EFFECTS OF ADDING CETANE ENHANCER WITH ETHANOL BLENDED DIESEL FUEL

ISO 9001 2008

A PROJECT REPORT

Submitted by

PRABHAKARAN.N (Register No: 0810103028)

SATHEESH.L (Register No: 0810103307)

SIVARAM.T.R (Register No: 0810103049)

In partial fulfillment for the award of the degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

COIMBATORE - 641049

APRIL 2012

KUMARAGURU COLLEGE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

ISO 9001:2000

BONAFIDE CERTIFICATE

Certified that this project report

EFFECTS OF ADDING CETANE ENHANCER WITH ETHANOL BLENDED DIESEL FUEL

is a bonafide work of

PRABHAKARAN.N (Register No: 0810103028)

SATHEESH.L (Register No: 0810103307)

SIVARAM.T.R (Register No: 0810103049)

who carried out the project work under my supervision.

Prof.S.Prabhu
Project Guide

Dr.N.Mohandas Gandhi
Head of the Department

Submitted for the end semester examination held on 12-04-2012

Internal Examiner

External Examiner

ACKNOWLEDGEMENT

First and foremost, I pay my sincere and humble salutations to the almighty for equipping me with all the strength and courage throughout my venture in the project work.

At this pleasing moment of having successfully completed the project work. I wish to acknowledge my sincere gratitude and heartfelt thanks to our beloved Principal **Dr.S.RAMACHANDRAN** for his kind permission to work on this project.

I express my sincere thanks to **Dr.N.MOHANDAS GANDHI** the Head of the Department of Mechanical Engineering for his support in carrying out this project.

I have my heartfelt thanks to my guide **Prof.S.PRABHU** Assistant Professor, Department of Mechanical Engineering for his guidance in carrying out this project.

I express my sincere thanks to **Prof.ARULPRAKASH** Assistant Professor, Department of Aeronautical Engineering for his support in carrying out this project

I also thank all the staff members and the lab technicians in the organization and Mechanical Engineering Department for their excellent cooperation throughout the project work.

ABSTRACT

The objective of this project is to study the effects of adding cetane enhancer and ethanol with diesel by comparing its performance with unblended pure diesel. The reason for choosing diesel is that it is cheaper than petrol and its thermal efficiency is higher than that of petrol. From the literature survey, it is clear that ethanol increases the heat release rate or combustion rate of diesel and hence increases thermal efficiency. In addition to that ethanol increases the ignition lag i.e., lowers the cetane number. Hence to enhance the cetane number, cetane enhancer has to be added. Cetane enhancer used in this project is 2-Ethyl Hexyl Nitrate (alkyl nitrate). Thus ethanol is varied from 5, 10, and 15% and fixed composition of 2-EHN as 0.75% is added to diesel, by means of which the brake thermal efficiency increases and brake specific fuel consumption decreases gradually. Performance graphs for both the blended and unblended diesel have been plotted. It is inferred that thermal efficiency is increased up to 4.21 % and specific fuel consumption decreased by 4.33%.

Keywords: Cetane number, 2-Ethyl Hexyl Nitrate, thermal efficiency, etc.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IMEP - Indicated Mean Effective Pressure

IP - Indicated Power

FP - Friction power

BMEP - Brake Mean Effective Pressure

BP - Brake Power

BSFC - Brake Specific Fuel Consumption

TFC – Total Fuel Consumption

η_{BTE} - Brake Thermal Efficiency

η_{vol} - Volumetric Efficiency

η_{mech} - Mechanical Efficiency

THC - Total Hydrocarbon

2-EHN – 2-Ethyl Hexyl Nitrate

CV – Calorific Value

CR – Compression Ratio

CN – Cetane Number

Γ – Kinematic viscosity

μ - Dynamic viscosity

ρ - Density

CHAPTER 1

INTRODUCTION

1.1 CURRENT SCENARIO

1.1.1 INTERNATIONAL MARKET

It is becoming increasingly clear that global oil production will soon go into terminal decline, with potentially devastating economic consequences. Although the idea of peak oil has traditionally been ridiculed by the industry, now even some of the world's most senior oilmen concede the case. Last year Thierry Desmarest, chairman of Total, the world's fourth largest oil company, declared that production would peak by around 2020.

The American Petroleum Institute estimated in 1999 the world's oil supply would be depleted between 2062 and 2094, assuming total world oil reserves at between 1.4 and 2 trillion barrels (220 and 320 km^3) and consumption at 80 million barrels per day (13,000,000 m^3/d). In 2004, total world reserves were estimated to be 1.25 trillion barrels (199 km^3) and daily consumption was about 85 million barrels (13,500,000 m^3), shifting the estimated oil depletion year to 2057. Hence it becomes absolutely mandatory to come up with alternatives like biodiesel, Ethanol, CNG etc. to keep the hope of automotive sector alive.

1.1.2 INDIAN MARKET

India imports nearly 70% of its annual crude petroleum requirement, which is approximately 110 million tons. The prices are in the range of US$ 50-70 per barrel, and the expenditure on crude purchase is in the range of Rs.1600 billion per year, impacting in a big way, the country's foreign exchange reserves.

Amid the depletion of petroleum oil, there is no choice other than to find an alternative. Ethanol is one such alternative automotive fuel by itself and can be mixed with gasoline or diesel to form what has been called "gasohol" - the most common blends contain 10% ethanol and 85% ethanol mixed with gasoline. Thus the use of ethanol can reduce our dependence upon foreign oil and reduce greenhouse gas emissions.

The petroleum industry now looks very committed to the use of ethanol as fuel, as it is expected to benefit sugarcane farmers as well as the oil industry in the long run. Ethanol (FUEL ETHANOL) can also be produced from wheat, corn, beet, sweet sorghum etc. Ethanol is one of the best tools to fight vehicular pollution, contains 35% oxygen that helps complete combustion of fuel and thus reduces harmful tailpipe emissions. It also reduces particulate emissions that pose a health hazard.

India being the world's second largest producer of sugar from cane after Brazil, is expected to use a growing portion of cane by-product molasses for making ethanol. For the world, Brazil stands as the shining example of very largely eliminating greenhouse gas emission by using ethanol either in a blend with petrol or on standalone basis in its automobile fleet. Brazil and the US between them are responsible for over 85 per cent of the world ethanol production. In Brazil, 25 per cent ethanol doping in gasoline is mandatory, while over 11 million Flex cars on Brazilian roads run entirely on ethanol. India needs catching up.

1.2 CONCEPTUAL STUDY OF PROJECT

The objective of this project is to study the effects of adding cetane enhancer and ethanol with diesel by comparing its performance with unblended pure diesel. The reason for choosing diesel is that it is cheaper than petrol and its thermal efficiency is higher than that of petrol. Initially the performance test for pure diesel was carried out in Multifuel variable compression ratio engine and its performance graphs are plotted and analyzed. From the literature survey, it is clear that ethanol increases the heat release rate or combustion rate of diesel and hence it helps to increase thermal efficiency. The reason for selecting Ethanol is that it has high calorific value and low cost when compared to other alternative fuels. One major disadvantage of Ethanol is, it increases the ignition lag i.e. reduces the cetane number of diesel fuel because of its low cetane number. Thus to increase the cetane number, cetane enhancer is added. Cetane enhancer used in this project is 2-Ethyl Hexyl Nitrate (2-EHN).

Hence, Ethanol and 2-EHN are to be added in proper ratios so as to increase the Thermal Efficiency and reduce the Specific Fuel Consumption. Different blends are prepared with fixed proportion of 2-EHN as 0.75% and Ethanol with 5%, 10% and 15% respectively. With these blends, initially we have to calculate the calorific value using bomb calorimeter. Then the density and viscosity for these blends should be calculated. Finally the performance test for these blends has to be conducted in the Multifuel variable compression ratio engine. Performance curves should be plotted and analyzed. Performance of both the pure diesel and blended diesel are studied and compared. It is inferred that the brake specific fuel consumption decreases and brake thermal efficiency increases with increase in Ethanol.

1.3 OBJECTIVE 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.

CHAPTER 2

LITERATURE REVIEW

Lu Xing-cai et al. (2004) investigated the influence of cetane number improver on heat release rate and emissions of a high-speed diesel engine fuelled with ethanol-diesel blend fuel. Different percentages of cetane number enhancer (0, 0.2, and 0.4%) were added to blends, and the engine tests were performed on a 4-cylinder high-speed DI diesel engine. The results show that: the brake specific fuel consumption(BSFC) decreased, the diesel equivalent BSFC decreased, the thermal efficiency improved remarkably, and NOx and smoke emissions decreased simultaneously when diesel engine fuelled with ethanol-diesel blend fuels; NOx and smoke emissions further reduced when CN improver was added to blends.

De-gang Li et al. (2004) had produced a technical note about physico-chemical properties of ethanol-diesel blend fuel and its effect on performance and emissions of diesel engines. Effects of different ethanol–diesel blended fuels on the performance and emissions of diesel engines have been evaluated experimentally and compared. The purpose of this project is to give optimum percentage of ethanol that gives simultaneously better performance and lower emissions. The experiments were conducted on 0% (neat diesel fuel), 5% (E5–D), 10% (E10–D), 15% (E15–D), and 20% (E20–D) ethanol–diesel blended fuels. With the same rated power for different blended fuels and pure diesel fuel, the engine performance parameters (including power, torque, fuel consumption, and exhaust temperature) and exhaust emissions were measured. The results indicate that the brake specific fuel consumption and brake thermal efficiency increased with an increase of ethanol contents in the blended fuel at overall operating conditions. And also smoke emissions decreased with ethanol–diesel blended fuel, especially with E10–D and E15–D. CO and NOx emissions reduced for ethanol–diesel blends.

Ajav et al. (1999) had produced a report about experimental study of some performance parameters of a constant speed stationary diesel engine using ethanol-diesel blends as fuel. The performance of a constant speed, stationary diesel engine using ethanol-diesel blends as fuel has been evaluated experimentally. The experiments were performed using 5, 10, 15 and 20% ethanol-diesel blends. Diesel fuel was used as a basis for comparison. The effect of using different blends of ethanol-diesel on engine horsepower. brake specific fuel consumption. brake thermal efficiency, the exhaust gas temperature and lubricating oil temperature were studied. The results indicate no significant power reduction in the engine operation on ethanol-diesel blends (up to 20%) at a 5% level of significance. Brake specific fuel consumption increased by up to 9% with an increase of ethanol up to 20% in the blends as compared to diesel alone.

Lunaidah Md Saad, Baljit Singh et al. (2010) investigated the effect of using additive on four stroke engine performance and exhaust emission. This investigation focused on the comparison of performances of an internal combustion engine fitted with the fuel additive. Performance tests were conducted for, fuel consumption, engine torque and engine power. while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide (C02). oxygen (02) and unburned hydrocarbons (HC) at variable engine speed ranging from 1000 to 6000 rpm. The results showed that the effect of the adding fuel addictive gives more power and increases fuel efficiency compared to the fuel without additives.

Manish K. Nandi et al. (2009) investigated the performance of di tertiary-butyl peroxide as cetane improver in diesel fuels. Here we are evaluating the performance of a peroxide based cetane improver for diesel fuel. A comparison is made between the performance of di-tertiary-butyl peroxide and the conventional cetane improver. 2-ethylhexyl nitrate. Correlation between the cetane responses of the peroxide with the different fuel properties is discussed. Both the additives significantly reduce all regulated and unregulated emissions including NOx emissions. The NOx emissions from the peroxide treated fuels are consistently lower than those for the nitrate treated fuels at similar cetane level. The chemistry for the synthesis of di-tertiary-butyl peroxide is discussed.

Hwanam kim et al. (2010) investigated the engine performance and emission characteristics of CRDI diesel engine equipped with wcc and doc using ethanol blended diesel fuel.
This experiment investigates on neat diesel fuel and a blend of diesel fuel with 15% ethanol with cetane improver EHN (2-ethylhexyl nitrate) of 7500ppm. The experiment measures engine performance according to ECE 13 mode cycles. The maximum torque provided by the ethanol diesel-EHN blended fuel was higher than neat diesel. The specific fuel consumption decreases

with 15% ethanol blended diesel in low load. The various exhaust gas treatments are done in this project. The performance test is done by means of CRDI(common rail direction injection), WCC(warm-up catalytic converter), DOC(diesel oxidation catalyst) which uses three types of fuels, namely neat diesel(D100), a blend of diesel fuel with 15% ethanol(E15+D) , a blend of diesel fuel with 15% ethanol and cetane number improver(E15+D+CI). The brake specific fuel consumption(BSFC) for each of the 3 kinds of fuels. The BSFC of the fuels were significantly different in low load conditions, but were similar in the middle and high load conditions. From the BSFC and lower heating value of the 3 kinds of fuel. The lower heating value of ethanol is about two thirds that of the diesel and is expected to increase the fuel consumption by about 6% when 15% of ethanol is blended in diesel. Thus the E15-D-CI has the highest thermal efficiency at the same horsepower. This result is due to the improved spray characteristics and atomization of fuel. The engine performance from E15-D and E15-D-CI was similar to that of the base diesel engine with respect to power output, and E15-D-CI had the highest thermal efficiency because of the addition of the cetane improver.

Donepudi Jagadish et al. (2011) studied the effect of supercharging on performance and emission characteristics of compression ignition engine with diesel-ethanol-ester blends. Ethanol-diesel blend fuel has been studied as a possible alternative fuel for petroleum. Because ethanol contains oxygen (34.3% of oxygen content) in the fuel, it can effectively reduce the emission of PM in the diesel engine. It is observed that E10B and E20B have shown similar fuel consumption values when compared with diesel but E30B observed to be little expensive at part load operation but economical at higher loads. With supercharging the fuel consumption values of E10B, E20B, and E30B are reduced in comparison to diesel fuel. The graphs of BTE vs. Load shows that Thermal efficiency values of E20B and E30B observed to be little high in comparison to diesel with no supercharging, whereas E10B showed values similar to diesel. With supercharging E10B and E20B showed improvement in thermal efficiency and E30B showed performance similar to diesel. It seems that addition of ethanol more than 20% is not advisable.

Richard stone (1999) has discussed various facts about internal combustion engines in his book called "Introduction to IC engines". According to him, additives in diesel fuel to improve the cetane number are also referred to as "the ignition accelerators". Their concentrations are greater than those of anti-knock additives used in petrol. Typically an improvement of 6 on the cetane scale is obtained by adding 1% by volume of amyl nitrate. Other effective substances are ethyl nitrate and ethyl nitrite. However the most widely used additive is currently 2-Ethyl hexyl nitrate (2-EHN), because of its good response in a wide range of fuels and comparatively low cost. Adding 1000 ppm of 2-EHN will increase the cetane rating by about 5 units. In some parts of the world there is legislation limiting the hydrogen content of diesel fuel; this is because although the mass of nitrogen is negligible to that available from air, fuel-bound nitrogen contributes disproportionately to nitric oxide formation. Under the circumstances peroxides can be used, such as ditertiary butyl peroxide.

CHAPTER 3

ADDITIVES USED

3.1 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 foreign oil and reduce greenhouse gas emissions. The most common blends contain 10% (E10)ethanol and 85% (E85)ethanol mixed with gasoline.

E10 (gasohol)

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 straight gasoline.[1]

E85

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

3.1.1 PROPERTIES OF ETHANOL

- Ethanol (E100) consumption in an engine is approximately 51% more than the gasoline since the energy per unit volume of ethanol is 34% lower than the gasoline.
- Wider flammable range than gasoline.
- In pure form, burning ethanol has no visible smoke & a hard-to-see blue flame.
- Ethanol increases the heat output of unleaded gasoline.
- Lower emissions from unburned hydrocarbons.
- Ethanol is less toxic than gasoline or methanol.
- Unlike gasoline, ethanol mixes easily with water.

