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Experimental Investigation on Diethyl Ether as an Ignition Improver in Diesel- Ethanol Emulsified Fuel for C.I Engine

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Abstract: *In the present day scenario, Fossil Fuel Depletion is increasing in a rapid manner due to the excess usage. Moreover the Pollution from automobile is drastically destroying this world. It is very important to find a solution for the pollution problem. Hence this paper concentrates on giving permanent solution for the permanent problem which is possible with a help of Ethanol and Diesel Emulsion as an alternate fuel with Diethyl Ether as an Ignition Improver, considering all other fuels most of them cost very high. The wide usage of Ethanol can reduce its price, because India is one of the largest producers of sugarcane in the world. When Ethanol mixed with Diesel it will not mix with it properly. The separation will take place in rapid manner. To avoid this phase separation Emulsification of Ethanol and Diesel is done. The usage of Ethanol along with Diesel and Diethyl Ether as an Alternate Fuel is done by Fumigation. The implementation of dual Injectors in this method (One for Ethanol and another for Diesel) is difficult and expensive. So, in order to overcome the above drawbacks "Emulsification method" is used. The main theme of this paper is to find the Stability of the Ethanol and Diesel Emulsion with Diethyl Ether, as an additive as well as an ignition improver, for different combinations and to find the performance and emission characteristics of the most stable combinations of the Ethanol, Diesel and Diethyl ether Emulsion. As a result, The BTE of the engine is increased by 20%.and the TFC is reduced by 14%.*

INTRODUCTION

Pollution has become major problem now days. Normally it is from industries, tanneries or vehicles. Though the contributors to the pollution are many, the smoke emitted by automobiles play a vital role towards pollution. It has been that nearly half of the current nonrenewable petroleum demand equivalent to about 20% of the world's energy consumption is being used by 550 million Automobiles. The following curve clearly shows the increasing fuel demand as the period increases. To meet this demand we should shift on alternative fuels which less polluting one.

The possible solutions for reducing the pollution are as follows,

- Design changes in the engine
- Fuel additives
- Catalytic Converter
- Exhaust Gas Recirculation
- Ammonia Injection
- Direct injection
- Electronic Injection

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Among these alternatives, the easiest and simplest one is using Fuel Additives.

Though the other methods are effective, demands changes in the existing design aspect which is an expensive affair. The fuel additives have drawn the attention of the world towards it owing to its inherent advantages. Many alternate fuels are being considered for automotive vehicles. Among them Ethanol is one of the best alternate fuel. It is a renewable fuel and its high oxygen content improves the combustion characteristics. Addition of Ethanol reduces harmful emissions from IC Engines like CO, SO2, NOX and

Particulate emissions. Apart from fuel saving, the farmers of our country will be benefited by the additional income from Ethanol production. Diethyl ether (DEE) has recently been shown to be a very low emission substitute for Diesel. Here we use DEE only as a acetone improver for Ethanol to be used in CI Engines. Since DEE is commercially produced from Ethanol.

Objectives

The objective of this paper is

- To find the stability of different combinations of the Emulsion of Diesel, Ethanol and Diethyl Ether.
- To find the performance of the most stable combinations of the Emulsion of Diesel, Ethanol and Diethyl ether (DEE) in a single cylinder engine.

To find the emission characteristics of the most stable combinations of the Emulsion of Diesel, Ethanol and Diethyl ether (DEE) in a single cylinder engine.

Ethanol Production

The process of production of Ethanol from sugarcanes or grain is well known. Basically, the starch in grain is converted to sugar by means of enzymes and the sugar is then fermented with yeast to produce a dilute alcohol solution. Distillation is used to separate and purify alcohol.

1. Ethanol from Grains

Ethanol can be manufactured from any feedstock containing carbohydrates such as corn, wheat, sugar beets, sugarcanes and other grains. In the production of Ethanol from grains such as corns, the grains is first grounded and cooked with water to convert the starch to sugar with enzyme amylases. The sugar is fermented with yeast to produce raw Ethanol. The raw Ethanol is distilled to remove impurities such as higher alcohols and to remove most of the water. Ethanol forms an azeotrope with 5% water, and the last step in producing anhydrous Ethanol is an extractive distillation with benzene. The optimum capacity of Ethanol fermentation plant is small because of the difficulties in controlling and storing raw materials and typically would be about 1.4 million barrel per stream day.

