke single cylinder, direct injection, and water cooled diesel engine was used in this experiment. The detail of the engine specifications are listed in Table 5. The engine was mounted to an electrical generator and the generator was then connected to an adjustable load cell to put load on the engine. The HHO gas was generated by electrolyzing water with KOH. But in reality it will be produced from the battery/alternator arrangement of the engine. The power needed to produce the HHO gas is included as an input energy to the engine. The generated mixture is then passed through a drier container and a flow meter before it is introduced to the engine via the air inlet manifold. The flow line of HHO gas mixture was connected to the ground using a normal wire. The CO and CO2 emissions were measured by exhaust gas analyzer. Smoke density emission is also has to consider. The engine was operated at a constant speed of 1500 rpm with four different varying loads. Under each load condition, the fuel consumption time is noted and other parameters were first recorded without any induction of HHO gas into the engine. Then, with no change in the experimental conditions, a small amount of HHO gas was introduced to the engine. The impacts of the induction of HHO gas on the engine performance parameters such as output power, diesel fuel consumption, constant engine speed, exhaust emissions, were recorded [4].

RESULTS AND DISCUSSION:

Hydrogen Production in Electrolyser Fuel Cell:

By a method called electrolysis, involves the passage of an electric current (DC) through electrode. As we know, batteries have a positive and a negative charge. Water is not a good conductor of electricity. So an electrolyte is commonly added to the water along with KOH to allow electric current to pass through the water to break it down into HHO. Thus HHO gas producing hydrogen which can be easily measure in the form of bubbles.

The electrolyser having capacity 1 liter and tube diameter 0.6 cm is used with different concentration of KOH solution. The average volume of flow-rate per minute for different KOH concentration i.e.10, 15, 20, 25, 30 and 35 pellets are 12.8866, 13.4518, 14.5822, 15.7126, 17.1821 and 17.8603 respectively.

Engine Performance and Exhaust Emission:

Theoretical aspects of diesel engine combustion, taking into consideration the widely differing physical and chemical properties of these ethanol blends against the normal diesel fuel, are used to aid the correct interpretation of the observed engine behavior and explain their relative performance and exhaust gas emission [6].

Engine Performance:

In this study, Torque, Brake power, Fuel consumption time, Fuel consumption rate, Break specific fuel consumption (BSFC), Break thermal efficiency (BTE) and Break specific energy consumption (BSEC) are the important engine parameters calculated at different varying load and compared with diesel fuel against ethanol-diesel blends with HHO and without HHO at a constant speed of 1500 rpm.

Torque and Brake power :

Indicated power is based in indicated net work and is thus a measure of the forces within the forces developed within the cylinder. The power is interchangeably referred to as Brake power (BP). BP used to indicate the power, actually delivered by the engine. Also, torque (T) depends on working load apply on engine.

For the engine performance, calculation of the torque and brake power had been done at a constant speed of 1500 rpm and varying value of the working load. It is observed that, the torque and brake power increases as the working load is increased as mentioned in table 6.

Fuel Consumption Time (FCT):

Fuel Consumption time is an important measureable parameter required for the calculation of BTE, BSFC and BSEC.

The 50 ml Fuel measuring unit (burette type) is used to measure the fuel consumption time. Table 7 shows the value of fuel consumption time for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the fuel consumption time decreases continuously at higher varying load both for normal diesel fuel and ethanol diesel blends. Comparably with HHO shows increasing time at varying load than that of without HHO. As the percentage of ethanol blends increases, then fuel consumption time increases.

Fuel Consumption Rate (FCR):

Fuel Consumption rate is an important measureable parameter required for the calculation of BTE, BSFC and BSEC.

Table 8 shows the value of fuel consumption rate for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the fuel consumption rate of normal diesel fuel being highest over lower working load. Fuel consumption rate of ethanol diesel blends decreases as the ethanol content increases. Consumption rate for normal diesel fuel and ethanol blends with HHO shows decreasing rate at varying load than that of without HHO.

Break Specific Fuel Consumption (BSFC):

The fuel consumption characteristics of an engine are generally expressed in terms of specific fuel consumption in kilograms of fuel per kilowatt-hour. It is an important parameter that reflects the performance of engine. It is inversely proportional to the thermal efficiency of the engine.

Table 9 shows the value of break specific fuel consumption for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the break specific fuel consumption at higher load increases with decreased in ethanol blends. Effectively specific fuel consumption increases as the working load increased. Comparably with HHO shows decreasing specific fuel consumption at varying load than that of without HHO. Overall, with HHO shows increase in BSFC. Figure 1 & 2 shows variation of Break specific fuel consumption with working load using HHO and without HHO.