- The higher the concentrations of ethanol, the more the fuel has polar solvent-type characteristics with corresponding effects on conducting fire suppression operations.
- Ethanol and gasoline are very similar in specific gravity.

PHYSICAL PROPERTIES

Table 3.1 Physical Properties of pure Ethanol

PROPERTIES	FUEL ETHANOL
Flash point	55 deg F
Density(g/cc)	0.789
Specific gravity	0.79
Vapor density	1.49
Boiling point	173 deg F
Flammable range (LEL-UEL)	3.3%-19%
Conductivity	Yes
Water Solubility	Completely
Vapour pressure	44mm Hg
Viscosity at 68 deg F (centipoise)	1.2
Ignition temperature	793 deg F
Cetane number	8

3.1.2 BENEFITS OF ETHANOL

Ethanol is a much cleaner fuel than petrol (gasoline):

- It is a renewable fuel made from plants
- It is not a fossil-fuel: manufacturing it and burning it does not increase the greenhouse effect.
- It provides high octane at low cost as an alternative to harmful fuel additives
- Ethanol blends can be used in all petrol engines without modifications
- Ethanol is biodegradable without harmful effects on the environment
- It significantly reduces harmful exhaust emissions
- Ethanol's high oxygen content reduces carbon monoxide levels more than any other oxygenate: by 25-30%, according to the US EPA
- Ethanol blends dramatically reduce emissions of hydrocarbons, a major contributor to the depletion of the ozone layer
- High-level ethanol blends reduce nitrogen oxide emissions by up to 20%
- Ethanol can reduce net carbon dioxide emissions by up to 100% on a full life-cycle basis
- High-level ethanol blends can reduce emissions of Volatile Organic Compounds (VOCs) by 30% or more (VOCs are major sources of ground-level ozone formation)
- As an octane enhancer, ethanol can cut emissions of cancer-causing benzene and butadiene by more than 50%
- Sulphur dioxide and Particulate Matter (PM) emissions are significantly decreased with ethanol.

3.1.3 DISADVANTAGES OF ETHANOL

- Ethanol`s greatest hazard as a motor fuel component is its flammability. It has a wider flammable range than gasoline (LEL is 3.3 percent and UEL is 19 percent).
- Calorific value of Ethanol is less when compared to diesel (Diesel: 44 MJ/kg, Ethanol: 30 MJ/kg).
- Cetane number of Ethanol is very less.
- Another disadvantage of using Ethanol is that it increases the ignition lag of diesel fuel.
- The cost of Ethanol is also comparably higher than that of diesel.

3.2 2-ETHYL HEXYL NITRATE

2-Ethyl Hexyl Nitrate is an Alkyl Nitrate used to raise the cetane number of diesel fuels. 2-Ethylhexyl nitrate (EHN) has been used as a commercial cetane improver for a number of years and today is the predominant cetane improving additive in the marketplace.

3.2.1 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 liquid and vapour.
- "Harmful by skin contact". Prolonged skin contact may produce temporary discomfort.
- 2-EHN is immiscible with water. The material floats on water and may emulsify.
- 2-EHN is combustible but it is not classified as a flammable liquid. The closed cup flash point of 2-EHN is above 70 deg C.

PHYSICAL PROPERTIES

Table 3.2 Physical Properties of 2-EHN

Properties	2-EHN
Flash point	168.8 deg F
Density(g/cc)	0.963
Viscosity(centistokes)	1.8
Molecular weight	175.23
Freezing point	Less than -45 deg C
Boiling point	>100 deg C
Vapour pressure	27 pa at 20 deg C
Heat of vaporisation	368 KJ/kg
Coefficient of thermal expansion	1.010

3.2.2 BENEFITS

- Used to enhance the cetane number of diesel fuel thereby decreasing the ignition lag.
- Increases the solubility of ethanol in diesel.
- Increases the thermal efficiency when blended with diesel fuel.

3.2.3 DISADVANTAGES

- Cost is the major disadvantage for 2-EHN.

CHAPTER 4

EXPERIMENTAL WORK

4.1 METHODOLOGY

From the literature review, it is clear that with addition of ethanol up to 20%, the brake thermal efficiency increases and brake specific fuel consumption decreases gradually. Similarly, the best ratio of 2-EHN to be added to obtain maximum 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 4.1 Combination of blends

S.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 multifuel VCR engine for different compression ratios-15, 16, 17, 18 and 19.

4.2 COMPUTERIZED VARIABLE COMPRESSION RATIO MULTI FUEL ENGINE SPECIFICATIONS

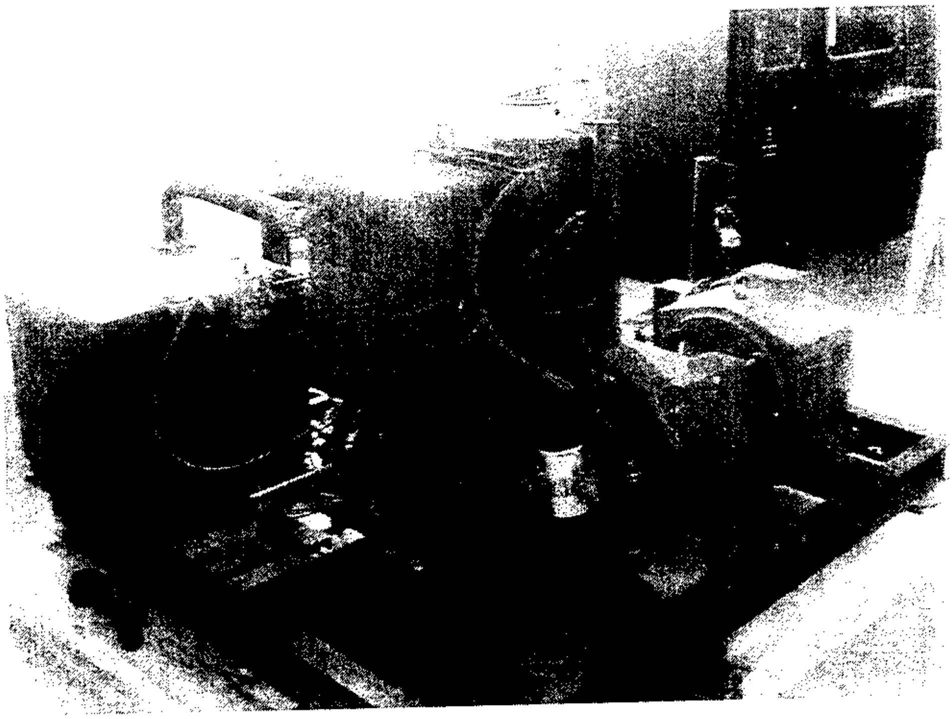

Fig. 4.1 Computerised VCR Engine Test Rig

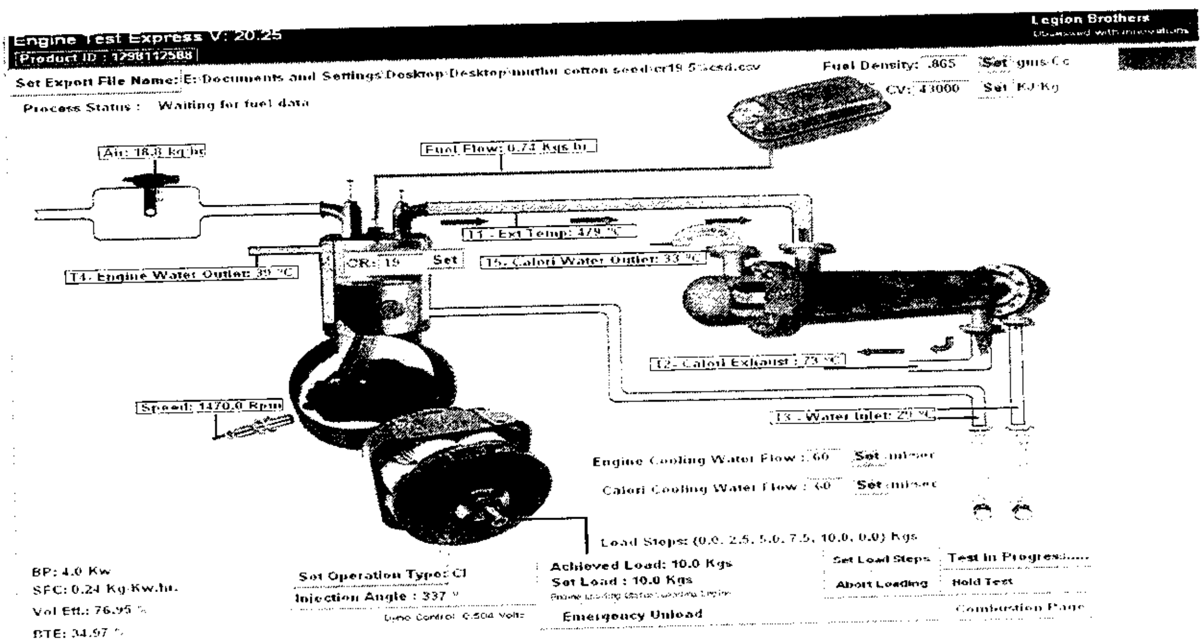

Fig. 4.2 Engine test Express V5.76

The Performance test is carried out using the computerised Multifuel VCR Engine Test Rig as shown in Fig. 4.1. The detailed arrangement of the Engine setup is shown in Fig. 4.2

SPECIFICATIONS

- 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 injector, diesel pump and carburettor. 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

4.3 CALCULATION OF CALORIFIC VALUE, DENSITY AND VISCOSITY OF BLENDS

4.3.1 CALCULATION OF CALORIFIC VALUE

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

FORMULA FOR WATER EQUIVALENT:

$$\text{Water Equivalent} = ((H*M) + (CV_T+CV_W))/T$$

Where

T = Final rise in temperature in deg C

M = Mass of sample in grams

H = Known calorific value of benzoic acid in cal/gm = 6350

W = Water equivalent in cal/ deg C

CV_T = Calorific value of thread

= 2.1/cm (when using thread 10cm, CV of thread = 2.1*10 = 21 cal)

CV_W = Calorific value of ignition wire

= 2.33/cm (using wire of 6 cm, CV of wire = 2.33*4 = 9.32 cal)

CV_s = Calorific value of sample

Case 1: when the temperature rise is 3.28 deg C

W = ((6350 * 1.5) + (21 + 9.32))/3.28

= 2913 cal/ deg C

Case 2: when the temperature rise is 3.08 deg C

W = 3102.37 cal/ deg C

The average Water equivalent is W = 2962.5cal/ deg C

For the blend with 5% Ethanol:

$$H = ((W*T) - (CV_T + CV_W))/M$$

Where the temperature rise T = 3.64 deg 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 4.2 Calorific value for various blends

S.NO	FUEL	CALORIFIC VALUE(MJ/KG)
1	Pure Diesel	44
2	5% Ethanol Blend	44.991
3	10% Ethanol Blend	45.363
4	15% Ethanol Blend	46.177

4.3.2 CALCULATION OF DENSITY

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

Table 4.3 Density values for various blends

S.NO	FUEL	DENSITY (gm/cc)
1	Pure Diesel	0.832
2	5% Ethanol Blend	0.815
3	10% Ethanol Blend	0.805
4	15% Ethanol Blend	0.795

4.3.3 CALCULATION OF VISCOSITY:

OBSERVATIONS:

Table 4.4 Viscosity Observations

S.NO	TIME TAKEN FOR SAMPLE (IN SEC)			
	5% ETHANOL BLEND	10% ETHANOL BLEND	15% ETHANOL BLEND	WATER
1	374	351	345	96

Viscosity of the fluid is given by the equation,

$$\mu = (\mu_s * \theta * \rho) / (\theta s * \rho_s)$$

μ is the kinematic viscosity of fluid in m^2/s

μ_s is the kinematic viscosity of water ($.801*10^{-6}$ m^2/s)

θ is time taken for the sample in seconds

θ_s is time taken for the water in seconds

ρ is density of sample in kg/m^3

ρ_s is density of water in kg/m^3 ($1000\ kg/m^3$)

For 5% Ethanol Blend:

Kinematic viscosity, $\gamma = (.801*10^{-6}*374*815)/(96*1000)$

$= 2.54*10^{-6}\ m^2/s$

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 = $1.89*10^{-3} Ns/m^2$

For 15% Ethanol Blend:

Kinematic viscosity = $2.288*10^{-6}\ m^2/s$

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

Table 4.5 Viscosity values for various blends

S.NO	FUEL	Kinematic Viscosity $*10^{-6}\ m^2/s$	Dynamic viscosity $*10^{-3}\ Ns/m^2$
1	5% Ethanol Blend	2.54	2.07
2	10% Ethanol Blend	2.357	1.89
3	15% Ethanol Blend	2.288	1.819

4.4 TABULATION FOR PURE AND BLENDED DIESEL

TABLE 4.6 PERFORMANCE CHARACTERISTICS FOR PURE DIESEL CR 15

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.700406	1.700406	0	22.74204	0	1530	0.331491	0	0	0	89.60953	0
2.477157	1.454123	1.451167	21.86123	2.483608	1500	0.457406	1.007561	0.453974	18.02266	87.86169	41.29873
3.085971	1.128634	2.889795	20.70362	5.033431	1500	0.592424	2.041984	0.290122	28.20133	83.20919	63.42695
3.55952	0.658895	4.282456	19.65652	7.544989	1470	0.743141	2.999666	0.247741	31.02564	80.6131	81.48921
4.044743	0.238747	5.736203	17.84068	10.06424	1440	0.9456	3.919589	0.24125	31.91432	74.69047	94.09734

TABLE 4.7 PERFORMANCE CHARACTERISTICS FOR PURE DIESEL CR 16

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.897539	1.897539	0	22.72203	0	1530	0.338334	0	0	0	89.53069	0
2.40378	1.40614	1.443448	21.68918	2.493108	1500	0.457406	1.011415	0.452244	18.0916	87.1702	41.50295
2.891513	0.928954	2.897505	20.71952	5.007267	1500	0.590054	1.990742	0.296399	27.60406	84.97253	67.87309
3.647659	0.699104	4.266157	19.77653	7.507209	1470	0.737568	2.984646	0.247121	33.1086	81.10523	80.83419
4.094332	0.24266	5.686573	18.24421	10.04266	1440	0.9517	3.911185	0.243328	33.62466	76.37984	94.07327

TABLE 4.8 PERFORMANCE CHARACTERISTICS FOR PURE DIESEL CR 17

o	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
	1.984026	1.984026	0	22.99651	0	1530	0.368784	0	0	0	90.61221	0
	2.471646	1.462188	1.460547	21.9947	2.494118	1500	0.473559	1.011825	0.468025	17.4816	88.3981	40.84152
	3.23671	1.274162	2.839538	20.93769	5.023927	1500	0.572868	2.038128	0.281076	29.10896	84.14991	60.63404
4	3.642515	0.726944	4.304523	19.76986	7.536783	1470	0.737568	2.996403	0.246151	33.23901	81.0779	80.0428
5	4.276322	0.471278	5.734768	18.39022	10.01214	1440	0.9517	3.899297	0.24407	33.52246	76.99113	88.97937

TABLE 4.9 PERFORMANCE CHARACTERISTICS FOR PURE DIESEL CR 18

lo	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
	2.039526	2.039526	0	22.58658	0	1530	0.353326	0	0	0	88.99696	0
	2.514242	1.507048	1.428698	21.66738	2.559009	1500	0.455993	1.03815	0.439236	18.6274	87.0826	40.05956
	3.218652	1.215407	2.898422	20.73391	4.987506	1470	0.584212	1.982886	0.294627	27.77007	85.03153	62.23863
	3.602108	0.643869	4.367516	19.7764	7.515258	1500	0.728462	3.048822	0.238932	33.4325	79.48261	82.12521
	4.310251	0.513189	5.722739	18.59965	10.09485	1470	0.899473	4.013415	**0.224117**	34.00696	76.27878	88.09376