2. Ethanol from Sugarcane

Ethanol is produced by fermentation of carbohydrates by the Gay Lussac relation,

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

In this process 180 gm of carbohydrate is converted to liquid fuel Ethanol weighing only 92 gm with almost no loss of energy. About 1.5 kg of sugarcane yields a litre of Ethanol. Molasses contain a large percentage of sugar, 30% or higher and most of the nutrient content that was in cane such as nitrogen, potassium and phosphorous. The potential of Ethanol production in India is 500 million litres per day.

Diethyl Ether Production

- Williamson synthesis.
- Dehydration of alcohols.

Williamson Synthesis

Any alkyl halide or sulphate can be reacted with sodium alkoxide or sodium phenoxide to give mixed ethers.

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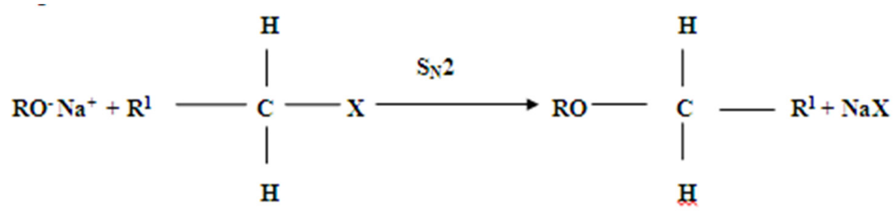
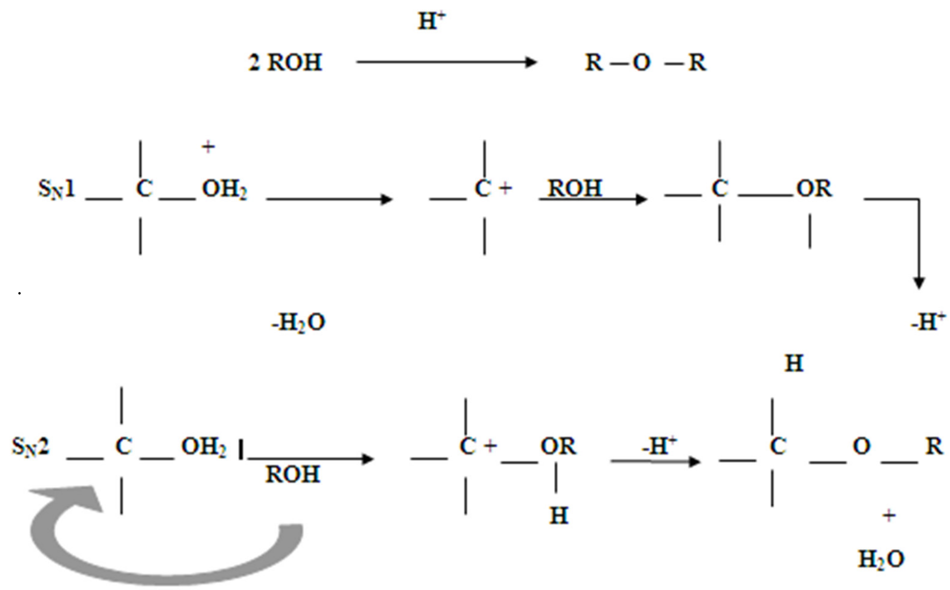


Primary Alkyl Halide

Dehydration of Alcohols

Diethyl ether is prepared by heating Ethanol with conc. H2SO4 at 1400 C. Alcohol is being added continuously to maintain an excess of alcohol concentration



Combustion Properties of Diethyl Ehter

- The burning velocity of DEE is 13% greater than normal heptanes.
- DEE with Ethanol has latent heat of vaporization and thus increases the efficiency.
- DEE has low heat release rate during early cool flame generation.
- Ignition delay time for DEE was slightly less than other hydrocarbons fuels.
- By blending DEE with Ethanol, it improves the cetane number and the Engine performance.

