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Four Stroke Diesel Engine's Surface Ignition using Ethanol

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ABSTRACT: The aim of this study to find strategies for using more water added with ethanol in diesel engines. To accomplish the goal, experiment investigations are conducted using a single cylinder diesel engine equipped with glow plug on the combustion chamber in the cylinder head. The performance and emission characteristics are studied and compare with base engine. This concept was effective not only in decreasing smoke density and fuel consumption but also in increasing engine output. The modification of the engine is carried out in such way that a pre combustion chamber is designed in the engine head with a provision for glow plug is made on the pre combustion chamber. Ethanol is a bio-based renewable and oxygenated fuel, thereby providing potential to reduce the PM emission in diesel engine and to provide reduction in life cycle of CO_2. This leads to reduce the ozone depletion there are several studies which report improvement in the engine performance and emission by using ethanol fuels. This motivated us to use ethanol as sole fuel in diesel engine. Even lot of researches completed in the area of ethanol as alternative fuel, commercialization of this fuel is not achieved in the India automobile scenario. It is mainly because of installing the refilling station and the problem encountered in the engine while ethanol is used as a fuel. The problem such a starting trouble Aldehyde emission coming out from the engine and the stringent norms followed by the government for the use of ethanol. Our project aims to overcome these problems and recommend the possible solutions.

I. INTRODUCTION

It is apparent from the increasing popularity of light-duty diesel engines that alternative fuels, such as alcohols, must be applicable to diesel combustion if they are to contribute significantly as substitutes for petroleum-based fuels. Although replacing diesel fuel entirely by alcohols is very difficult, an increased interest has emerged for the use of alcohols, and particularly lower alcohols (methanol and ethanol) with different amounts and different techniques in diesel engines as a dual fuel operation during recent years.

Ethanol is an alternative renewable fuel produced from different agricultural products. The ethanol–Diesel emulsion technique is one of the techniques to use ethanol in Diesel engines. The most important advantage of this technique is to be able to use ethanol without any modification in Diesel engines.

The increase in prices petroleum based fuels, strict governmental regulations on exhaust emissions and future depletion of worldwide petroleum reserves encourage studies to search for alternative fuels. Ethanol is alternative fuel for diesel engines. It biomass – based renewable fuel, it offers reduction in life cycle co2 and it shows a significant PM reduction. Recently, the economics have also become much more favorable in the production of ethanol and it is able to compete with the standard diesel fuels. Studies on the use of ethanol in Diesel engines have been continuing since the 1970s. The initial investigations were focused on reduction of the smoke and particle levels in the exhaust. Ethanol addition to Diesel fuel results in different physical-chemical changes in Diesel fuel properties, particularly reductions in cetane number, viscosity and heating value. Therefore, different techniques involving alcohol–Diesel dual fuel operation have been developed to make Diesel engine technology compatible with the properties of ethanol based fuels. The studies on the use of ethanol in Diesel engines can be divided into four techniques. These are the alcohol–Diesel fuel blend (mixture of the fuels prior to injection), alcohol fumigation

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(the addition of alcohols to the intake air charge, alcohol–Diesel fuel emulsion (using an emulsifier to mix the fuels to prevent separation) and dual injection (separate injection systems for each fuel).

The addition of ethanol to diesel fuel simultaneously decreases cetane number, high heating value, aromatics fractions and kinematics viscosity of ethanol blended diesel fuels and changes distillation temperatures. An additive used to keep the blends homogenous and stable, and an ignition improver, which can enhance cetane number of the blends, have favorable effects on the physicochemical properties related to ignition and combustion of the blends with 10% and 30% ethanol by volume. Ethanol is a promising oxygenated fuel. Pure ethanol with additives such as cetane improver can sharply reduce particulates. At the early stage, poor fuel economy and low ignitability were the main barriers to apply ethanol fuel on diesel engines. Since late 1990s, ethanol blended diesel fuel has been used on heavy-duty and light-duty diesel engines in order to modify their emission characteristics. As alternate fuels, ethyl and methyl alcohols stand out because of the feasibility of producing them in bulk from plentifully available raw materials. In the present work, ethanol is used as the only fuel, in the standard and low heat rejection (LHR) diesel engines by adopting three different methods. In the first method, ethanol as the sole fuel was used in the LHR engine with normal metal glow plug and in the second method spark plug assistance was used to initiate combustion. In the third method, ethanol was used as the sole fuel in a LHR engine and a ceramic glow plug was used to initiate combustion.

