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Effects of Adding Cetane Enhancer with Ethanol Blended Diesel Fuel at Various Compression Ratios

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Abstract: *This paper studies the effects of combining a cetane enhancer, ethanol and diesel by comparing its performance with unblended pure diesel against various compression ratios. The reason for using diesel is due to the fact that it has a higher thermal efficiency than that of petrol. Ethanol has the capability to increase the thermal efficiency. But, a drawback to using ethanol is that it lowers the cetane number. Hence, to enhance the cetane number, a cetane enhancer is added. The cetane enhancer used in this method is 2-Ethyl Hexyl Nitrate (alkyl nitrate). For this project ethanol is varied between 5, 10 and 15% and a fixed composition of 2-EHN at 0.75% is added to unblended pure diesel and tested.*

1. INTRODUCTION

The world as we know it is changing. With the price fossil fuels getting dearer by the day the need for alternate sources of energy/fuel is growing stronger by the minute. Among one of the alternative sources is ethanol. This has proved to be a common alternative automotive fuel itself and can be mixed with gasoline or diesel to form "gasohol"–of which the most common blends contain 10% ethanol and 85% ethanol mixed with gasoline.

Ethanol is also capable in helping in the fight against vehicular pollution (as it contains 35% oxygen which in turn helps in complete combustion and reduces harmful tailpipe emissions). Ethanol can also be produced from wheat, corn etc., and can help benefit farmers and the oil industry in the long run as it proves to be a viable and cheap source of energy.

1.1 CONCEPTUAL STUDY OF THE PROJECT

The project was started with the aim of providing an economical and feasible source of energy to the multitude in the long run. Ethanol and 2-EHN were decided to be added in proper ratios so as to increase the thermal efficiency and reduce the specific fuel consumption [4]. Different blends are prepared with fixed proportion of 2-EHN at 0.75% and ethanol at 5, 10 and 15% respectively.

With these blends, initially we calculate the calorific value using a bomb calorimeter. Then the density and viscosity of these blends were calculated and finally the performance test was conducted using a multifuel variable compression ratio engine. Performance curves were plotted and analyzed and performances of both pure and blended diesel were studied and compared.

1.2 OBJECTIVES OF THE PROJECT

- To study the properties of Ethanol and 2-EHN in detail
- To study the Performance characteristics of diesel engine by adding Ethanol and 2-EHN with diesel.

2. ADDITIVES USED

2.1 ETHANOL

Ethanol is an alcohol-based fuel made by fermenting and distilling starch crops, such as corn. It can also be made from "cellulosic biomass" such as trees and grasses. The use of ethanol can reduce our dependence upon fossil fuels to a certain extent. The most common blends contain 10% (E10) ethanol and 85% (E85) ethanol mixed with gasoline [2].

E10 (also called "gasohol") is a blend of 10% ethanol and 90% gasoline sold in many parts of the country. All auto manufacturers approve the use of blends of 10% ethanol or less in their gasoline vehicles. However, vehicles will typically go 3-4% fewer miles per gallon on E10 than on pure gasoline.

E85, a blend of 85% ethanol and 15% gasoline can be used in flexible fuel vehicles (FFVs) which are specifically designed to run on gasoline, E85, or any mixture of the two. FFVs are offered by several vehicle manufacturers.

2.2 properties of ethanol

Table 2.1: Physical Properties of Pure Ethanol

PROPETIES	FUEL ETHANOL
Flash Point	550 F
Density (g/cc)	0.789
Specific Gravity	0.79
Vapor Density	1.49
Boiling Point	1730 F
Flammable Range (LUL-UEL)	3.3%-19%
Conductivity	Yes
Water Solubility	Completely
Vapor Pressure	44 mm of Hg
Viscosity at 680 F	1.2 centipoise
Ignition Temperature	7930 F
Cetane Number	8

- Ethanol (E100) consumption in an engine is approximately 51% more than gasoline.
- Wider flammable range than gasoline
- Lower emissions due to unburned hydrocarbons
- Ethanol and gasoline are very similar in specific gravity

2.3 2-ETHYL HEXYL NITRATE

2-Ethyl Hexyl Nitrate is an alkyl nitrate used to raise the cetane number of diesel fuels [5]. 2-Ethyl Hexyl Nitrate has been used as a commercial cetane improver for a number of years and today is the predominant cetane improving additive in the marketplace.