TABLE 4.10 PERFORMANCE CHARACTERISTICS FOR PURE DIESEL CR 19

o	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTF}	η_{vol}	η_{mech}
	2.165674	2.165674	0	22.65684	0	1530	0.39337	0	0	0	89.27381	0
	2.69828	1.701449	1.471713	21.44417	2.516571	1500	0.491712	1.020933	0.48163	16.98778	86.18551	36.94322
	3.366684	1.376573	2.879418	20.83173	5.021743	1500	0.61209	2.037242	0.30045	27.23187	83.72407	59.11189
	3.812278	0.819255	4.330496	20.07194	7.464585	1470	0.746904	2.9677	0.251678	33.5091	82.31675	78.5101
	4.421952	0.521777	5.758183	18.89451	9.983623	1470	0.899473	3.978644	0.226075	**34.8068**	77.48799	88.20031

TABLE 4.11 PERFORMANCE CHARACTERISTICS FOR 5% ETHANOL BLEND – CR 15

No	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTH}	η_{vol}	η_{mech}
	1.890869	1.890869	0	23.31996	0	1560	0.369564	0	0	0	90.11964	0
	2.53123	1.547858	1.422804	21.68054	2.475307	1500	0.466127	1.004193	0.464181	17.23811	87.1355	38.84957
	3.271224	1.243864	2.875796	20.61667	5.012795	1500	0.608419	2.033612	0.299181	26.74499	82.85973	61.97558
	3.618824	0.697924	4.31239	19.46013	7.504281	1470	0.760524	2.983482	0.254911	31.38973	79.80767	80.71406
	3.795484	0.051406	5.762946	17.96883	10.06353	1440	1.021197	3.919311	0.260555	30.70979	75.22697	97.64561

TABLE 4.14 PERFORMANCE CHARACTERISTICS FOR 5% ETHANOL BLEND - CR 18

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
2.202119	2.202119	0	22.50001	0	1530	0.380262	0	0	0	88.65587	0
2.613109	1.720417	1.291604	21.55225	2.521566	1500	0.487351	0.932467	0.522646	15.30978	86.61987	34.16208
3.180439	1.365285	2.626279	20.85803	4.990392	1500	0.602081	1.845431	0.326255	25.52561	83.82978	57.07243
3.596941	0.931633	3.935037	19.76107	7.486776	1470	0.726128	2.713215	0.267626	30.89841	81.04186	74.0993
4.187944	0.661067	5.20705	18.76297	10.04632	1470	0.894716	3.640795	0.245748	34.56025	76.94853	84.21501

TABLE 4.15 PERFORMANCE CHARACTERISTICS FOR 5% ETHANOL BLEND - CR 19

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.809806	1.809806	0	21.77394	0	1530	0.34201	0	0	0	85.79497	0
2.406542	1.401083	1.454762	21.35262	2.481097	1500	0.455116	1.006542	0.452158	17.69646	85.81754	41.78024
2.981261	1.031401	2.878756	20.21392	5.013166	1500	0.572275	2.033763	0.281387	28.43626	81.24103	65.40387
3.543418	0.573545	4.297	19.53813	7.499355	1470	0.691385	2.981523	0.23189	33.50603	80.12756	83.81379
4.091751	0.28805	5.732745	18.32559	10.02425	1440	0.849997	3.904016	0.217724	35.15117	76.72053	92.96021

TABLE 4.16 PERFORMANCE CHARACTERISTICS FOR 10% ETHANOL BLEND – CR 15

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.43851	1.43851	0	21.44004	0	1500	0.331922	0	0	0	86.16888	0
1.957858	0.982422	1.440124	20.77152	2.489961	1470	0.460408	0.989936	0.465089	17.06337	85.1858	49.82158
2.437727	0.540586	2.859275	20.12746	5.029342	1500	0.588563	2.040325	0.288465	27.51107	80.89356	77.82418
2.975237	0.074129	4.28317	19.00678	7.602846	1470	0.726343	3.022668	0.240299	33.02549	77.94844	97.50848
4.075276	0.262681	5.746149	17.71164	9.946638	1440	0.957896	3.873[illegible]87	0.247276	32.09358	74.08931	93.55428

TABLE 4.17 PERFORMANCE CHARACTERISTICS FOR 10% ETHANOL BLEND - CR 16

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
0.989167	0.989167	0	21.6845	0	1500	0.352411	0	0	0	87.15141	0
1.659428	0.680493	1.416385	21.01997	2.501743	1470	0.478146	0.99462	0.480732	16.50812	86.20472	58.99232
2.338709	0.432871	2.872382	20.51994	5.016022	1500	0.594694	2.034922	0.292244	27.15533	82.47097	81.49102
3.191294	0.266975	4.317439	19.47451	7.536617	1470	0.67965	2.996338	0.226827	33.48697	79.86662	91.63429
3.924506	0.188234	5.750929	18.27812	10.02075	1440	0.967637	3.90265	0.247944	34.00722	76.52182	95.20362

TABLE 4.18 PERFORMANCE CHARACTERISTICS FOR 10% ETHANOL BLEND – CR 17

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.595735	1.595735	0	21.56297	0	1500	0.332696	0	0	0	86.66297	0
1.422884	0.442298	1.447729	20.81899	2.467015	1500	0.465666	1.000829	0.46528	17.05637	83.67286	58.91542
2.830585	0.878673	2.881786	20.13473	5.015605	1500	0.592226	2.034752	0.291056	27.26622	80.92276	68.95792
3.366066	0.453133	4.300629	19.28711	7.523301	1470	0.731931	2.991044	0.244707	32.43049	79.09808	86.53821
3.904205	0.088466	5.750887	18.01988	10.01562	1440	0.929813	3.900651	0.238374	33.29216	75.44069	97.73409

TABLE 4.19 PERFORMANCE CHARACTERISTICS FOR 10% ETHANOL BLEND – CR 18

No	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1	1.688034	1.688034	0	21.28211	0	1500	0.328107	0	0	0	85.53417	0
2	1.998714	1.026673	1.435113	20.42347	2.504441	1470	0.4531	0.995692	0.45506	17.43942	83.75842	48.63334
3	2.650242	0.698202	2.881975	3.889319	5.01567	810	0.579527	2.104326	0.298943	28.44349	28.94708	73.65518
4	3.138222	0.281941	4.304841	18.49273	7.523646	1470	0.704822	2.991181	0.235633	33.67937	75.84028	91.01589
5	4.169113	0.40242	5.676969	17.87458	10.02223	1440	0.878317	4.003229	0.225023	35.26741	74.83239	90.31759

TABLE 4.20 PERFORMANCE CHARACTERISTICS FOR 10% ETHANOL BLEND - CR 19

	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
	1.314898	1.314898	0	21.59272	0	1500	0.358159	0	0	0	86.78253	0
	2.308418	1.334637	1.437682	20.88503	2.501687	1500	0.475755	1.014895	0.468772	16.92929	83.93827	42.18392
	3.149248	1.138909	2.908685	20.26737	4.980116	1470	0.588563	1.979948	0.297262	28.69696	83.11821	63.83552
	3.58899	0.720668	4.234765	19.34048	7.508099	1470	0.710082	2.99985	0.237883	33.36081	79.31697	79.92005
	4.126424	0.327404	5.72569	18.3035	9.99422	1470	0.883755	4.079049	0.222102	35.73123	75.03001	92.06568

TABLE 4.21 PERFORMANCE CHARACTERISTICS FOR 15% ETHANOL BLEND - CR 15

No	IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
	0.168774	0.168774	0	21.63936	0	1530	0.343789	0	0	0	85.26468	0
	2.22607	1.235477	1.433253	20.96654	2.520095	1500	0.473793	1.022363	0.46343	16.82259	84.26585	44.49964
	2.940271	0.993336	2.874437	20.37895	4.977772	1470	0.599802	2.021776	0.296671	26.27858	81.90431	66.21618
	3.415841	0.423568	4.417765	19.14573	7.480664	1470	0.737976	2.974092	0.248135	31.41874	78.51829	87.5999
	3.888812	0.105643	5.823114	17.77015	10.0311	1440	1.00681	3.906683	0.257715	30.25083	74.39517	97.68341

TABLE 4.22 PERFORMANCE CHARACTERISTICS FOR 15% ETHANOL BLEND – CR 16

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.412835	1.412835	0	21.26727	0	1500	0.329716	0	0	0	85.47452	0
1.921694	0.943305	1.444485	20.64402	2.534449	1500	0.454689	1.028186	0.442224	17.62928	82.96965	50.91285
2.683455	0.729065	2.885444	19.80607	5.01075	1470	0.581251	1.992127	0.291774	26.71959	81.22641	72.8311
3.561342	0.649249	4.299388	18.62899	7.54556	1470	0.732226	2.999893	0.244084	31.94019	76.3991	81.76954
4.100419	0.32262	5.693706	17.5588	9.991003	1440	0.955617	3.891066	0.245593	31.74399	73.51036	92.13202

TABLE 4.23 PERFORMANCE CHARACTERISTICS FOR 15% ETHANOL BLEND – CR 17

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
2.032144	2.032144	0	22.68077	0	1530	0.381988	0	0	0	89.36811	0
2.697802	1.732467	1.425212	21.35167	2.508152	1500	0.486047	1.017518	0.477679	16.32078	85.81375	35.78228
3.175035	1.240509	2.856116	20.57507	4.985878	1470	0.595998	1.982239	0.300669	25.92914	84.38014	60.92926
3.757922	0.855639	4.284905	19.6801	7.488365	1470	0.737976	2.977154	0.24788	31.45109	80.7098	77.23107
4.208603	0.466135	5.760466	18.48486	10.01308	1470	0.918264	3.980905	0.230667	33.99801	75.80798	88.92123

TABLE 4.24 PERFORMANCE CHARACTERISTICS FOR 15% ETHANOL BLEND – CR 18

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
1.931764	1.931764	0	21.41071	0	1500	0.345898	0	0	0	86.05104	0
2.464626	1.459179	1.454743	20.98059	2.473821	1470	0.469845	0.983519	0.477718	16.31942	86.0432	40.7951
3.088704	1.149768	2.862629	20.32654	5.010963	1470	0.587306	1.992212	0.294801	26.44525	83.36088	62.77508
3.611777	0.759847	4.298284	19.60078	7.506677	1500	0.728441	3.045341	0.239199	32.59254	78.77679	78.96197
4.285214	0.486427	5.72534	18.41206	10.02831	1440	0.900661	3.905594	0.230608	34.70668	77.08256	88.64872

TABLE 4.25 PERFORMANCE CHARACTERISTICS FOR 15% ETHANOL BLEND – CR 19

IP (kW)	FP (kW)	BMEP (bar)	Air (kg/hr)	Load (kg)	Speed (rpm)	Fuel (kg/hr)	BP (kW)	SFC (kg/kWh)	η_{BTE}	η_{vol}	η_{mech}
2.010904	2.010901	0	21.68649	0	1500	0.349327	0	0	0	87.1594	0
2.077568	1.092501	1.425258	20.88746	2.500466	1500	0.469845	1.0144	0.463175	16.83183	83.94803	47.41444
3.024688	1.083578	2.865837	20.09434	5.000035	1500	0.58489	2.028436	0.288345	27.03733	80.76043	64.17555
3.535639	0.682712	4.299785	19.48546	7.50612	1470	0.713689	2.984213	0.239155	33.59852	79.91154	80.69055
4.249096	0.439587	5.91498	18.5051	10.06316	1470	0.889296	4.000818	**0.216279**	**36.27351**	75.89101	89.65457

MODEL CALCULATION

GIVEN DATA:

Cylinder bore, d = 80 mm

Stroke length, l = 110 mm

Brake drum diameter = 260 mm

FOR 15% ETHANOL BLEND – CR 19:

1. Indicated power = (P_m *L*A*N*k*n)/60 kW

Where

n = number of cylinders

P_m = Indicated mean effective pressure (kPa)

L = Length of stroke (m)

A = Area of piston (m^2) = $\pi d^2/4$, where d=piston diameter in m

k = 1/2 for 4-stroke engine

k = 1 for 2 – stroke engine

N = No. of revolution of crank shaft / minute (r.p.m.)

$$= (6.4040*100*0.11*5.02*10^{-3}*1470*(1/2))/60$$

$$= 4.3319 \text{ kW}$$

2. Brake power = (2*π*N*T)/60 kW

Where

T = toque in Nm = F*r, r = radius of brake drum in m

$$= (2*\pi*1470*10*10*0.26)/60$$

$$= 4.002 \text{ kW}$$

3. Friction power = IP – BP

= 4.415 – 4.0023

= 0.3299 kW

4. Brake mean effective pressure (BMEP) = (P_B *60*1000)/(L*A*(N/2))

Where

P_B = brake power in kW

= (4.002*60*1000)/(0.11*5.02*10^{-3}*735)

= 5.9162 bar

5. Total fuel consumption (TFC):

Time for 10 ml fuel consumption = 33 seconds

For 0ne sec = 10/33 = 0.3030 ml/sec

= 0.3030*10^{-3} l/sec

= 0.3030*10^{-3} *3600 l/hr

= 1.0908 l/hr

= 1.0908*0.795 kg/hr

= 0.8671 kg/hr

6. Specific fuel consumption (SFC) = TFC/BP kg/kWh

= 0.8671/4.002

= 0.2166 kg/kWh

7. Brake thermal efficiency (η_{bte}) = (P_B * 3600)/(m_f*C)

Where

m_f = mass of fuel consumed per hour

$= (4.002*3600)/(0.8671*46177)$

$= 36.12\%$

8. Mechanical effiency (η_{mech}) = BP/IP

$= 4.002/4.3319$

$= 92.38\%$

CHAPTER 5

RESULTS AND DISCUSSIONS

BRAKE POWER Vs SFC

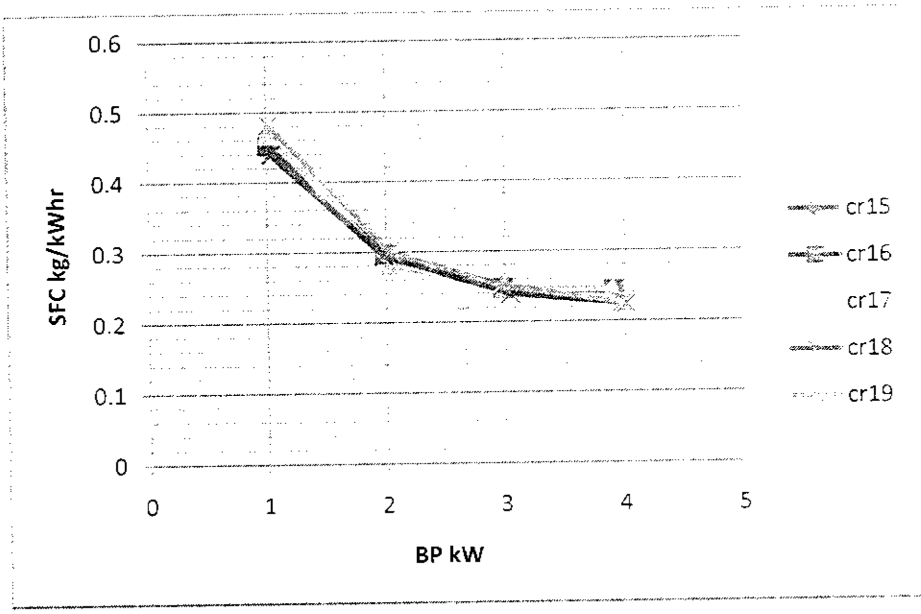

Fig.5.1 Pure diesel

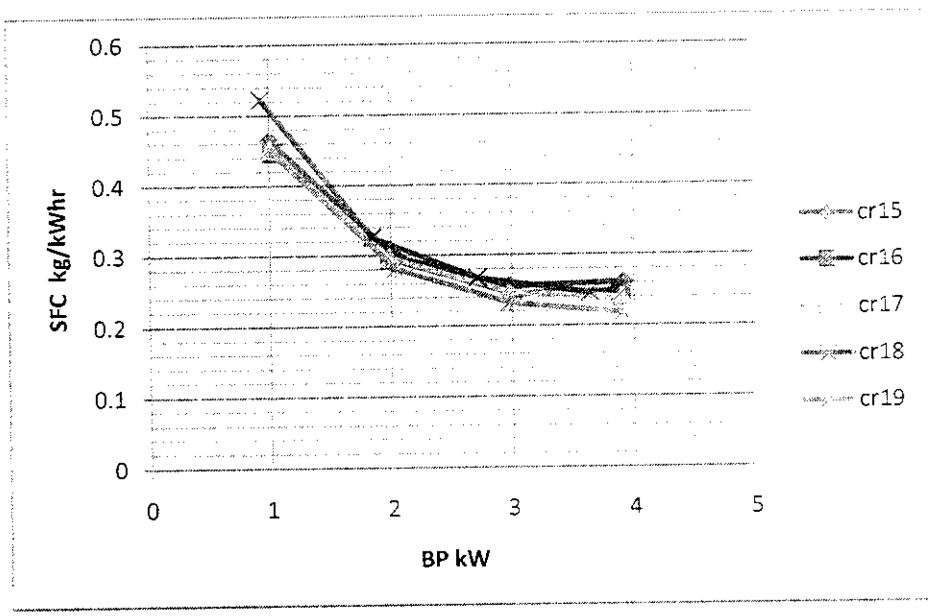

Fig.5.2 5% Ethanol blend

From Fig.5.1, SFC for pure diesel is lowest for CR-18 with value 0.224117 kg/kWh. From Fig.5 2, SFC for 5% Ethanol blend is lowest for CR-19 as 0.217724 kg/kWh.