The engine was tested for performance and emissions for the above three methods of 100% ethanol operation in both the standard and LHR diesel engine and the results are compared. The spark plug assisted ethanol operation in the LHR engine gave the highest brake thermal efficiency and the lowest emissions.

II. SCOPE OF ALCOHOLS

As said earlier alcohols are the most abundant and promising substitute for fossil fuels. These alcohols can be readily made from a number of non-petroleum sources. Methanol or methyl alcohol can be made from coal, a relatively abundant fossil fuel. Ethanol or ethyl alcohol can be produced by fermentation of carbohydrates which occur naturally and abundantly in some plants like sugarcane, potatoes, corn etc. hence these fuels can be made from highly reliable and long lasting raw material sources. Since ethanol and methanol have higher self ignition temperature compared to the existing conventional fuels, we need to develop a high intensity spark to ignite these fuels, the existing spark plugs do develop necessary temperature to ignite the fuel and hence we go for the catalytic plug.

III. DUAL FUEL SYSTEMS

Fumigation
- Addition of secondary fuel to the intake air charge
- Displacing up to 50% of the diesel fuel demand

Dual injection
- Separate injection system with control for each fuel
- Displacing up to 90% of diesel engine demand

Blend Fuel
- Mixture of the fuel just prior to injection
- Displacing up to 25% of diesel engine demand

Fuel Emulsion
- Mixture of the fuel by using emulsifier
- Displacing up to 25% of diesel engine demand

Ethanol Fuel

Application of Ethanol
- Gasoline blend (5 – 10%)
- Diesel blend (E-diesel)

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Characteristic of Ethanol

- Lower volumetric energy content
- High octane rating
- Result in increased engine efficiency and performance

Environmental characteristics

- Produced “renewably”
- Reducing greenhouse gas emission

IV. PRE-COMBUSTION CHAMBER

In CI engine, combustion space is provided in to two parts namely, Pre-combustion chamber and main combustion chamber. The Pre -combustion chamber is always located in the cylinder head. The main combustion chamber enclosed between the piston and cylinder head. Orifices interconnect the two combustion chambers.

Pre-combustion chamber is built in various shapes and relative sizes. Pre-combustion chamber volume is about 30 to 40 percent of the total combustion chamber.

During compression, air in the cylinder enters the Pre-combustion chamber. At the end of compression, the whole of the fuel is injected in the Pre-combustion chamber. The hot air ignites the fuel. Combustion starts in this chamber. Pressures rise in it. Rise of pressure in the Pre-combustion chamber forces out the products of combustion, in to main combustion chamber and ignite the fuel in main combustion.

V. INJECTION AND POWER STROKE IN PRE COMBUSTION CHAMBER

The Pre-combustion chamber (is an auxiliary chamber at the top of thecylinder. It is connected to the main combustion chamber by a restrictedthroat or passage. The Pre-combustion chamber conditions the fuel for finalcombustion in the cylinder. A hollowed-out portion of the piston top, Causesturbulence in the main combustion chamber, as the fuel enters from the Precombustionchamber to aid in mixing with air. The following processes arehappens in the Pre-combustion chamber:

• During the compression stroke of the engine, air is forced into the Precombustionchamber and, because the air is compressed, it is hot. Atthe beginning of injection, the Pre-combustion chamber contains adefinite volume of air.

• As the injection begins, combustion begins in the Pre-combustionchamber. The burning of the fuel, combined with the restrictedpassage to the main combustion chamber, creates a tremendousamount of pressure in the combustion chamber. The pressure and theinitial combustion cause a super-heated fuel charge to enter the maincombustion chamber at a high velocity.

