Use Of Ethanol In A Diesel Engine Using Blending And Fumigation Techniques- A Comparative Study

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Abstract- *The use of oxygenated fuels in diesel engine is aimed at achieving thermal efficiencies without exceeding the limit imposed by the emission regulation on exhaust emission. Though biodegradability, low toxicity, regeneration capability and clean burning characteristics are favorable for the use of alcohol in diesel engine, the properties of alcohol like immiscibility with diesel, low cetane number, poor auto ignition capability poor lubrication property and lower thermal efficiencies are the constraints.In this work an experimental investigation was carried out to evaluate the performance and emission characteristics of a diesel engine run using ethanol, as secondary fuel, by blending and fumigation techniques. Tests were conducted by running the engine at five different loads using blend fuels, containing varying proportions of ethanol (up to 20% by Volume), and also using fumigation technique. The substitution capability of diesel by ethanol was also evaluated. While the brake thermal efficiency was used to evaluate the performance, the constituents of emission, namely NOx, HC, CO, CO2 and O2 were used for emission characteristics. The investigation indicates that the blending technique marginally decreased the brake thermal efficiency of the engine and NOx levels in engine emissions, with increase in HC levels. Further the results of the investigation confirmed the superiority of the fumigation technique over blending technique as far as the percentage substitution of diesel by ethanol and reduction in NOx levels in engine emission are concerned.*

Keywords- IC engine, Emission, Blending, Fumigation, Alternative fuels, and Aldehydes. [6]

I. INTRODUCTION

The Industrial Revolution of the 19th century ushered in new Technologies. The spurt in inventions in that century was unprecedented in many ways. Some of these inventions involved use of natural resources like coal and oil. The thought of exhaustible nature of these resources and the environmental damage from the use of these resources never occurred either to the inventors or the subsequent generations. In the quest to sustain galloping economic activity, the dependence on coal and oil has soared at a phenomenal rate over the years. The burnt fuels result in the release of carbon dioxide and other gases into the atmosphere causing environmental damage. It has become imperative to look at energy technology with a new perspective. There are abundant renewable sources of energy such as wind, sun, water, sea, biomass apart from even daily wastes. These sources are pollution free and hence clean energy apart from being unlimited/ inexhaustible.

Power generation in India has grown in size to around 1 lakh MW and in Tamil Nadu it has increased to 7924 MW which is distributed through a vast network of transmission, sub-transmission and distribution lines that reach all villages even in remote areas. The demand for power is growing rapidly. The problem will be compounded due to fast depletion of fossil fuel deposits, quality of fuels, heavy price to be paid for basic materials plus their transportation cost and above all the environmental degradation caused by the use of conventional energy sources. Under such conditions, environment friendly and pollution-free, non-conventional and renewable energy sources known as 'clean and green energy' have emerged as an important alternative to conventional energy sources. The renewable energy sources are clean and inexhaustible as they rely on sun, wind, biomass, etc., as primary sources of energy. It is estimated that, about 2000 MW can be generated from wind potential available in Tamil Nadu. As against this potential, 19 MW of power in the State Sector mostly through demonstration wind farms and 838 MW in the private sector.

II. CONVENTIONAL FUELS

The conventional fuels are mainly classified under three categories as petroleum, natural gas and coal.

TYPES OF CONVENTIONAL FUELS

1. **COAL-** Wood, peat, lignite, brown coal, bituminous coal, anthracite coal, and tar etc.

2. **NATURAL GAS-** coal gas, coke oven gas, water gas, producer gas, carbureted water gas, oil gas, blast furnace

gas, refinery oil gas, synthesis gas, acetylene and liquid petroleum gas.

3. **CRUDE OIL OR PETROLEUM-** Gasoline or motor spirit, diesel oil, kerosene fuels, oils, alcohols and synthetic sprits.

III. ALTERNATIVE FUELS

1. BIO-DIESEL

Bio-diesel is made from animal fats or vegetable oils, renewable resources that come from plants such as, soybean, sunflowers, corn, olive, peanut, palm, coconut, safflower, canola, sesame, cottonseed, etc.

2. ALCOHOL FUELS

Methanol and Ethanol fuel are typically primary sources of energy; they are convenient fuels for storing and transporting energy. These alcohols can be used in "internal combustion engines as alternative fuels".