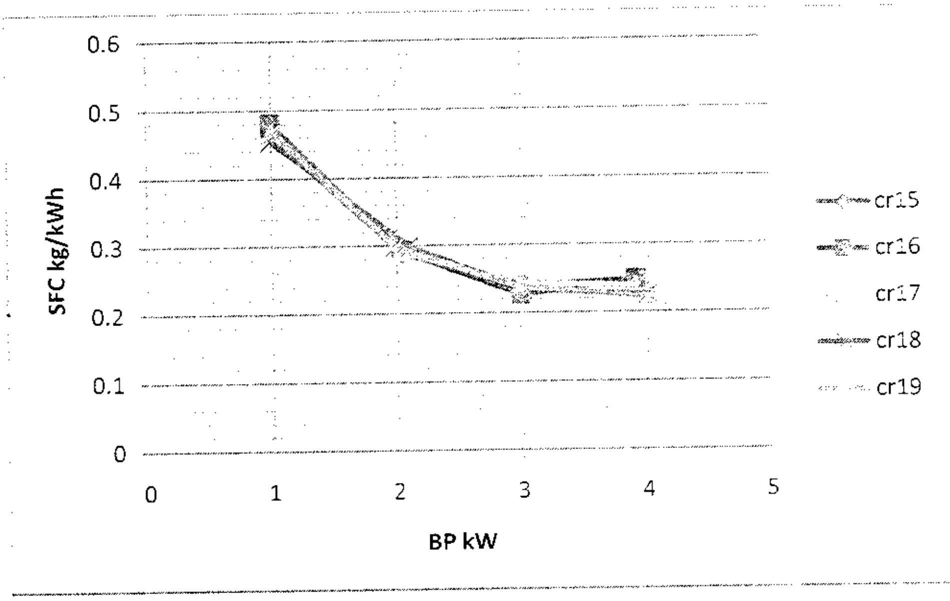

Fig.5.3 10% Ethanol blend

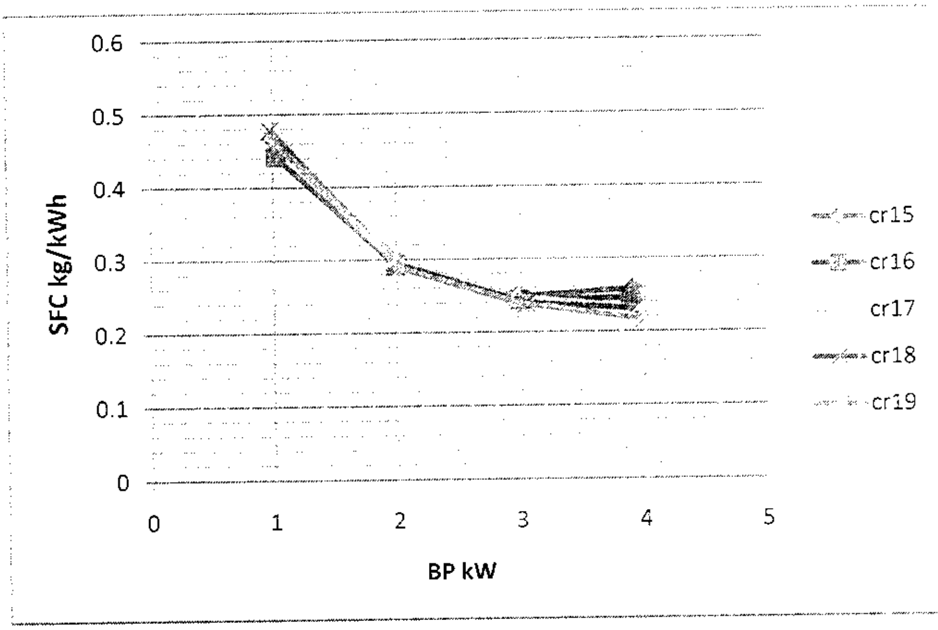

Fig.5.4 15% Ethanol blend

From Fig.5.3, SFC for 10% Ethanol blend is lowest for CR-19 with value 0.222102 kg/kWh. From Fig.5.4, SFC for 15% Ethanol blend is lowest for CR-19 as 0.216279 kg/kWh. Thus, we infer that the SFC is low for pure Diesel in CR-18, while among the Blends SFC is low for 15% Ethanol Blend in CR-19. Hence Specific Fuel Consumption is decreased by 4.33% for 15% Ethanol Blend when compared to pure diesel.

BMEP VS SFC

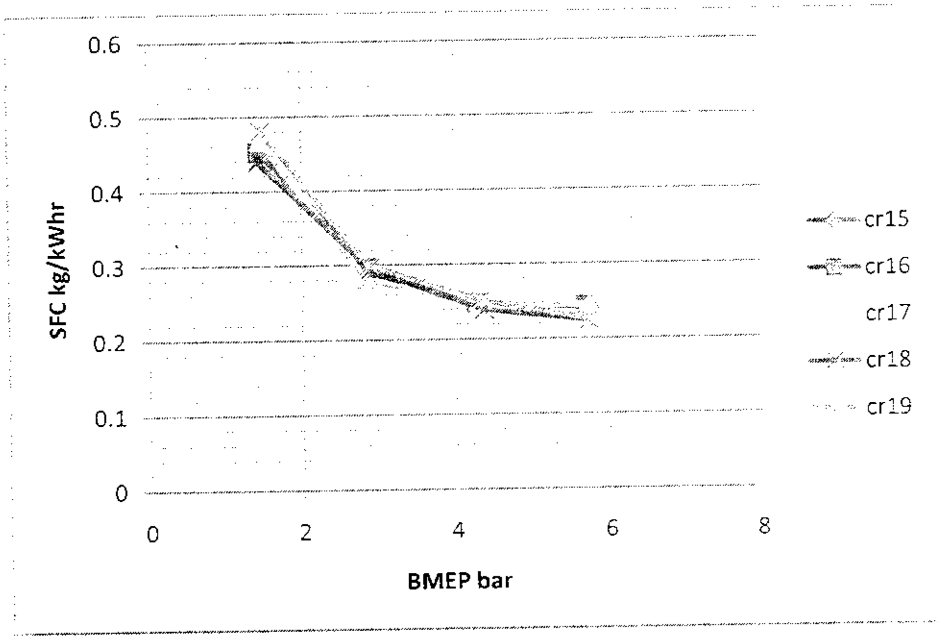

Fig.5.5 Pure diesel

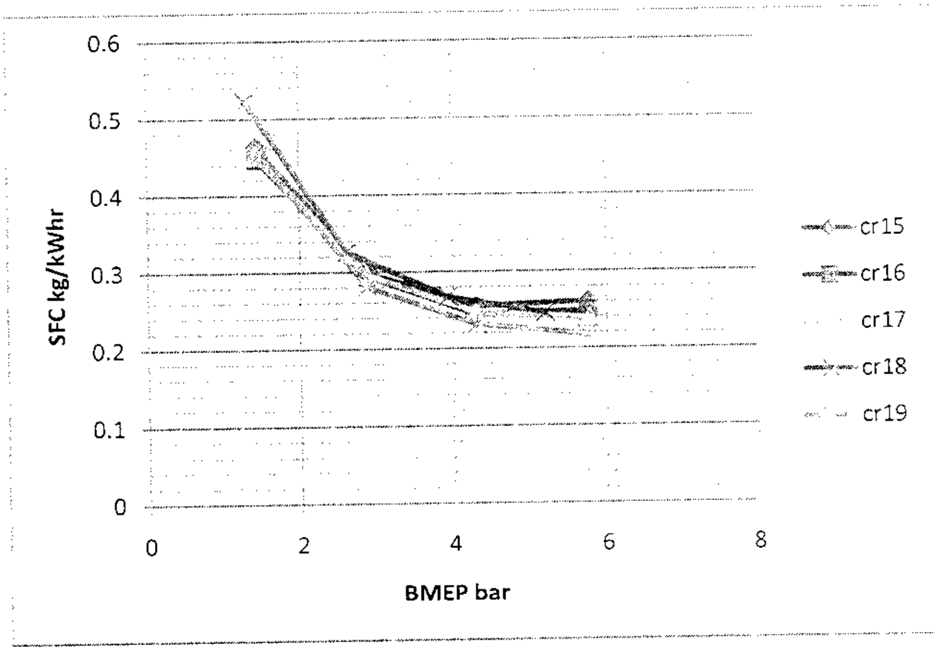

Fig.5.6 5% Ethanol blend

From Fig.5.5, BMEP for pure diesel is highest for CR-19 with value 5.758183 bar. From Fig.5 6, BMEP for 5% Ethanol blend is highest for CR-17 as 5.778559 bar.

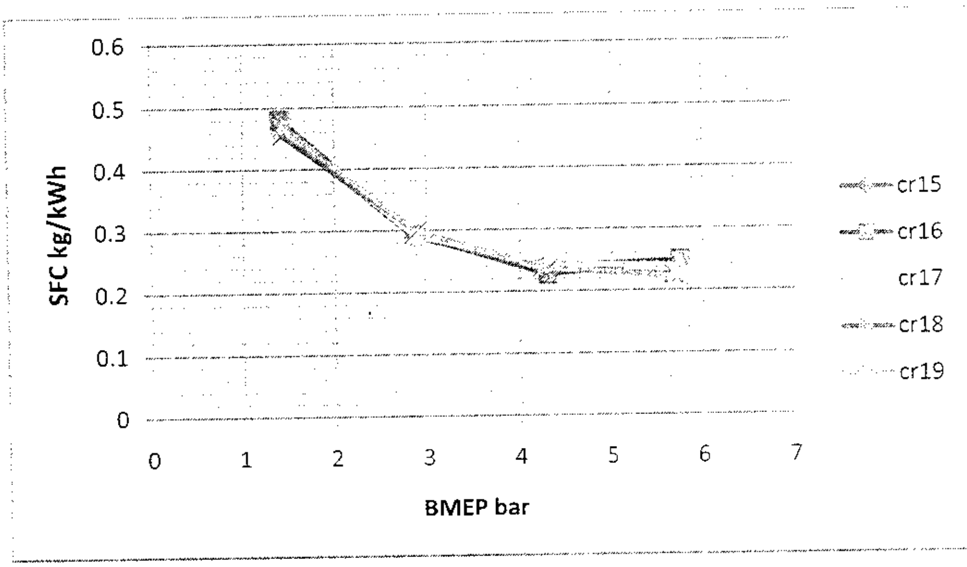

Fig.5.7 10% Ethanol blend

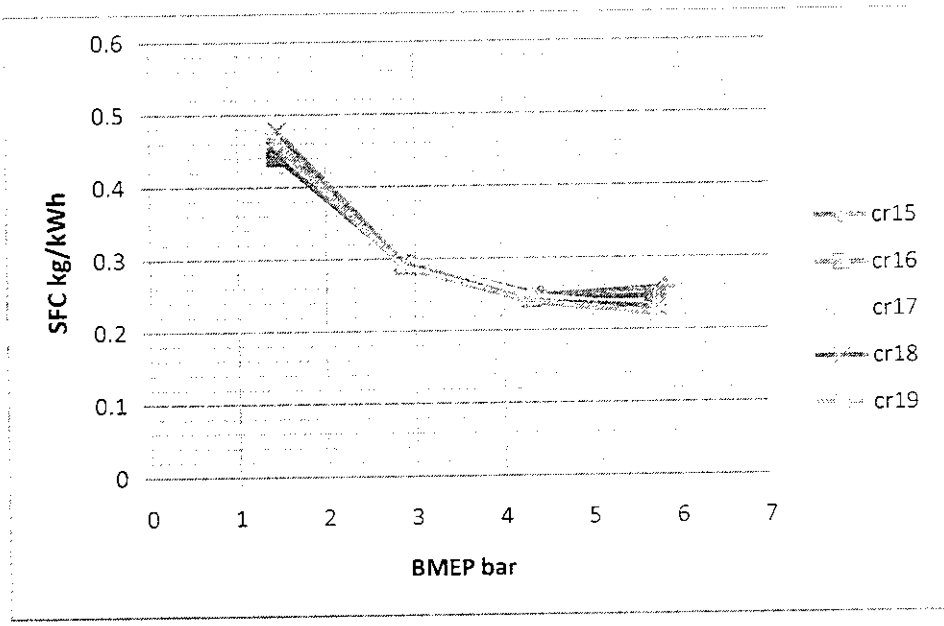

Fig.5.8 15% Ethanol blend

From Fig.5.7, BMEP for 10% Ethanol blend is highest for CR-16 with value 5.750929 bar. From Fig.5 8, BMEP for 15% Ethanol blend is highest for CR-19 with value 5.91498 bar. Thus, 15% Ethanol blend holds good results for BMEP.