• The entering mixture hits the hollowed-out piston top, creatingturbulence in the chamber to ensure complete mixing of the fuelcharge with the air. This mixing ensures even and completescombustion.

VI. PROPERTIES OF ETHANOL

Chemical formula	- C2H5OH
Molecular weight	- 46
Density at 15.5° c	- 789 kg/m3
Boiling point	- 78° C
Heating value	- 27700 kJ/kg
Latent heat of vaporization	- 855 kJ/kg
Self-ignition temperature	- 366° C
Cetane number	- 8
Octane number	- 111

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Stoichiometric A/F ratio - 9.0

Composition of Ethanol

Carbon - 52% by weight

Hydrogen - 13% by weight

Oxygen - 35% by weight

Comparison of Fuel Properties:

PROPERTIES	DIESEL	GASOLINE	ETHANOL
Boiling point (ºC)	188 - 343	27-225	28
Auto ignition temperature (ºC)	210	300	420
Stoichiometric A/F Ratio	14.6	14.5	9
Lower heating value (MJ/kg)	43.2	44.0	26.9
Density gm/cc	0.84	0.72	0.789

VII.ENGINE MODIFICATION

Requirements to burn ethanol in ic engine

1. Engine needs glow plug setup to ignite ethanol, because octane rating of ethanol is high.
2. It's important to ensure proper airfuel mixture admitting to the combustion chamber, so we can use a simple carburetor to facilitate proper air-fuel mixture.
3. If we want to use carburetor we need proper air correction system which will ensure proper vacuum pressure in the inlet manifold, so that fuel from carburetor sub tank will be lifted up to air passage and mixtures with air.
4. Engine needs proper temperature that should be maintained inside the combustion chamber because ethanol fuel has high temperature of vaporization (78.9 C) so that is a possibility of condense of fuel inside the combustion chamber.
5. As vaporization temperature of the fuel is higher, it will condense in inlet manifold itself mostly during cold climatic conditions. So it may need a manifold heater, which can be used in such a climatic conditions.
6. We can take a simple four stroke petrol engine to our project but it needs compression ratio (up to 16.1) in order to maintain high temperature. So that fuel will be proper mixture to facilitate easy catching of fuel.

VIII. ENGINE SELECTION

Selection of engine is very important thing considering properties of ethanol fuel as less range modification preferable over engine it is important to have an ethanol vaporization temperature is high it is needed to maintain good, for that it needs an engine with comparison ratio more than 16:1

As octane rating of ethanol is high, it is not easy to auto ignite Ethanol by Compression ignition, so it needs a carbureted SI engine with compression ratio 16.1. In general we don't have SI engine with compression ratio 16.1. So a CI engine with required compression ratio has been chosen, further that is converted into SI engine by doing necessary modification.

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To initiate the ignition spark ignition circuit is obtained and to supply the excess fuel the various jets in the carburetor is used. The engine has a peperpot type pre combustion chamber with two exit holes and pre-combustion chamber with two exit holes and the pre combustion chamber was located at the outer located at the outlet periphery of bore.

IX. SURFACE – IGNITION ALCOHOL CI ENGINE

The Surface ignition plug mounted on an alcohol fuelled direct injection diesel engine can be seen in fig. The basic Concept of the system is as follows.

A slab of insulator material, wound with a few strands of heating wire is fixed on the combustion chamber with the wire running on the face exposed to the gases. The fuel injector is located such that a part of the spray impinges head on this surface. Ignition is thus initiated. The combustion chamber, which is in the cylinder head, is made relatively narrow so that the combustion is spreads quickly to the rest at the space.