2.4 PROPERTIES OF 2-EHN

- Increases the cetane number 2-9 units of diesel fuel when added in 0.4-0.75%
- Increases the solubility of ethanol in diesel
- Combustible in both liquid and vapor formats
- 2-EHN is immiscible with water

Table 2.2: Physical Properties of 2-EHN

PROPERTIES	2-EHN
Flash Point	168.80 F
Density (g/cc)	0.963
Viscosity (centistokes)	1.8
Molecular Weight	175.23
Freezing Point	Less than450 C
Boiling Point	less than1000 C
Vapor Pressure	27 Pa at 200 C
Heat of Vaporization	368 KJ/kg
Coefficient of Thermal Expansion	1.01

3. EXPERIMENTAL WORK

3.1 METHODOLOGY

From the [1] it is clear that with the addition of ethanol up to 15% the brake thermal efficiency increases and brake specific fuel consumption decreases gradually. Similarly, the best ratio of 2-EHN to be added to obtain optimal performance is 0.75%.

Thus different blends are prepared with fixed proportion of 2-EHN (0.75%) and ethanol with 5%, 10% and 15% respectively and rest diesel. Finally the calorific value, density and viscosity of these blends have to be calculated and the performance test was conducted. The various combination of the blends to which performance is to be conducted

Table.3.1: Combination of Blends

SL.NO	DIESEL	ETHANOL	2EHN
1	94.25%	5%	0.75%
2	89.25%	10%	0.75%
3	84.25%	15%	0.75%

The tests are conducted for the above combination of blends in multi-fuel VCR engine for different compression ratios–15, 16, 17, 18 and 19.

3.2 COMPUTERIZED VARIABLE COMPRESSION RATIO MULTI FUEL ENGINE SPECIFICATIONS

The performance test is carried out using the computerized multi-fuel VCR Engine Test Rig as shown in Fig.3.1.in accordance with [3]

Fig. 3.1: Mulitfuel VCR Engine

3.3 SPECIFICATION

- Compression ratio variable from 5:1 to 10:1 for petrol
- Compression ratio variable from 14:1 to 20:1 for diesel
- Runs on both petrol and diesel fuel
- Consists of spark plug, ignition coil, diesel injection, diesel pump and carburetor. Therefore very useful in testing alternative fuels.
- Make : Legion Brothers

- No of cylinder : Single
- Speed : 1400–1500 RPM
- HP : 3–5 HP
- Cylinder bore : 80 mm
- Stroke length : 110 mm
- Brake drum diameter : 260 mm

3.4 CALCULATION OF CALORIFIC VALUE, DENSITY AND VISCOSITY OF BLENDS

Calculation of Calorific Value

The calorific value of the blends was calculated using Bomb Calorimeter as follows

Water Equipment=[(H × M) + (CV_T + CV_W)]/T

Where,
T=Final rise in temperature in ^{0}C
M=Mass of sample in grams
H=Known calorific value of benzoic acid (6350 cal/gm)
W=Water equivalent in cal/^{0}C
CV_Y=Calorific value of thread
=2.1/cm
CV_W=Calorific value of ignition wire
=2.33/ cm