LOAD VS BMEP

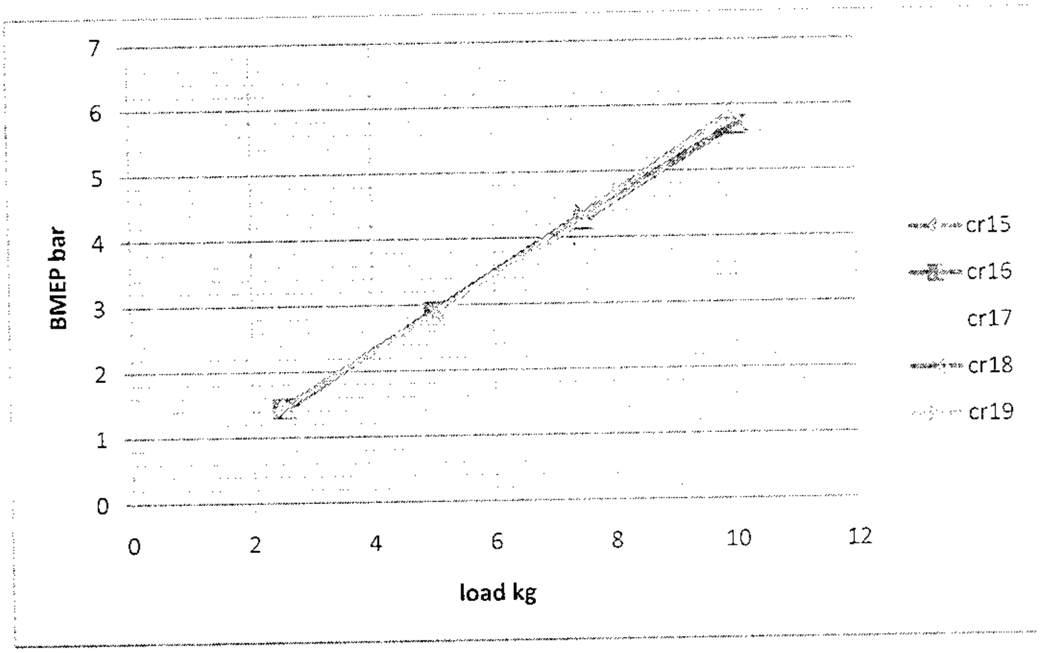

Fig.5.9 Pure diesel

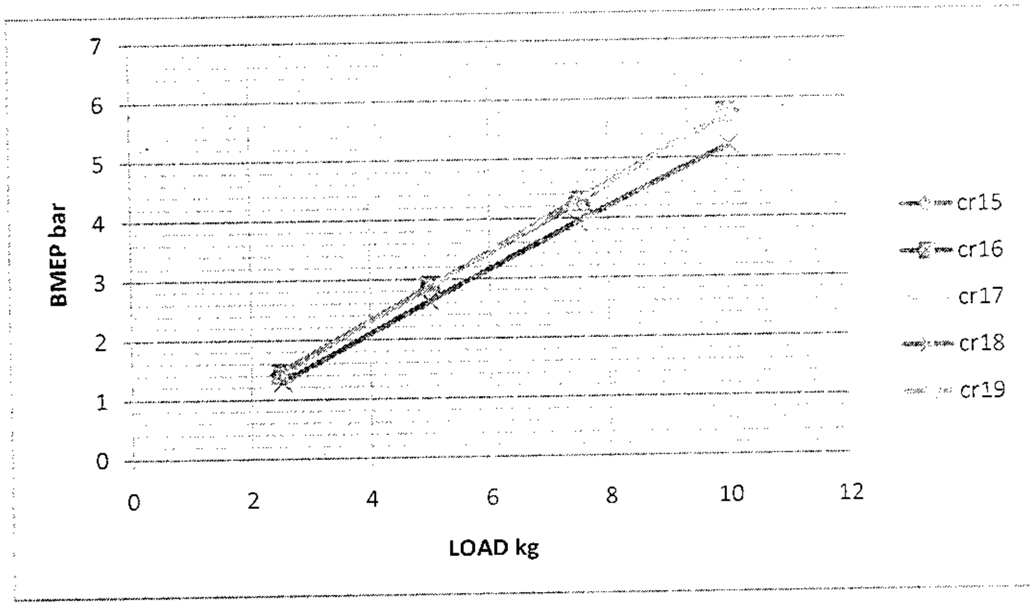

Fig.5.10 5% Ethanol blend

From Fig.5.9, BMEP increases when load increases and for pure diesel it is highest for CR-19 with value 5.758183 bar. From Fig.5 10, BMEP for 5% Ethanol blend is highest for CR-17 as 5.778559 bar.

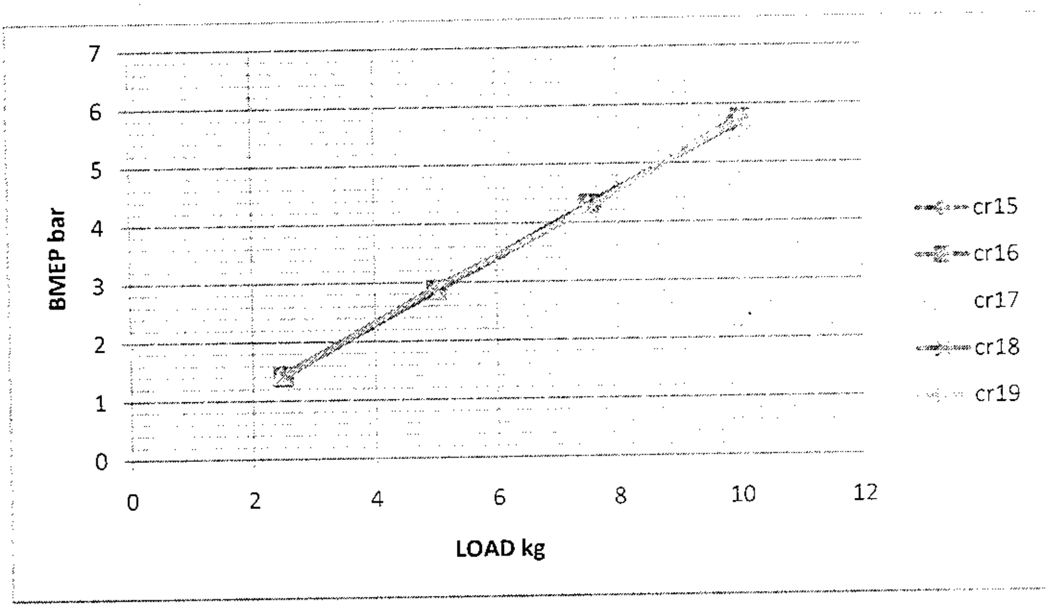

Fig.5.11 10% Ethanol blend

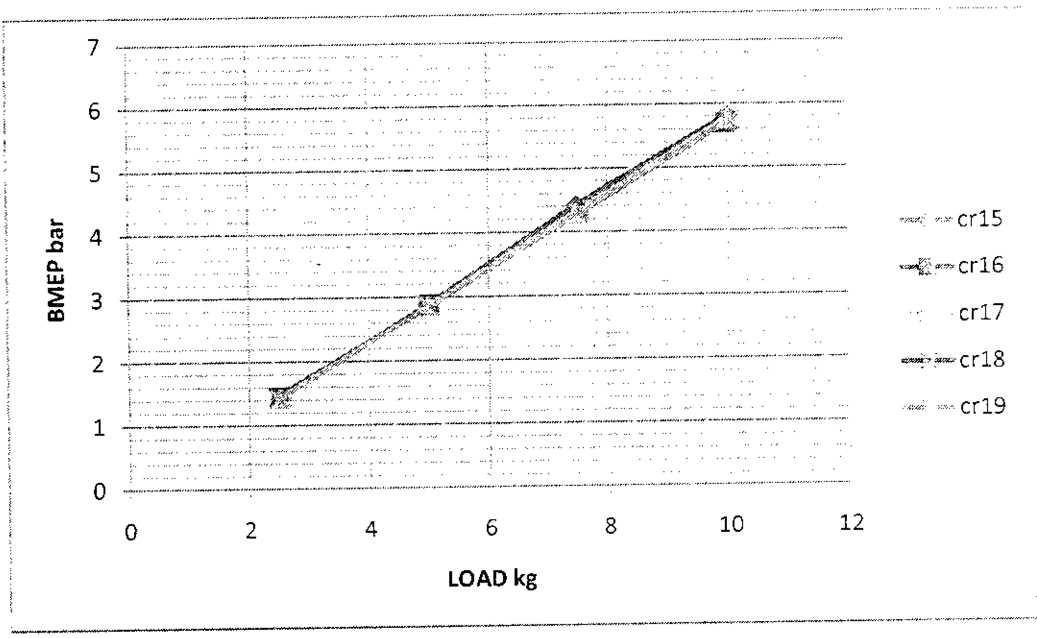

Fig.5.12 15% Ethanol blend

From Fig.5.11, BMEP for 10% Ethanol blend is highest for CR-16 with value 5.750929 bar. From Fig.5 12, BMEP for 15% Ethanol blend is highest for CR-19 with value 5.91498 bar for load 10 kg.

LOAD VS SFC

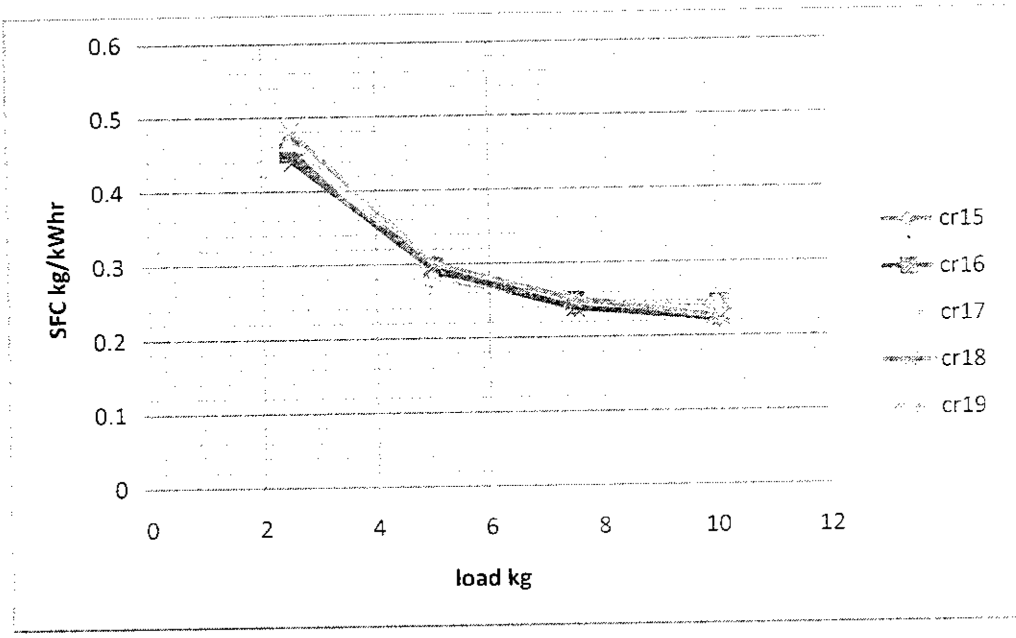

Fig.5.13 Pure diesel

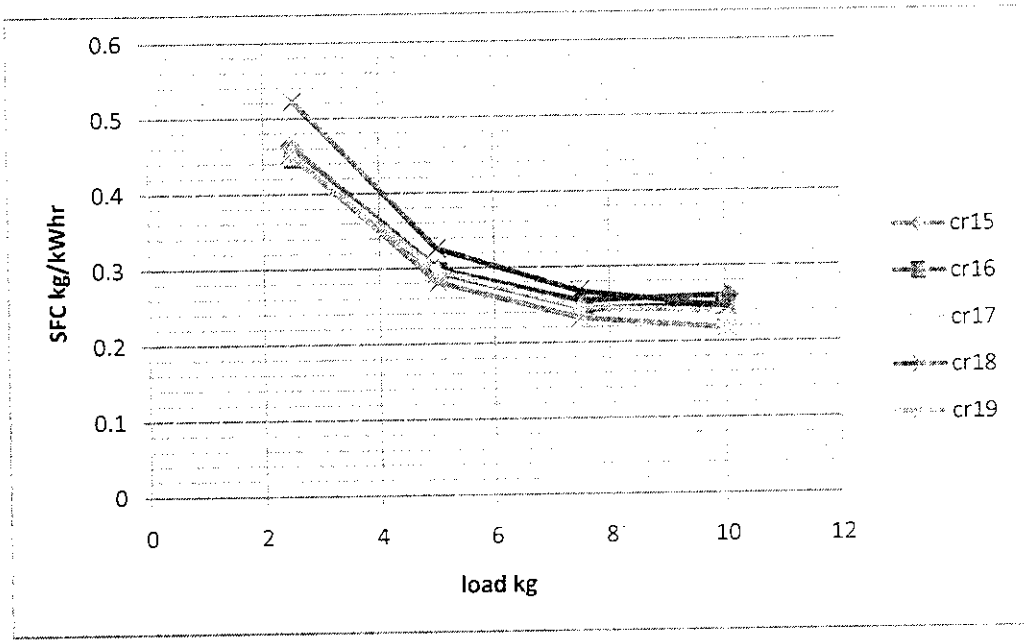

Fig.5.14 5% Ethanol blend

From Fig.5.13, SFC mostly decreases with increase in load and for pure diesel is lowest for CR-18 with value 0.224117 kg/kWh. From Fig.5 14, SFC for 5% Ethanol blend is lowest for CR-19 as 0.217724 kg/kWh.

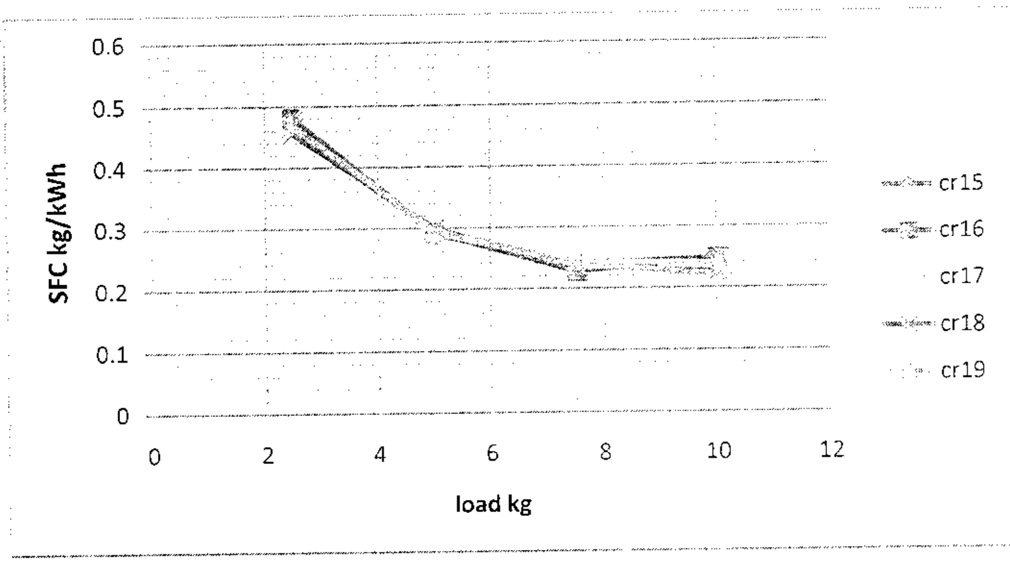

Fig.5.15 10% Ethanol blend

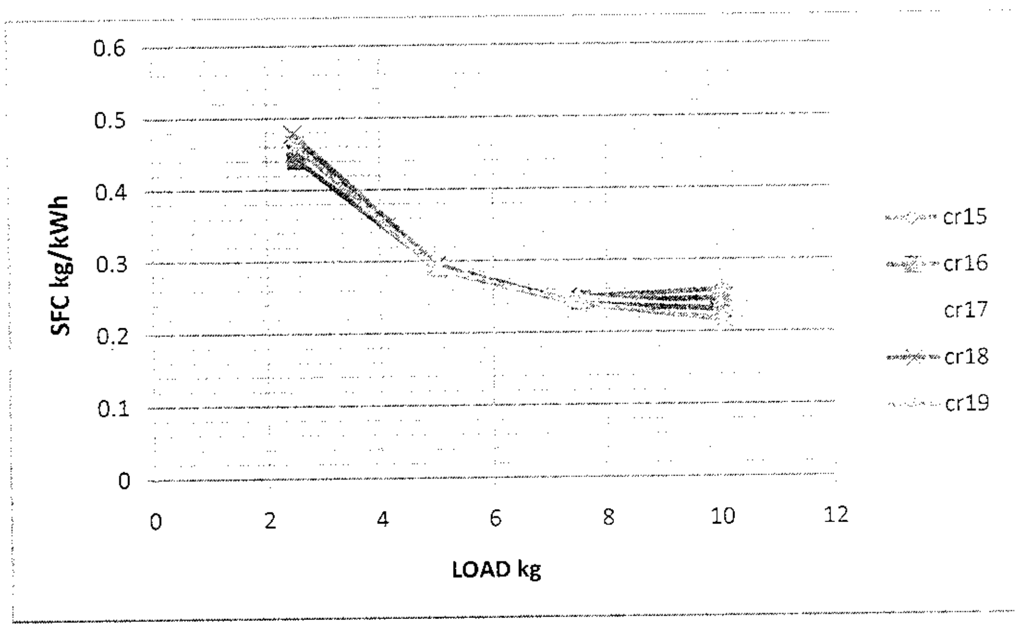

Fig.5.16 15% Ethanol blend

From Fig.5.15, SFC for 10% Ethanol blend is lowest for CR-19 with value 0.222102 kg/kWh. From Fig.5 16, SFC for 15% Ethanol blend is lowest for CR-19 as 0.216279 kg/kWh.