(So this paper is mainly concerned with the usage of Ethanol in Diesel by the way of blending with ignition improver Diethyl ether)

Precautions in Handling of DEE

- Flammable liquid and vapors.
- Keep container closed and do not breathe vapors.
- Avoid contact with skin, eyes and mucous membranes.
- Keep away from heat, sparks and flame.
- Protective neoprene or rubber gloves and apron are recommended.
- Store in an area designed for storage of flammable liquids.
- Protect from temperature extremes and sunlight and store away from incompatible substances.
- Avoid acids, bases, oxidizers, explosives, nitrogen-fluorine compounds, sulfites.

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- Once liquid solvent has been completely dispensed, containers which appear "Empty" should be handled in the same manner as when they were "Full" of liquid solvent.

Stability Test

It is clearly known that the Ethanol will not mix completely with Diesel. Due to this property, it is impossible to mix the Ethanol with Diesel more than 15%. When Ethanol is mixed with Diesel, it reduces acetone value of Diesel, lubricity and creates potential wear in Fuel pump. In order to improve the acetone value of Diesel, we are using Diethyl ether as an additive as well as an ignition improver. Although the additive has been added some of the combinations of the Ethanol blended diesel (E-Diesel) will not be stable. In order to find out the stable combinations of E – Diesel we performed the stability test.

Table 1: comparitative analysis of various fuels

PROPERTIES	DIESEL	ETHANOL	DI-ETHYL ETHER
Formula	$-C_{10}-H_{18}-$	C_2H_5OH	$- C_2H_5 -O- C_2H_5-$
Boiling point (^0C)	71 – 193	78.4	34.6
Cetane number	40 - 55	8	>125
Self ignition temp (^0C)	220	422	170
Stoichiometric air fuel ratio	14.1	9.0	11.1
Calorific value(kJ/kg)	42500	25500	31875
Viscosity (Cp)	2 – 4	1.19	0.23
Latent heat of vaporization (kJ/kg)	600	881.94	350
Specific Gravity@15^{0}C	0.88	0.785	0.71
Molecular weight	48.6	46.07	74.14

The test is performed from 10% - 90% replacement of the mixture of Ethanol and Diethyl ether with Diesel. In each replacement, the ratio from 0 – 100% for both. After conducting this test, the result proved that a few combinations remains stable more than 35 hours and while testing able to give better results when comparing to Diesel.

Among that few combinations we selected some of the following combinations and tested the performance and emission characteristics.

The selected combinations are as follows:

- 10% volume replacement of Diesel with Ethanol- ether mix(75% DEE & 25% Ethanol)
- 20% volume replacement of Diesel with Ethanol-ether mix(75% DEE & 25 % Ethanol)
- 30% volume replacement of Diesel with Ethanol-ether mix(75% DEE & 25% Ethanol)

Experimental Setup

The experimental setup consists of an Engine and all the latest equipment's and accessories required for measuring the engine parameters. The Engine used is single cylinder water cooled CI Engine (Kirloskar Engine). The Engine was loaded with the coupled Eddy current Dynamometer – the coupling arrangement is made with propeller shaft by slip joint and universal joint is shown in Fig(1).

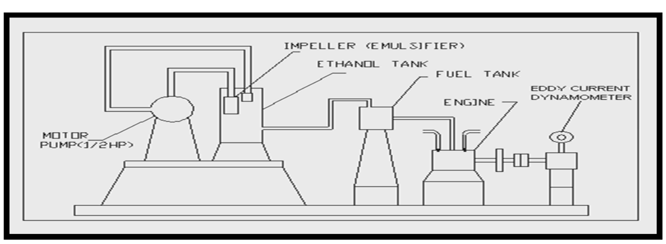

Fig 1.Experimental Setup for Emulsification

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Admission of (Diesel, Ethanol and DEE) emulsified mixture into the Engine is done by means of an electronic injector which is located conveniently in an inlet manifold. Supply of pressurized Emulsified mixture to the injector is by means of an external nitrogen cylinder where the pressure is constantly maintained at 2 bar is shown in Fig (2).