3. AMMONIA

Ammonia can be used as fuel. Benefits of ammonia include, no need for oil, zero emissions, low cost, and distributed production reducing transport and related pollution.

4. HYDROGEN

Hydrogen is an emission less fuel. Some mono-nitrogen oxides NOx are produced when hydrogen is burned with air.

5. ALTERNATIVE FOSSIL FUELS

Compressed natural gas (CNG) is a cleaner burning alternative to conventional petroleum automobile fuels. The energy efficiency is generally equal to that of gasoline engines, but lower compared with modern diesel engines. CNG vehicles require a greater amount of space for fuel storage than conventional gasoline power vehicles.

Natural gas, like hydrogen, is another fuel that burns cleanly; cleaner than both gasoline and diesel engines.

Advantageous of use of alcohol in diesel Engine

1. It is a high octane fuel with anti-knock index numbers of over 100. Engines using high octane fuel can run more efficiently by using higher compression ratios. Alcohols have higher flame speed.
2. It produces less overall emissions compared to gasoline.
3. When alcohols are burned, it forms more moles of exhaust gases, which gives higher pressure and more power in the expansion stroke.
4. It has high latent heat of vaporization which results in a cooler intake process. This raises the volumetric efficiency of the engine and reduces the required work input in the compression stroke.
5. Alcohols have low sulphur content in the fuel.

Disadvantages in use of alcohol in Diesel Engines

1. Alcohols have low energy content or low calorific value.
2. Combustion of alcohols produces more aldehydes in the exhaust.
3. Alcohol is much more corrosive than gasoline on copper, brass, aluminum, rubber, and many plastics.
4. It has poor cold weather starting characteristics due to low vapor pressure and evaporation.
5. Alcohols have poor ignition characteristics in general.
6. Alcohols have an almost invisible flame, which is considered dangerous when handling fuel.
7. There is the danger of storage tank flammability, due to low vapor pressure. Air can leak into storage tanks and create combustible mixtures.
8. There will be less NOx emission because of low flame temperatures.
9. Many people find the strong odor of alcohol very offensive. Headaches and drizzles have been experienced when refueling an automobile.

There is a possibility of vapor lock in fuel delivery systems.

IV. DIFFERENT METHODS OF USING ETHANOL IN INTERNAL COMBUSTION ENGINE.

There are mainly four known methods by means of which Ethanol is used in Internal Combustion Engine, these are as follow:

1. **Blending:** A technique to produce alcoholic beverages by mixing together different brews. Mixture of the fuels just prior to injection, displacing up to25% of diesel fuel demand.

2. **Emulsion:** using an emulsifier to mix the fuels to prevent separation, displacing up to 25% fuel demand.

3. **Dual Injection:** separate injections system for each fuel, displacing up to 90% of fuel demands.

4. **Fumigation Process:** Fumigation is a method by which alcohol is introduced into the engine by carbureting, vaporizing or injecting the alcohol into the intake air stream. This requires the addition of a carburetor, vaporizer or injector along with control valves. This requires the addition of a carburetor, vaporizer or injector along with control valves.

V. EMMISSIONS OF DIESEL ENGINE

A variety of combustion products are formed when diesel fuel is burnt. These are typically carbon monoxide, hydrocarbons, nitrogen oxides and fine particles. Where leaded fuels are used lead is also a major pollutant.

1. CARBON MONOXIDE

Carbon oxide is formed at the intermediate combustion stage because of air deficiency, which results in incomplete oxidization. Exposure to elevated levels of CO affects visual perception, work capacity, manual dexterity, and learning ability. The health threat from CO is particularly more serious for people suffering from heart diseases.

2. HYDROCARBONS

Hydrocarbons are elements of unburned fuel, which have formed because of a low combustion temperature and a poor fuel to air mixture.

3. NITROUS OXIDES

Nitrous oxides are formed by a reaction between the N and O in the air at high temperatures. NOx emissions produce a wide variety of health and welfare effects. It can affect ecosystem leading to acid rains.

4. PARTICULATE MATTER

Particulate matter consists of a core of carbon (<10mm) and comes from the fuel and the lubricating oil. Particulate matter is a general term covering solid particles and liquid droplets in the air. It includes dirt, dust, soot, and smoke. The health impact mainly includes breathing and respiratory symptoms.