LOAD VS BP

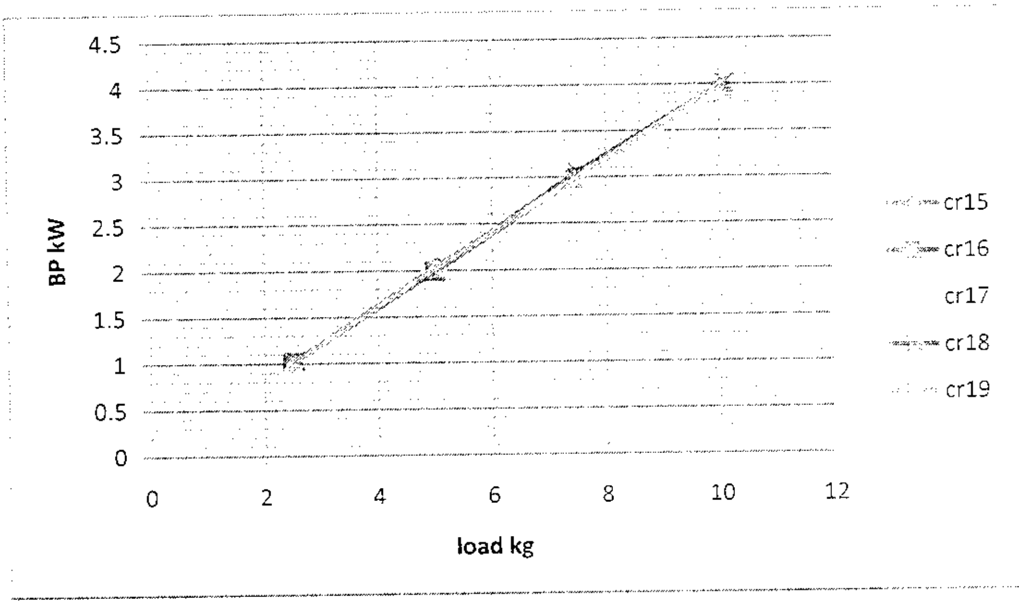

Fig.5.17 Pure diesel

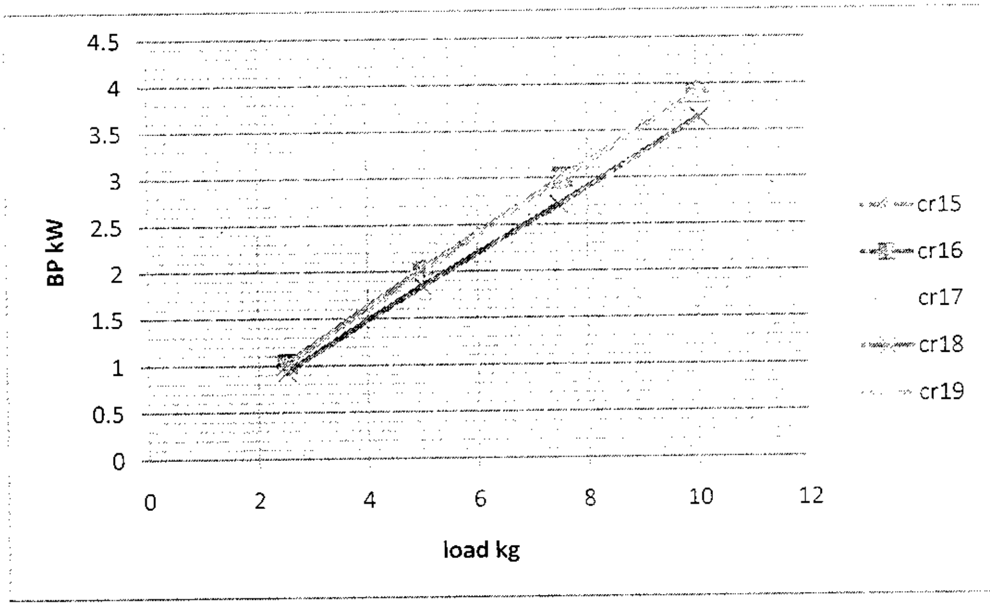

Fig.5.18 5% Ethanol blend

From Fig.5.17, BP for pure diesel is highest for CR-18 with value 4.0134 kW. From Fig.5 18. BP for 5% Ethanol blend is highest for CR-15 as 3.919311 kW.

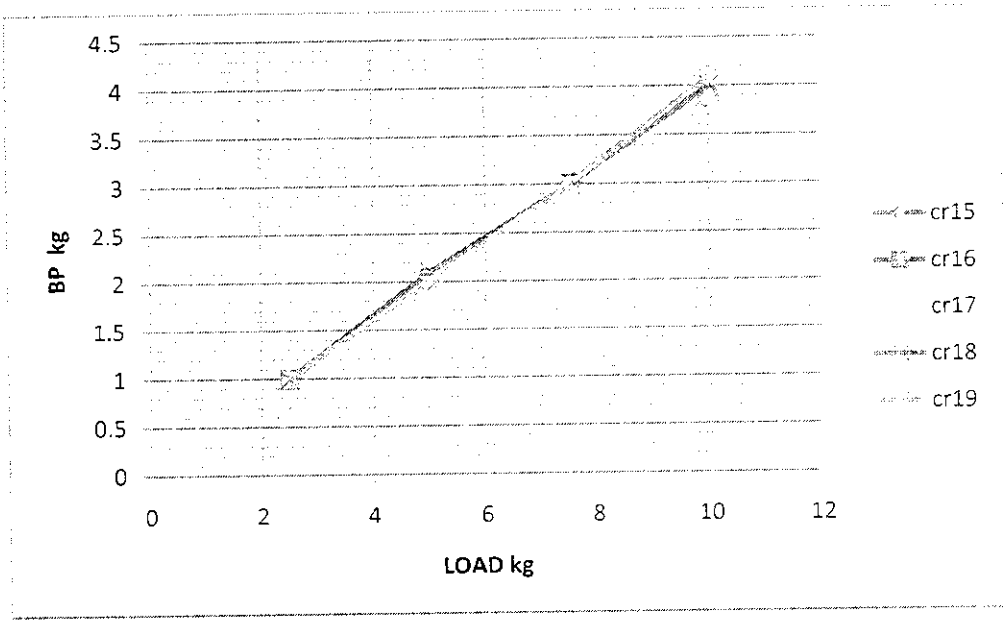

Fig.5.19 10% Ethanol blend

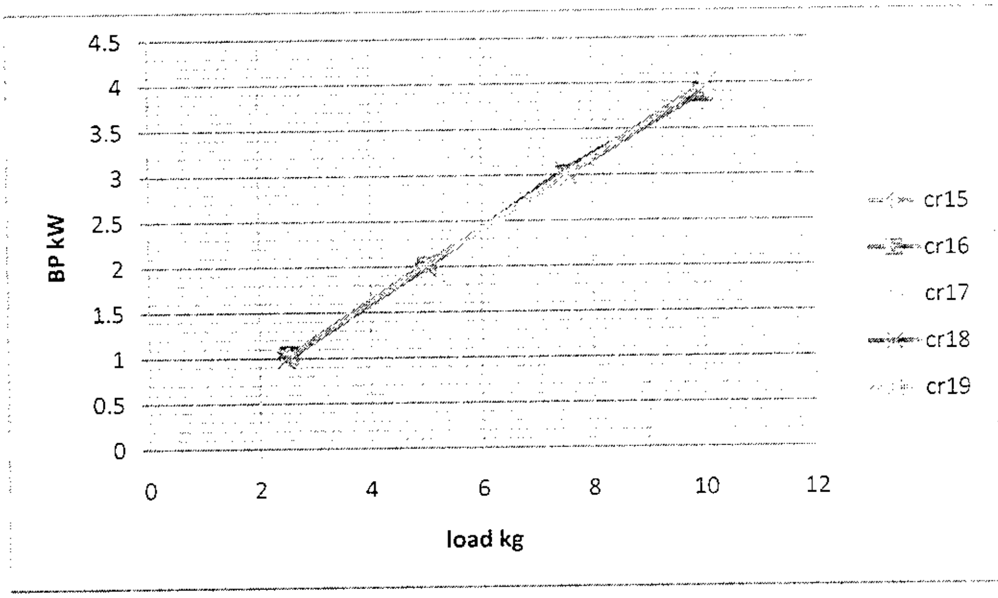

Fig.5.20 15% Ethanol blend

From Fig.5.19, BP for 10% Ethanol blend is highest for CR-19 with value 4.079049 kW. From Fig.5 20, BP for 15% Ethanol blend is highest for CR-15 as 4.000818 kW. Thus 10% Ethanol blend has maximum BP among the blends and is increased by 1.6% compared to pure diesel.

BP VS MECH %

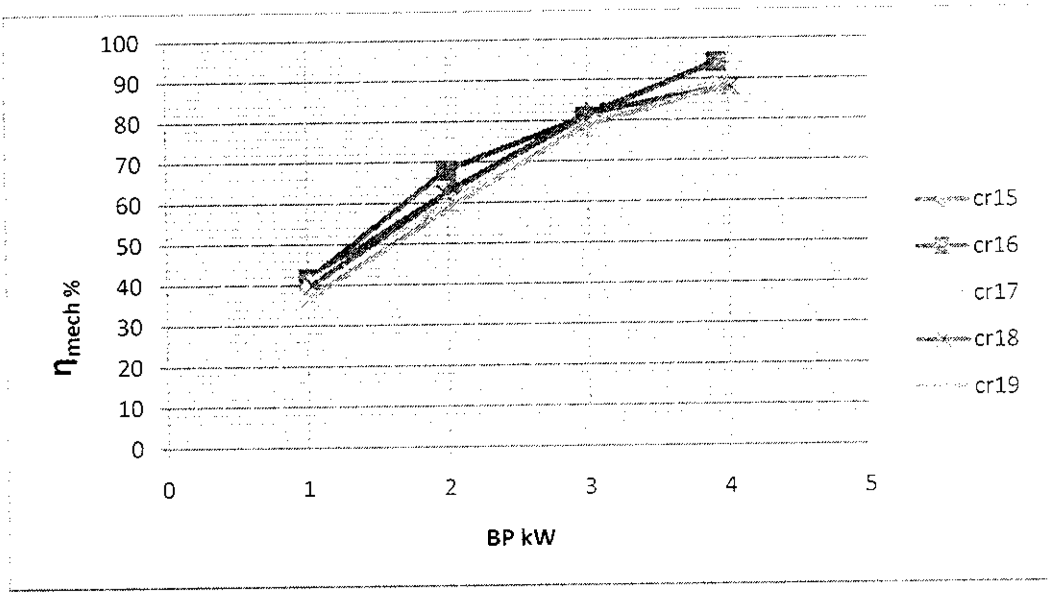

Fig.5.21 Pure diesel

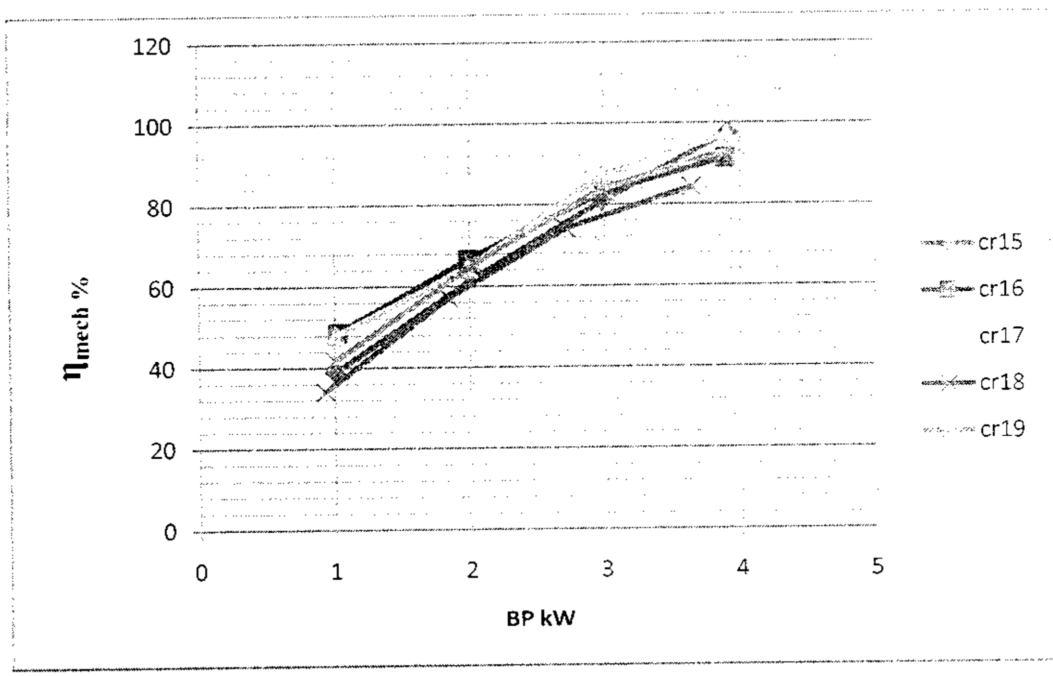

Fig.5.22 5% Ethanol blend

From Fig.5 21, mechanical efficiency for pure diesel is highest for CR-15 with value 94.09734 %. From Fig.5 22, mechanical efficiency for 5% Ethanol blend is highest for CR-15 as 97.64561%.