The main attraction of the experimental setup is the Engine computer interface. The important parameter mainly the mean effective pressure is acquired with the help of software called Data Acquisition System. The physical connection between the Engine and the computer is achieved by mounting a pressure transducer on a cylinder head. The pressure sensor or the pressure transducer houses a piezoelectric crystal which senses the pressure inside the Engine cylinder and converts it into charge amplifier where the signals are amplified and fed into the computer for display on the monitor

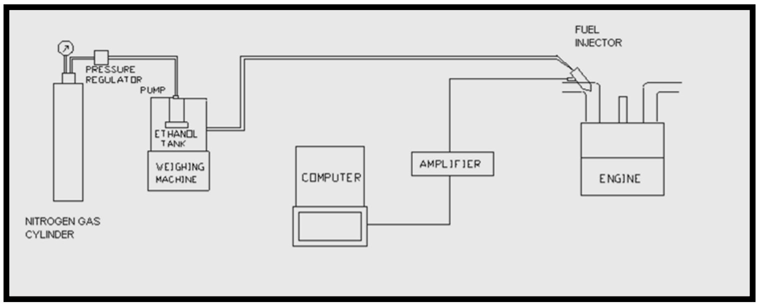

Fig 2. Block diagram of electronic fuel injector

.Engine Specifications

Kirloskar Engine

Engine type	: Vertical, 4-stroke cycle, single acting High CI Engine
Is rating at 1800 rpm	: 5.9 KW (8 BHP)
Bore	: 87.5 mm
Stoke	: 110 mm
Cubic capacity	: 0.61 lit
Normal compression ratio	: 17.5:1

Preparation of Emulsion

Emulsion is prepared by shaking or stirring by the dispersed phase on dispersed medium or subjecting them to vibration when the emulsifiers are present. Emulsors, stirrers and collide mills and alter sound are used for emulsification. Emulsification consists of dispersion property, the formation of droplets of the dispersed phase face in dispersion medium and their stabilization by absorption in the emulsifier surface. Emulsion stabilized by non-inorganic emulsifiers is more difficult to destroy.

Lab Preparation of Emulsion

In this project the Emulsion is prepared externally and is used for combustion. Diesel and Ethanol were poured into the Emulsion tank. The mechanical stirrer with motor placed near. The stirrer is immersed into the Emulsion tank.

When the motor pump pumps the Diesel –Ethanol altogether through the static stirrer, proper Emulsion is obtained by pressurization.

Experimental Procedure

The various steps involved in conducting this experiment are explained below:

- Initially the Emulsion of Diesel, Ethanol and Diethyl ether is filled in the fuel tank and connected to the Engine.
- The water pump is switched on and the Engine cooling temperature should be maintained between 60- 70oC.
- The Engine is cranked and run in idling for few minutes.
- The Engine is loaded by the dynamometer.
- The fuel consumption for 180 seconds is obtained from the electronic weighing machine.

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- The inlet air flow rate is measured from the manometer reading.
- The temperature of inlet air, exhaust gas, inlet water and water outlet are measured by the thermocouples at the suitable places.
- A part of the tail pipe emissions are connected to the smoke meter and five gas analyzer to measure the exhaust emission.
- In the same manner the readings corresponding for different loads are taken.
- From the readings obtained, the performances and emission characteristics are calculated and the results obtained at the different modes operation are compared.

Performance Curves

Performance curves were obtained by varying the different parameters which were obtained during various phases of tests. They are as follows:

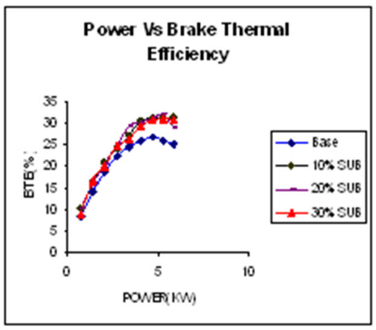


Fig 1: Brake Power Vs. Brake Thermal Efficiency

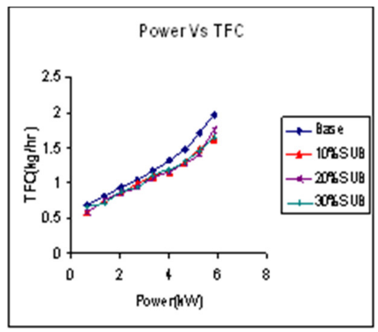
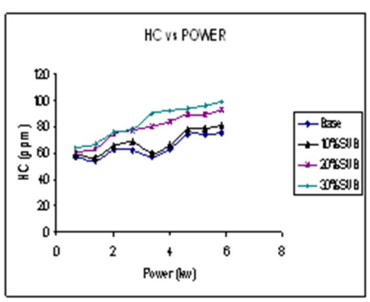