CV_S=Calorific value of sample
Case 1: When the temperature raise is 3.28^{0}C
W=[(6350 × 1.5) + (21 + 9.32)]/3.28
=2913 cal/^{0}C
Case 2: When the temperature rise is 3.08^0 C
W=3102.37 cal/^{0}C
The average water equivalent is W=2962.5 cal/^{0}C
For the blend with 5% Ethanol:
H=[(W×T)-(CV_T+CV_W)]/M
Where
Temperature rise T=3.64^0 C
Mass of the sample=1 gram.
H=(2962.5×T)-30.32
H=10753.18 cal/gm
H=44.991 MJ/kg
Similarly,
For the blend with 10% Ethanol:
H=45.363 MJ/kg
For the blend with 15% Ethanol:
H=46.177 MJ/kg

Table 3.2: Calorific Value for Various Blends

Sl. No	FUEL	Calorific Value (MJ/kg)
1	Pure Diesel	44
2	5% Ethanol Blended	44.991
3	10% Ethanol Blended	45.363
4	15% Ethanol Blended	46.177

Calculation of Density

Table 3.3: Density Values for Various Blends

Sl. No	Fuel	Density (gm/cc)
1	Pure Diesel	0.832
2	5% Ethanol Blended	0.815
3	10% Ethanol Blended	0.805
4	15% Ethanol Blended	0.795

We know that,
Density=Mass/Volume
For 5% Ethanol Blend:
For 100 ml fuel, mass=81.5 grams
Density = 81.5/100=0.815 g/cc
For 10% Ethanol Blend:
Density = 80.5/100=0.805 g/cc
For 15% Ethanol Blend:
Density = 79.5/100=0.795 g/cc

Calculation of Viscosity

Table 3.4: Viscosity Observation

SL NO	TIME TAKEN FOR SAMPLES (in sec)			
	5% ETHANOL BLENDED	10% ETHANOL BLENDED	15% ETHANOL BLENDED	WATER
1	374	351	345	96

Viscosity of the fluid is given by the equation,
$\mu=(\mu_s \times \theta \times \rho)/ (\theta_s \times \rho_s)$
Where,
μ=Kinematic viscosity of fluid in m^2/s
μ_s=Kinematic viscosity of water (0.801×10^{-6} m^2/s)
θ=Time taken for the sample in seconds
θ_s=Time takenfor the water in seconds
ρ=Density of sample in kg/m^3
ρ_s=Density of water in kg/m^3 (1000kg /m^3)
For 5% Ethanol Blend:
Kinematic viscosity
ɣ=(0.801× 10^{-6} ×374 × 815)/ (96 × 1000)
= 2.54×10^{-6} m^2/s
Dynamic viscosity =Kinematic viscosity × Density
= 2.54 × 10^{-6} × 815
=2.07 × 10^{-3} Ns/m^2
Similarly,
For 10% Ethanol Blend:
Kinematic viscosity=2.357 × 10^{-6} m^2/s
Dynamic viscosity=1.89 × 10^{-3} Ns/m^2

Table 3.5: Viscosity Values for Various Blends

SL NO	FUEL	KINE-MATIC VISCOSITY × 10-6 m2/s	DYNAMIC VISCO-SITY × 10-3 Ns/m2
1	5% Ethanol Blended	2.54	2.07

2	10% Ethanol Blended	2.357	1.89
3	15% Ethanol Blended	2.288	1.819

For 15% Ethanol Blend:

Kinematic viscosity=2.288×10^{-6} m^2/s

Dynamic viscosity=1.819×10^{-3} Ns/m^2

4. RESULTS AND DISCUSSION

From the readings obtained through extensive testing of both pure and blended diesel we have inferred thatCR19 is the most effective compression ratio. We can justify through the following graphs.