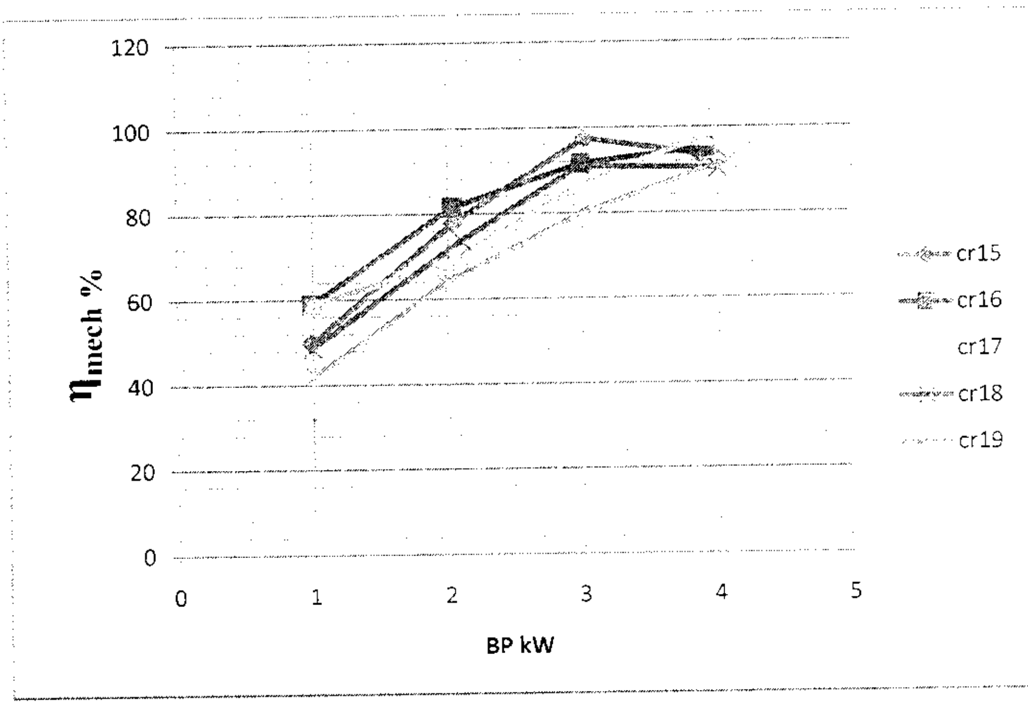

Fig.5.23 10% Ethanol blend

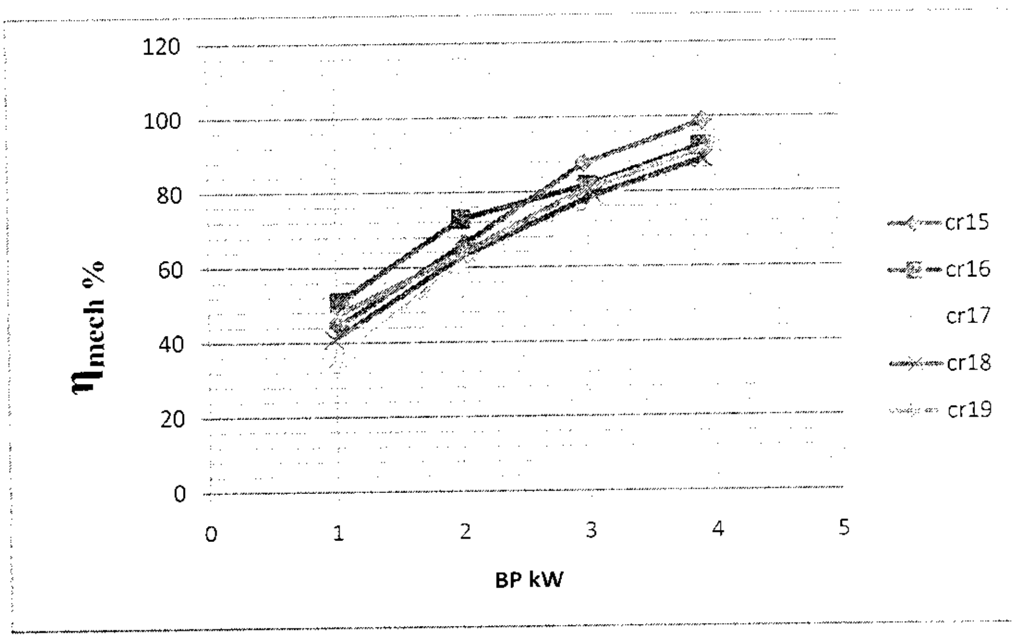

Fig.5.24 15% Ethanol blend

From Fig.5 23, mechanical efficiency for 10% Ethanol blend is highest for CR-17 with value 97.73409 %. From Fig.5 24, mechanical efficiency for 15% Ethanol blend is highest for CR-15 as 97.68341%. so,

SFC VS BTE (%)

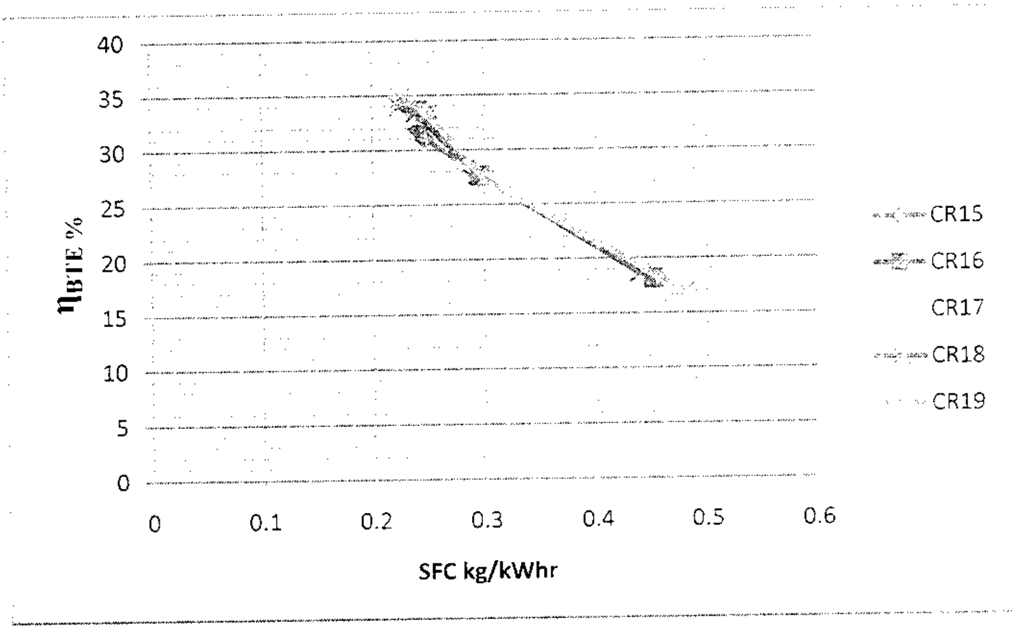

Fig.5.25 Pure diesel

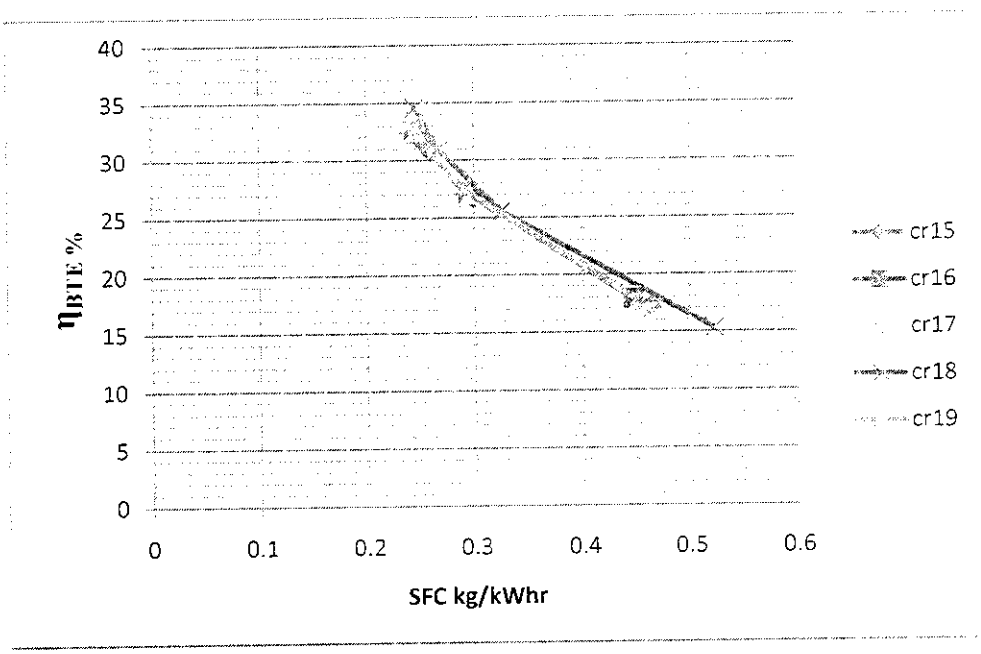

Fig.5.26 5% Ethanol blend

From Fig.5 25, thermal efficiency for pure diesel is highest for CR-19 with value 34.8068%. From Fig.5 26, thermal efficiency for 5% Ethanol blend is highest for CR-19 as 35.15117%.

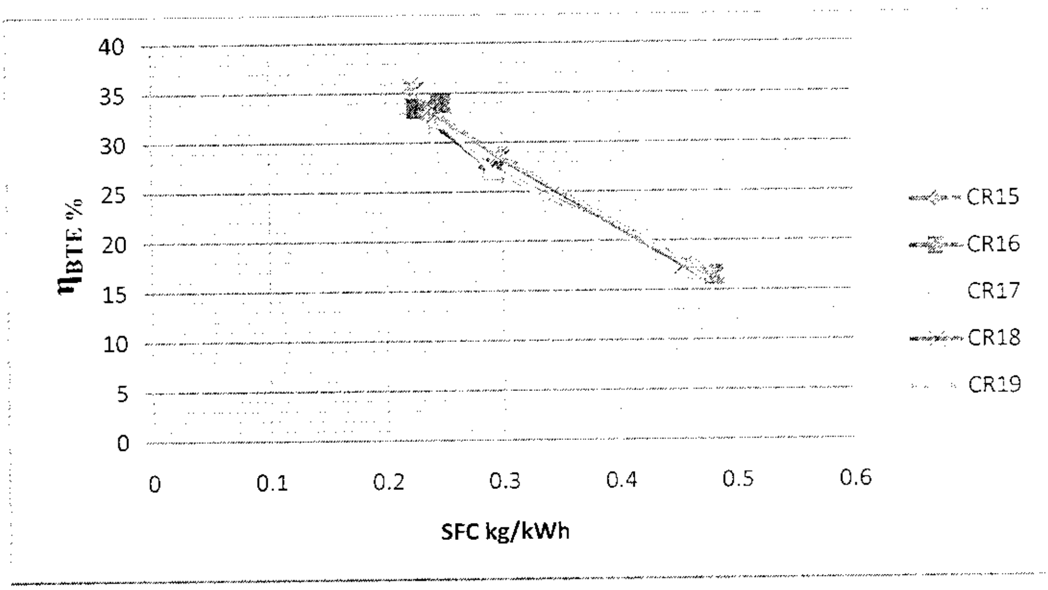

Fig.5.27 10% Ethanol blend

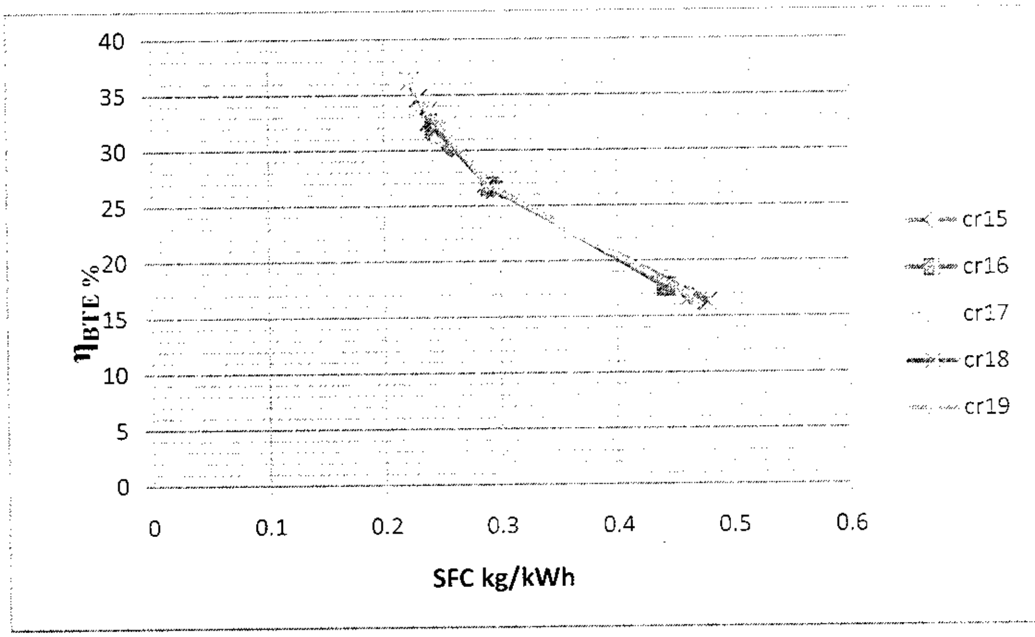

Fig.5.28 15% Ethanol blend

From Fig.5 27, thermal efficiency for 10% Ethanol blend is highest for CR-19 with value 35.73123%. From Fig.5 28, thermal efficiency for 15% Ethanol blend is highest for CR-19 as 36.27351%. Thus, 15% Ethanol blend shows best results for η_{BTE} and is increasd by 4.21% when compared to pure diesel.

BTE (%) VS TFC

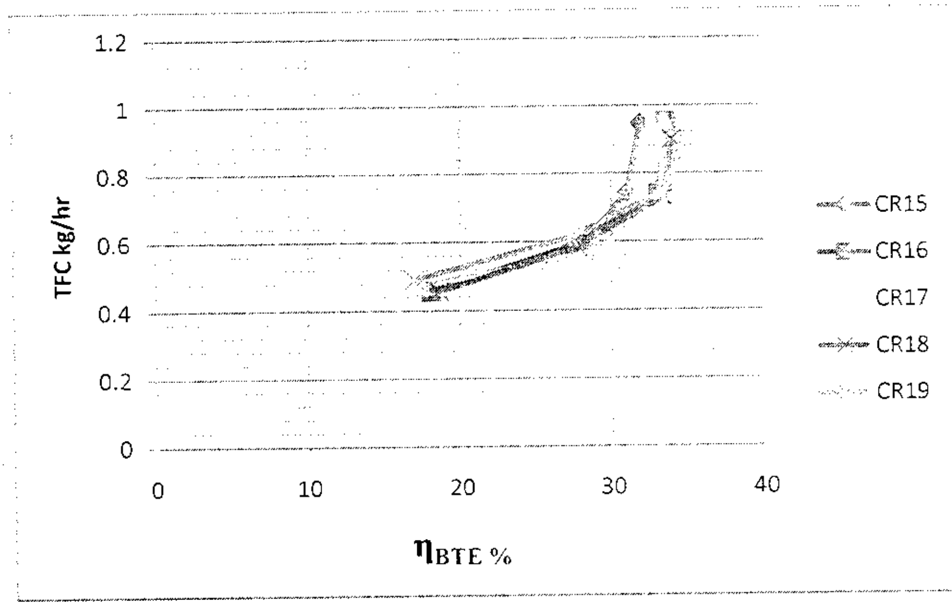

Fig.5.29 Pure diesel

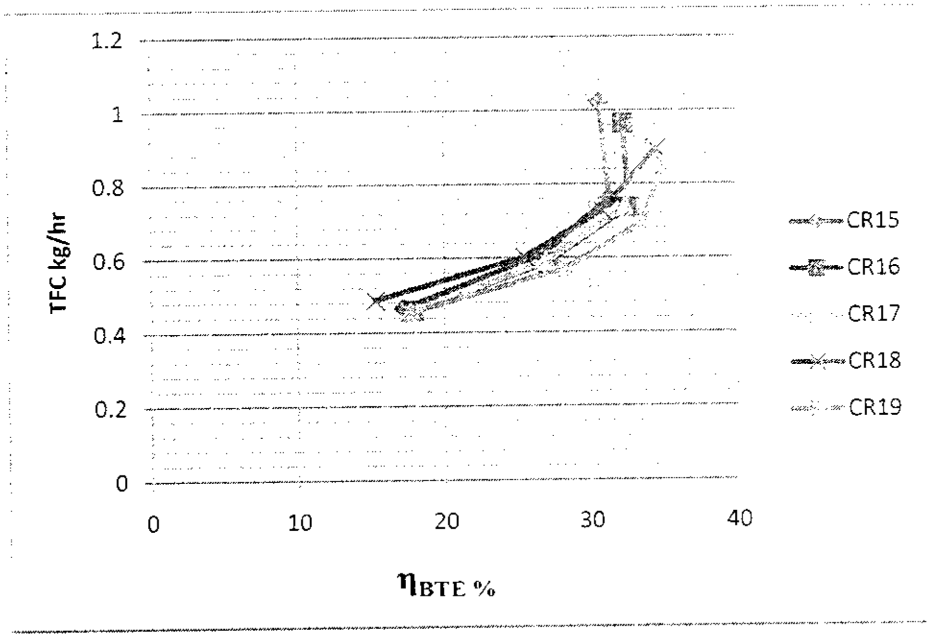

Fig.5.30 5% Ethanol blend

From Fig.5 29, TFC for pure diesel is lowest for CR-19 with value 0.899473 kg/hr. From Fig.5 30, TFC for 5% Ethanol blend is lowest for CR-19 as 0.849997 kg/hr.