Break Thermal Efficiency (BTE):

Brake Thermal Efficiency is defined as the ratio of energy in brake power to the input fuel energy in appropriate units. For the large of C.I. engines, break thermal efficiency of about 40%.

Table 10 shows the value of break thermal efficiency for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the break thermal efficiency at higher load increases with increased in ethanol blends. Effectively thermal efficiency increases as the working load increased. Comparably with HHO shows increasing thermal efficiency at varying load than that of without HHO. Overall, with HHO shows increase in BTE. Figure 3 & 4 shows variation of Break thermal efficiency with working load using HHO and without HHO.

Break Specific Energy Consumption (BSEC):

The engine consumption characteristics of an engine are generally expressed in terms of specific energy consumption in mega joules per kilowatt-hour. It is an important parameter that reflects the performance of engine.

Table 11 shows the value of break specific energy consumption for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the break specific energy consumption at varying working load decreases continuously with increased in ethanol blends. Comparably with HHO shows decreasing specific energy consumption at varying working load than that of without HHO. Overall, with HHO shows decrease in BSEC. Figure 5 & 6 shows variation of Break specific energy consumption with working load using HHO and without HHO.

Engine Exhaust Emission:

For the reduction of pollutant emissions, researchers have focused their interest on the domain of fuel-related techniques, for example the use of alternative fuels often in fumigated form, or gaseous fuels of renewable nature that are friendly to the environment, or oxygenated fuels that show the ability to reduce Carbon monoxide emissions [6]. Smoke density, CO, CO2, Smoke temperature are the important engine emission parameters.

Smoke density (SD):

Smoke density is an important exhaust parameter that reflects the emission of engine. Table 12 shows the value of smoke density for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the smoke density at varying working load increases with increased in ethanol blends. Comparably with HHO shows decreasing smoke density at varying working load than that of without HHO. Overall, with HHO shows decrease in Smoke density. Figure 7 & 8 shows variation of Smoke density with working load using HHO and without HHO.

Carbon Monoxide (CO):

Carbon monoxide is an important exhaust parameter that reflects the emission of engine. Table 13 shows the value of Carbon monoxide for diesel fuel and ethanol-diesel blends with HHO and without HHO at lower load on diesel engine at constant speed of 1500 rpm.

It is observed that, the carbon monoxide at lower load increases with increased in ethanol blends. Comparably with HHO shows decreasing Carbon monoxide continuously at lower load than that of without HHO. Overall, with HHO shows decrease in carbon monoxide. Figure 9 shows variation of Carbon monoxide with lower load using HHO and without HHO

Carbon Dioxide (CO_2):

Carbon dioxide is an important exhaust parameter that reflects the emission of engine. Table 14 shows the value of Carbon dioxide for diesel fuel and ethanol-diesel blends with HHO and without HHO at lower load on diesel engine at constant speed of 1500 rpm.

It is observed that, the carbon dioxide at lower load increases with increase in ethanol blends. Comparably with HHO shows increasing Carbon dioxide continuously at lower load than that of without HHO. Overall, with HHO shows increase in carbon dioxide. Figure 10 shows variation of Carbon dioxide with lower load using HHO and without HHO.

Smoke Temperature (ST):

Smoke temperature is an important exhaust parameter that reflects the emission of engine. Table 15 shows the value of Smoke temperature for diesel fuel and ethanol-diesel blends with HHO and without HHO at different working load on diesel engine at constant speed of 1500 rpm.

It is observed that, the smoke temperature at varying working load increases with increased in ethanol blends. Comparably with HHO shows increasing Smoke temperature continuously at working load than that of without HHO, because it consists of hydrogen gas. Overall, with HHO shows increase in Smoke temperature. Figure 11 & 12 shows variation of Smoke temperature

with working load using HHO and without HHO.

CONCLUSION:

It is observed that,

i. The alcohol-diesel fuel blends are very promising fuel alternative.
ii. 15 % Ethanol-Diesel blends with addition of 2% hexanol as an additive are very promising for longer duration of 90 days.
iii. With the addition of hydrogen-oxygen gas, the ethanol–diesel fuel blends properties have a significant effect on engine performance and emission.
iv. With hydrogen-oxygen injection the CO emission, Smoke density, fuel consumption rate, break specific fuel consumption and break specific energy consumption decreases.
v. With hydrogen-oxygen injection the CO_2 emission, fuel consumption time and break thermal efficiency increases.
vi. Thus, with the addition of HHO gas an increase in the performance of CI engine and reduction in an exhaust emission as been observed.
vii. HHO boost engine performance; reduce pollution, eco-friendly and no maintenance required.

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