5. LEAD

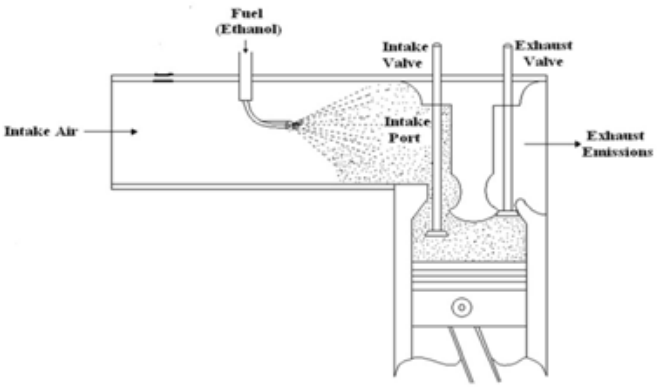
Lead gets deposited on soil and water, reaching humans through food and drinking water.

VI. EXPERIMENTAL FACILITY AND PROCEDURE

While a lot of work had been carried out in the field of use of alcohols in diesel engines using fumigation and blending techniques in an individual manner, only few research works compared these two techniques based on the performance and emission characteristics. In this work an attempt has been made to compare the fumigation and blending techniques using ethanol as the secondary fuel.

DESCRIPTION OF THE EXPERIMENTAL FACILITY

To ascertain the performance and emission characteristics of the engine, experiments are conducted by running the engine at the rated speed and at five different loads with diesel and ethanol as fuels using both blending and fumigation techniques. The specifications of the engine are as follows.



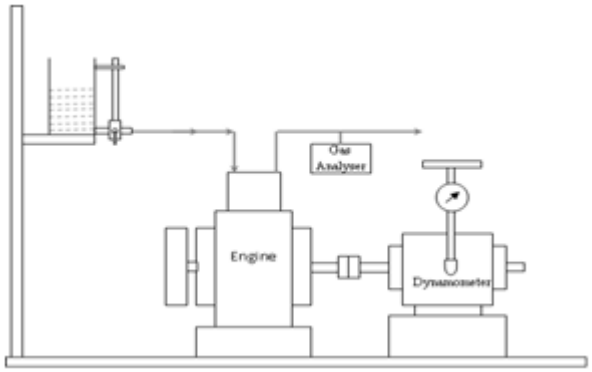
VII. SPECIFICATIONS OF THE ENGINE

Engine	Kirloskar AV-I
Type	Diesel engine, Single cylinder, Vertical, Water cooled
Maximum power	3.7 KW
Bore	80 mm
Stroke	110 mm
Speed	1500 rpm
Loading device	Swing field electrical Dynamometer
Injection timing	23^0 before TDC
Injection pressure	(220 kgf/cm^2) 215.82 bar

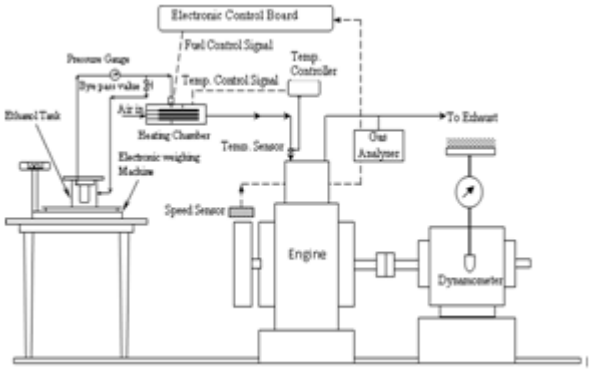
For applying the load on the engine, a swing field electrical dynamometer is used. A custom made tank and flow

metering system is used for fuel consumption measurement of the various blend sample as follows. A glass burette of known volume was used the time measured for its complete evacuation of the fuel sample feeding the engine.