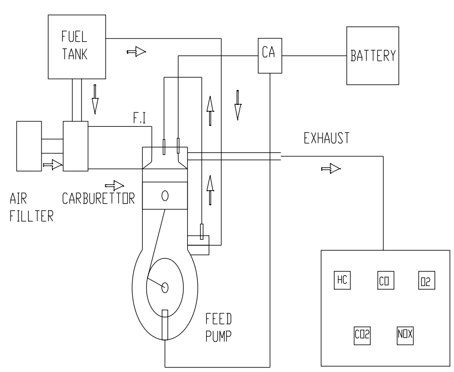
Since the part of fuel burns on the insulator surface and the head losses from the plate are low, the surface after some minute's operation reaches a temperature sufficient to initiate ignition without the aid of external electrical supply. the engine was found to run smoothly on ethanol with performance compared to diesel operation. The engine operates more smoothly at a lower speed than higher speed.

The selected engine cylinder head has an inlet manifold, exhaust manifold, water jacket, In this modification of the engine head is carried out in such way that a pre-combustion chamber is designed in engine head and a provision for glow plug is made on the pre-combustion chamber.

Surface Ignition Timing

Contact angle, and therefore surface ignition, is a function of igniter geometry and compression ratio. Catalytically – assisted ignition in internal combustion engine has two distinct phases. The first phase is catalytic oxidation of the fresh mixture entering the pre combustion chamber. Provided that the catalyst is above the surface ignition temperature for a given fuel, this begins as soon as the interface between the fresh charge and the residualgas from the previous cycle contacts the catalyst. The second phase is the auto-ignition of the unburned mixture that accumulates in the case, controlling the crank angle at which the fresh mixture contacts the catalyst can set ignition timing.

X. EXPERIMENTAL SETUP



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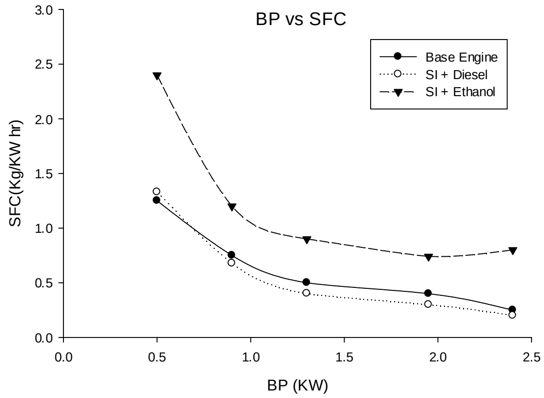
XI. RESULTS AND DISCUSSION

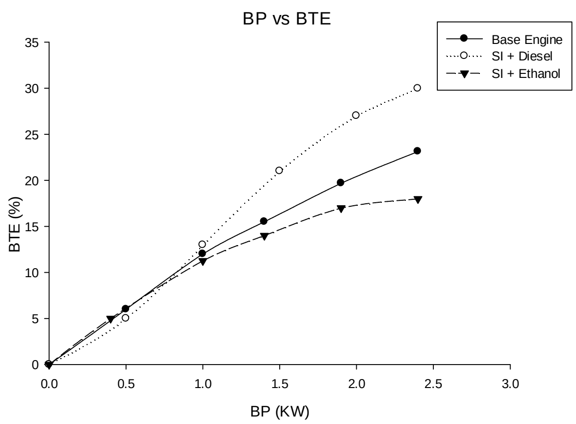
The results obtained after carrying out experiments are presented and discussed in this section.