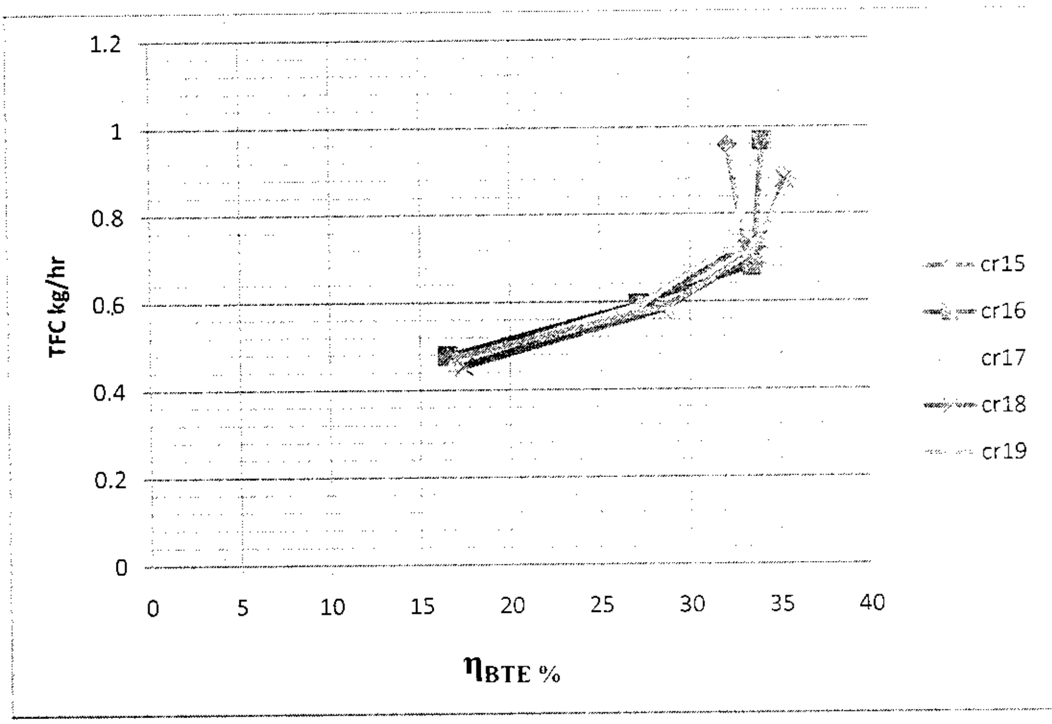

Fig.5.31 10% Ethanol blend

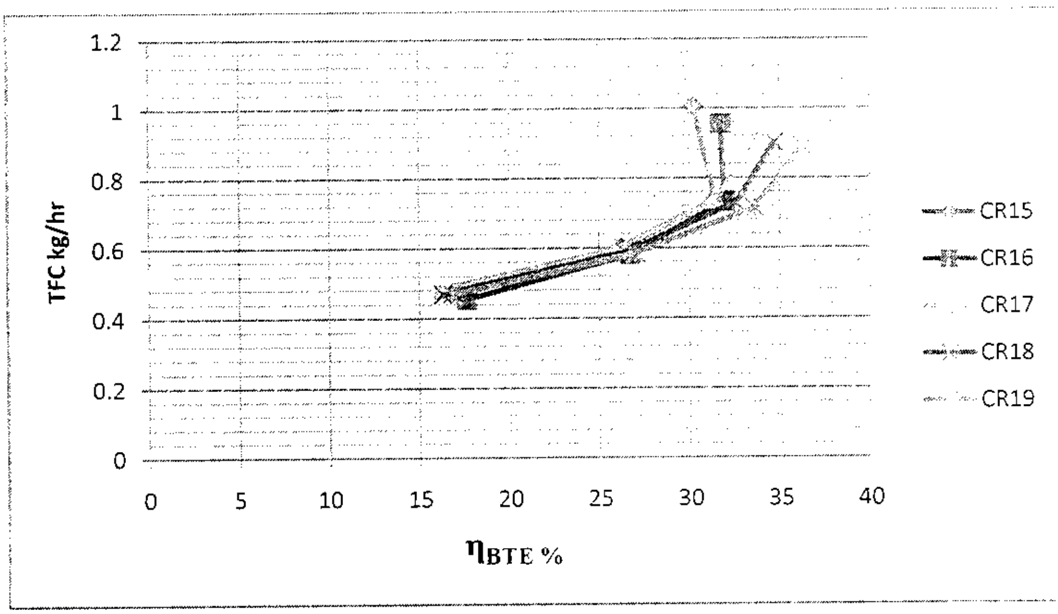

Fig.5.32 15% Ethanol blend

From Fig.5 31, TFC for 10% Ethanol blend is lowest for CR-18 with value 0.878317 kg/hr. From Fig.5 32, TFC for 15% Ethanol blend is lowest for CR-19 as 0.889296 kg/hr. Thus, 5% Ethanol blend has lowest TFC compared to other blends.

LOAD VS BTE (%)

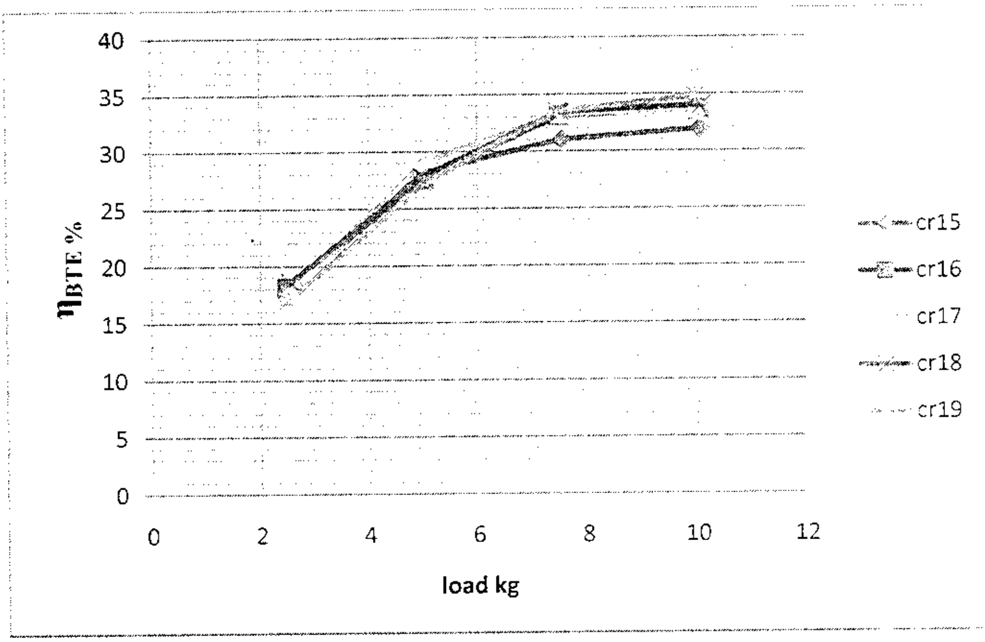

Fig.5.33 Pure diesel

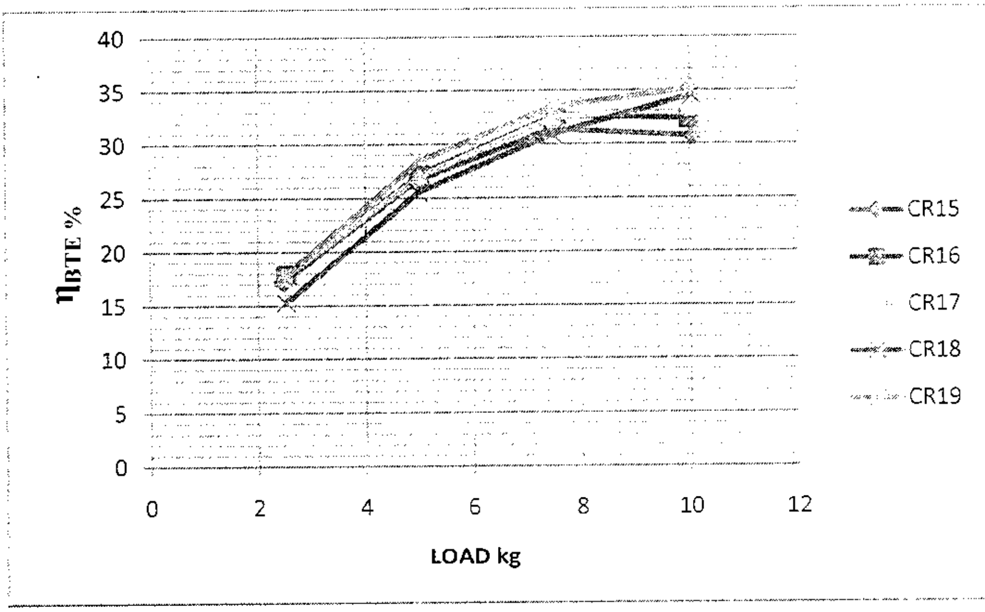

Fig.5.34 5% Ethanol blend

From Fig.5 33, thermal efficiency increases gradually with load and for pure diesel it is highest for CR-19 with value 34.8068%. From Fig.5 34, thermal efficiency for 5% Ethanol blend is highest for CR-19 as 35.15117%.

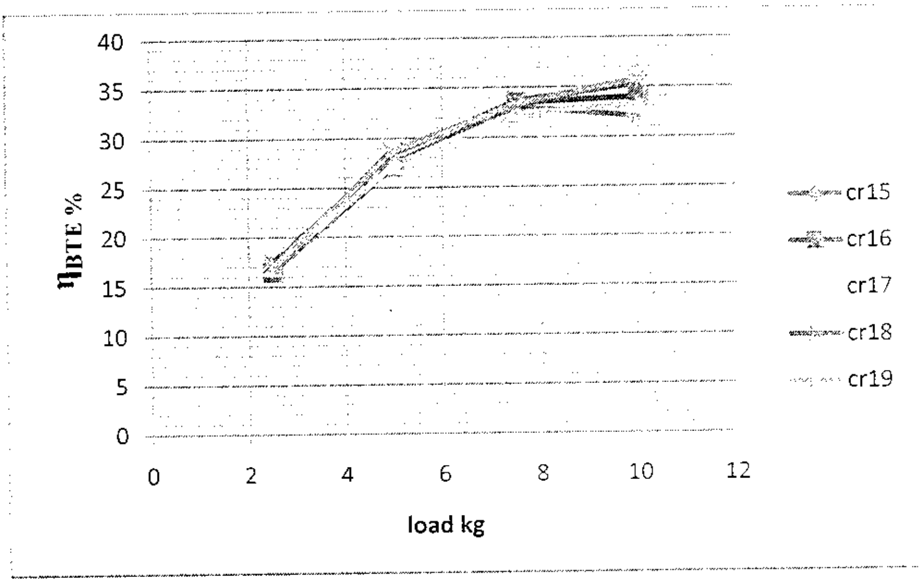

Fig.5.35 10% Ethanol blend

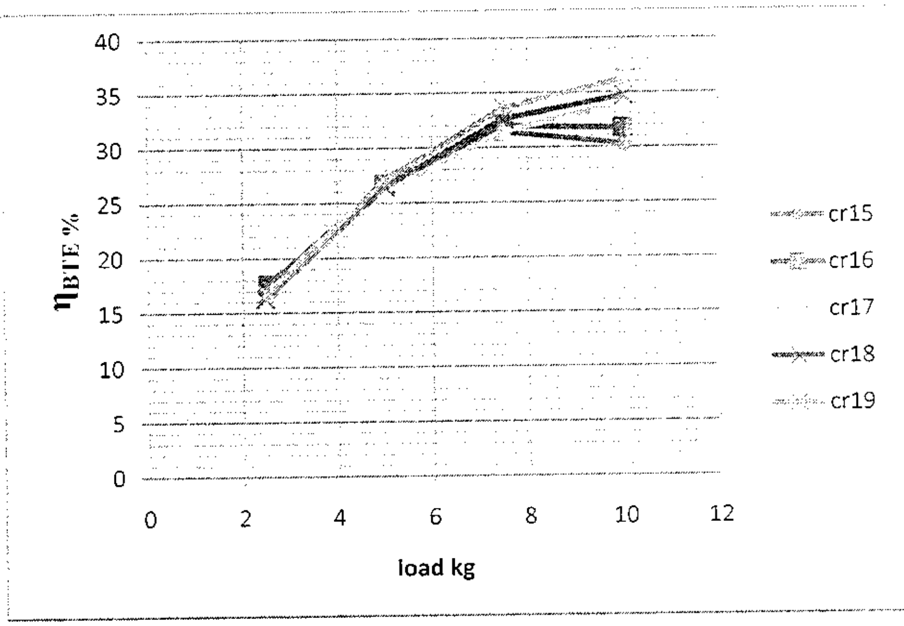

Fig.5.36 15% Ethanol blend

From Fig.5 35, thermal efficiency for 10% Ethanol blend is highest for CR-19 with value 35.73123%. From Fig.5 36, thermal efficiency for 15% Ethanol blend is highest for CR-19 as 36.27351%.

CHAPTER 6

CONCLUSION

From the Results and Discussion, we inferred that:

- 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 thermal efficiency is 34.8068%. Thus BTE is increased up to 4.21% by blending 15% Ethanol with diesel.
- From the results, it is clear that, among the blends, 15% Ethanol Blend holds best results when compared to other blends.

Table. 6.1 Comparison of the Results

Performance Parameters	Unblended diesel(CR-19)	15% Ethanol blend(CR-19)	Result
Brake thermal efficiency	34.8068%	36.27351%	BTE increased by 4.21%
Brake specific fuel consumption(BSFC)	0.224117	0.216279	BSFC decreased by 4.33%

REFERENCES

Lu" Xing-cai, Yang Jian-guang, Zhang Wu-gao, Huang Zhen (2004). "Effect of cetane number improver on heat release rate and emissions of high speed diesel engine fuelled with ethanol- diesel blend fuel". Institute of Internal Combustion Engine. P.No:848-859.

De-gang Li, Huang Zhen, Lu Xingcai, Zhang Wu-gao,Yang Jian-guang (2004) "Physical-chemical properties of Ethanol–diesel blend fuel and its effect on performance and emissions of diesel engines", Shanghai Jiaotong University, Shanghai.P.No:967-976.

E.A. Ajav, Bachchan Singh, T.K. Bhattacharya (1999). "Experimental study of some performance parameters of a constant speed stationary diesel engine using ethanol-diesel blends as fuel". Faculty of Technology, University of Ibadan, Nigeria.P.No:323-332.

Lunaidah Md Saad, Baljit Singh & Aswatha Narayana.P.A (2010) "The Effect of Fuel Additives on Performance and Emission of Four Stroke Engine" International Conference on Science and Social Research (CSSR 2010), P.No:1218-1222.

Manish K. Nandi (2004) "The performance of dctertiary-butyl peroxide as cetane improver in diesel fuels" ARCO chemical company, New Town Square, P.No:863-867.

Hwanam Kim, Byungchul Choi and Yong-Kil Kim(2010) "Engine performance and emission characteristics of CRDi diesel engine equipped with WCC and DOC using ethanol blended diesel fuel", Kwangju, P.No: 500-757.

Donepudi JAGADISH , Puli RAVI KUMAR, and Madhu MURTHY.K (2011) "The effect of supercharging on performance and emission characteristics of compression ignition engine with diesel-ethanol-ester blends" , Warangal, Andhra Pradesh, P.No:1165-1174.

Huseyin KoSE, Eyub CANLI, Murat CINIVIZ and Ozgur SOLMAZ (2011) "An experimental investigation on effects of methanol blended diesel fuels to engine performance and emissions of a diesel engine", Turkeya, Vol.6, P.No:3189-3199.