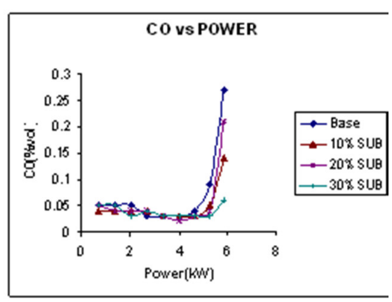
fig 2: Brake Power Vs. Total Fuel Consumption

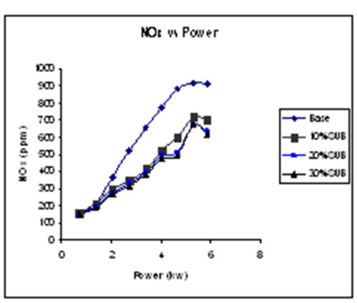
Emission Curves

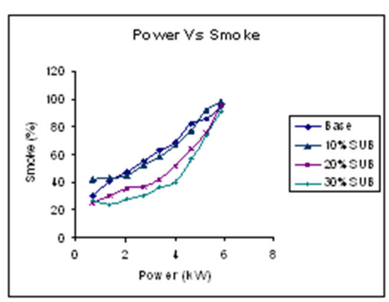
Emission curves were obtained by varying the different parameters which were obtained during various phases of tests.

- Brake Power Vs Hydrocarbons
- Brake Power Vs Carbon monoxide
- Brake Power Vs Oxides of nitrogen
- Brake Power Vs Smoke









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Results and Discussion

(a) Brake Thermal Efficiency (BTE)

- BTE is increased for all blends of DEE and Ethanol than that of the setup ran with Diesel.
- The maximum of 20% increase in BTE was obtained in 20% substitution.
- This is due to the addition of DEE, which acts as an ignition improver, which promotes better combustion and increases BTE.

(b) Total Fuel Consumption (TFC)

- TFC is reduced for all blends of DEE and Ethanol than of the Diesel.
- We are having a reduction of about 14% in TFC.

(c) CO2 Emission

- CO2 Emission is reduced for all blends of DEE and Ethanol than that of the Diesel.
- Here the CO2 emission is reduced by 10% from the base.

(d) CO Emission

- There is reduction in CO emission in the case of the Engine ran with the Emulsion of Diesel, Ethanol and DEE.
- There is a drastic reduction of CO about 75% at higher loads.
- This is due to the fact of complete combustion which takes place in the Engine due to the addition of DEE as an ignition improver.

(e) NOx Emission

- 30%decreases in NOx Emission is observed.
- This fact is mainly due to the temperature which was prevailing inside the combustion chamber due to better combustion.

(f) HC Emission

- A slightly increases in kin HC emission is mainly due to less carbon and hydrogen ratio kin diethyl ether and ethanol.

(g) Smoke

- At part loads the smoke is reduced to 20% and at full loads the reduction is about less than 10%.

Conclusion

Diesel engines are the largest consumer of petroleum products. The projected requirement of petroleum products are: 150 million tones for the year 2006, 190 million tones for the year 2012 and 365 million tones for 2025. Every year we are producing more vehicles and the demand for the diesel fuel increases. Based on the work carried out in the paper, the following conclusions are

- The BTE of the engine is increased by 20%.
- The TFC is reduced by 14%.
- At part loads the smoke is reduced to 20% and at full loads the reduction is about less than 10%.
- 30% decrease in NOx emission is observed due to better combustion in the combustion chamber.
- A slightly increased in HC emission is observed
- Reduction in CO and CO2 emission.
- The operation of the engine was smoother and there was a reduction in engine noise.

Thus the project proves that DEE + Ethanol will be the most sustainable alternate fuel in future for a compression ignition engine as an ignition improver.

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