Performance:-

Specific fuel consumption:-



Brake thermal efficiency:-



Carbon monoxide emission:-

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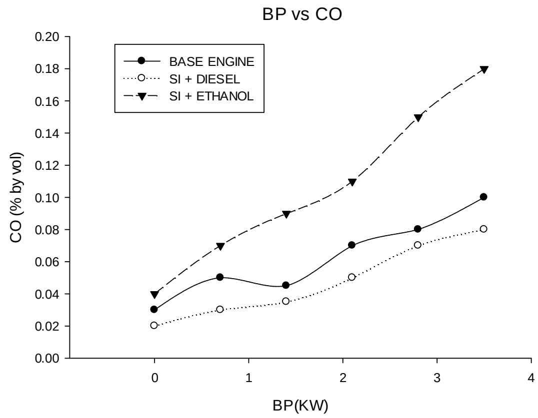
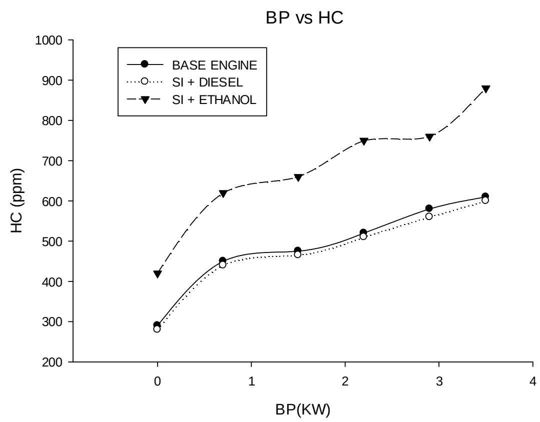
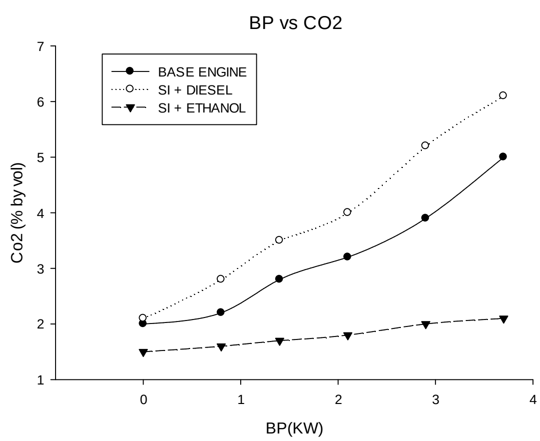


Hydrocarbon emission:-



Carbon dioxide emission:-



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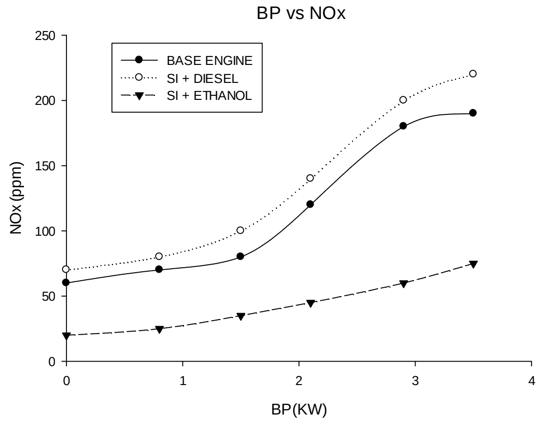
Oxides of nitrogen emission:-



XII.CONCLUSION

A detailed experimental analysis for finding out the emission characteristic of ethanol in comparison with base diesel was carried out. The experiment result of this investigation is summarized as follows:

- The total fuel consumption increase with increase in brake power. TFC for diesel lower than that of ethanol. Because ethanol has lower calorific value that that of diesel. TFC for base diesel is less than the SI + Ethanol.
- It can be seen that the efficiency of the engine of the engine SI + Diesel is higher than the diesel the increase in percentage of thermal efficiency is than diesel thermal efficiency is lower for SI + Ethanol about this is also due to low heating value of ethanol.
- The engine was found to run smoothly on ethanol with performance compared to diesel operation. The engine operates more smoothly at a lower speed than higher speed.
- The emission of unburned HC from the engine with SI + Ethanol is lower by 31.67% than base diesel. And for base engine, HC emission depressing gradually. Base engine and SI + Ethanol have higher HC emission because of incomplete combustion.
- The CO emission is lower for SI + Diesel about 22.2% compare to diesel. CO is gradually decreasing for SI + Diesel. This is due to oxygen content in the SI + Ethanol fuels is higher than the base engine, so it will react easily with hydrocarbons and better combustion take place.
- Ethanol reduces the NOx formation because it absorbs heat during Combustion due to its high latent heat vaporization. So it reduces the peak combustion temperature.

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