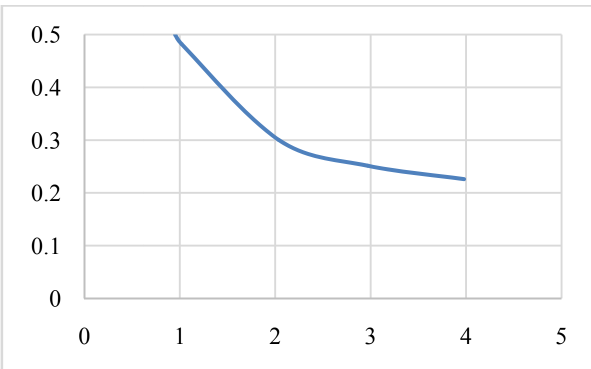

Fig. 4.1: BP vs SFC (Pure Diesel)

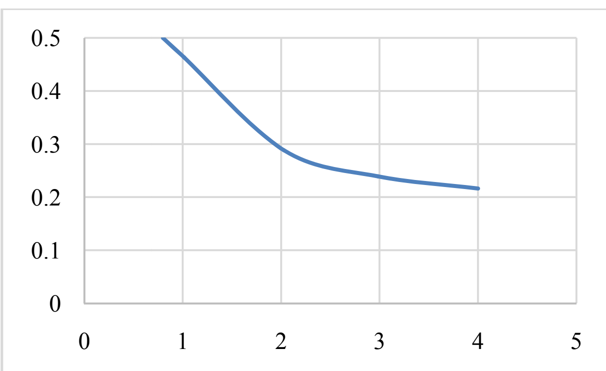

Fig. 4.2: BP vs SFC (15% Ethanol Blend)

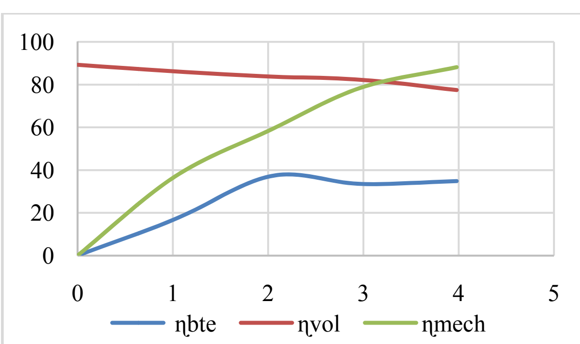

Fig. 4.3: BP vs VARIOUS EFFICIENCIES (Pure Diesel)

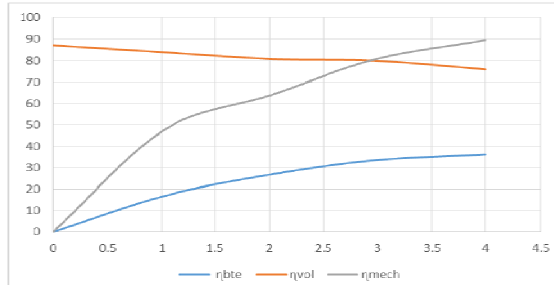

Fig. 4.3: BP vs VARIOUS EFFICIENCIES (15% Ethanol Blend)

5. CONCLUSION

From the Result and Discussion, we inferred that:

Table 5.1: Comparison of the Results

Performance Parameters	Unblended Diesel (CR-19)	15% Ethanol Blended (CR-19)	Result
Brake Thermal Efficiency	34.81%	36.27%	BTE Increased by 4.21%
Brake Specific Fuel Consumption (BSFC)	0.224117	0.216279	BSFC Decreased by 4.33%

- At the maximum load condition, the Specific fuel consumption (SFC) for 15% Ethanol Blend (CR 19) is 0.216279 kg/kWh while comparing this condition with unblended diesel (compression ratio 19) the SFC is 0.226075 kg /kWh. Thus SFC is decreased up to 4.33% by blending 15% Ethanol with diesel.
- Brake thermal efficiency (BTE) for 15% Ethanol blend (CR 19) is 36.2735% while among the unblended diesel (CR 19) the brake thermal efficiency is 34.8068%. Thus BTE is increased up to 4.21% by blending 15% Ethanol with diesel.
- From the result, it is clear that, among the blend, 15% Ethanol Blend holds best results when compared to other blend.

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