For measuring the speed, a tachometer is used. The various constituents of the exhaust emissions like NOx, CO, CO2, and HC are measured using a gas analyzer of Horiba make. The schematic representation of the experimental setup used for blending technique is as shown in fig



Experimental setup for Blending



VIII. PROPERTIES OF FUELS

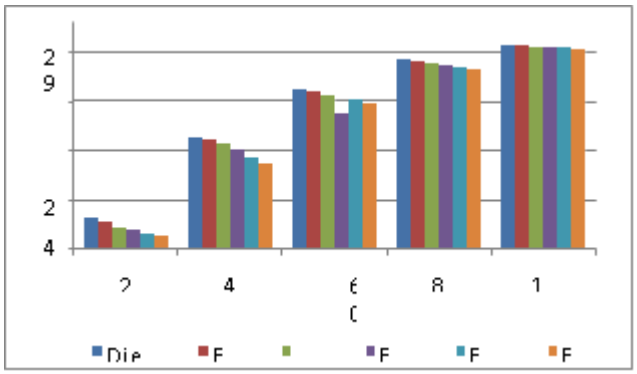
Blends of ethanol in various proportions with diesel fuel are prepared with dodecanol as surfactant. The blend fuels are prepared in such a way that the percentage of ethanol in the blend varied from 4% to 20% in steps of 4% and the fuels are named as E4, E8, E12, E16 & E20.

Due to the problems encountered in running the engine, the percentage of ethanol in the blend fuel is limited to a maximum of twenty. The proportions of surfactant which show no phase separation after satisfying homogeneity conditions are first determined. For the present work no cetane improving additives [ignition improve] or emulsifying agents are used. The physical and chemical properties of diesel, ethanol and dodecanol are as shown in table.

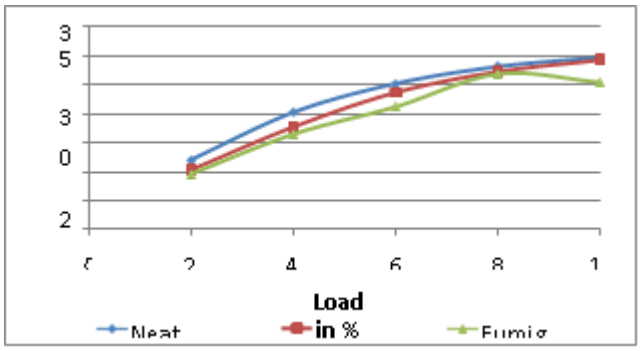
Properties	Diesel	Ethanol	Dodecanol
Formula	CxHy	CH_3CH_2OH	
Calorific value in KJ/kg	41000	30000	39860
Viscosity in mpa.s	3.35	1.2	-
Flash point in ^0C	65-88	13-14	16.136
Pour point in ^0C	-1 to3	-117.3	-
Boiling point ^0C	180 to 360	78.4	186.4
Density in(10^3X kg/m^3)	0.829	0.789	0.83
Molecular weight	190-220	46.07	107
Cetane number	45-50	5-8	-
Appearance	Mild brown liquid	Colorless	Colorless

IX. RESULTS AND DISCUSSION

Tests were conducted in a diesel engine to ascertain the performance and emission characteristics of the engine by running it with ethanol using both blending and fumigation techniques. While the normal running of the engine permitted the use of E20 blend fuels [which contain a maximum of 20% of ethanol by Volume] using blending technique, the fumigation technique allowed a maximum fumigation rate of 1Kg/hr of a fumigation temperature of 1350C. The results of the tests are represented using graphs or bar charts and discussed as follows.



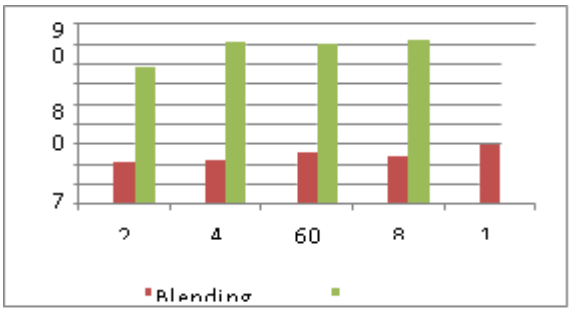
Effect of percentage of ethanol in the blend fuel on the brake thermal efficiency.



Effect of percentage of ethanol in the blend fuel on CO_2 emission.

X. CONCLUSION

To conclude, while blending technique can be used to run a diesel engine using ethanol without affecting much the brake thermal efficiency of engine, the fumigation technique can be recommended as an emission control method to reduce NOx levels and a method for higher percentage substitution of diesel by ethanol compared to blending technique.



Effect of ethanol blending and fumigation on percentage substation of diesel by ethanol with respect to load.

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