

**“Study on the performance and Emission characteristics  
using castor and mustard seed oil mixture and diesel blend  
in C.I Engine”**

A THESIS SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF

**Bachelor of Technology  
In  
Mechanical Engineering**

By  
**Debiprasad Behera  
10603014**

Under the Guidance of  
**Prof. S. Murugun**



**Department of Mechanical Engineering  
National Institute of Technology  
Rourkela**

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2010



**National Institute of Technology  
Rourkela**

## **CERTIFICATE**

This is to certify that the project entitled, “**Study on Performance and Emission characteristics using Castor and Mustard oil mixture and Diesel blend in C.I Engine**” submitted by ‘**Mr Debiprasad Behera**’ in partial fulfillments for the requirements for the award of Bachelor of Technology Degree in Mechanical Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by her under my supervision and guidance.

To the best of my knowledge, the matter embodied in the report has not been submitted to any other University / Institute for the award of any Degree or Diploma.

**Date:**

**(Prof. S.Murugan)**

**Dept. of Mechanical Engineering,  
National Institute of Technology**

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Rourkela - 769008, Orissa

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Date:

Debiprasad Behera

Roll No: 10603014

Dept. of Mechanical Engineering National  
Institute of Technology Rourkela

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## **Abstract**

Bio-diesel is one of the most promising alternatives for diesel needs..The present work has focused on the performance of castor non-edible vegetable oil and Mustard oil edible vegetable oil and its blend with diesel on a double cylinder, 4 stroke, naturally aspirated, direct injection, water cooled, eddy current dynamometer Kirloskar Diesel Engine at 1500 rpm for variable loads. Initially, castor eat oil and their blends were chosen. The physical and chemical properties of Castor oil, Mustard oil and its blend were determined. In general, viscosity of neat vegetable oil is high, which can be reduced through blending with diesel and heating them. The performance and emission characteristics of engine are determined using Castor and Mustard oil and their blends with diesel. These results are compared to those of pure diesel. Byanalyzing the graphs, it was observed that the performance characteristics are reduced and emission characteristics are increased at the rated load compared to those of diesel. This is mainly due to lower calorific value, high viscosity and delayed combustion process. From the critical analysis of graphs, it can be observed that 10% of Castor oil and Mustard oil mixture mixed with 90% of diesel is the best suited blend for Diesel engine without eating and without any engine modifications. It is concluded that castor and Mustard oil can be used as an alternate to diesel

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# Chapter 1

## INTRODUCTION

## INTRODUCTION

Energy comes in a variety of renewable forms; wood, biomass, wind, sunlight. It also comes in the nonrenewable form of fossil fuels- oil and coal and their use is a major source of pollution of land, sea and above all the air we breathe. Two centuries of unprecedented industrialization, driven mainly by fossil fuels, have changed the face of this planet. The present civilization can't survive without motor cars and electricity. The increasing rate at which the changes in human lives are occurring has important consequences for the environment and carrying capacity of earth. The industrial revolution has brought greatly increased wealth to one quarter of the population and severe inequalities. Pollution and accelerating energy consumption has already affected equilibrium of earth's land masses, oceans and atmosphere. Particularly, important is the loss of biodiversity. Fortunately, the last 25 years has seen growing awareness of some of these consequences.

Since the dawn of oil age man has burnt about 800 million barrels of petroleum. About 71 barrels are burnt everyday throughout the world. And this consumption rate goes on increasing by 2% every year. The 2% doubles the quantity every 34 years. Somewhere between 1000 to 1600 billion barrels of fuel consumption are assumed to be in formation where economic recovery is possible. By 2010 the world would have consumed about one-half of the total amounts that is technically and economically feasible to extract. And at the current rate of consumption 1600 billion barrels would be depleted in 60 years. It's high time to think about the alternative fuels.

# Chapter 2

## TYPES OF FUELS

## **2.1 TYPES OF FUEL**

The engine converts heat energy obtained from the chemical combination of fuel with oxygen, into mechanical energy. Since the heat energy is derived from the fuel, a fundamental knowledge of the types of fuel and their characteristics is essential in order to understand the combustion phenomenon. The characteristics of the fuel used have considerable influence on the design, efficiency, output and particularly, the reliability and durability of the engine. IC engines can be operated on different types of fuels such as liquid, gaseous and even solid fuels depending upon the types of fuels to be used in the engine has to be designed accordingly.

### **2.1.1 SOLID FUELS**

The solid fuels find little practical application at present because of the problems in handling the fuel as well as in disposing off, the solid residue or ash after combustion. However, in the initial stages of the engine development, solid fuels such as finely powdered coal were attempted. Compared to gaseous and liquid fuels, the solid fuels are quite difficult to handle and storage and feeding are quite cumbersome. Because of the complications in the design of the fuel feed systems these fuels have become unsuitable in solid forms. Attempts are being made to generate gaseous or liquid fuels from charcoal for the use in IC Engine.

### **2.1.2 GASEOUS FUELS**

Gaseous fuels are ideal and pose no problems whatsoever in using them in IC engine. Being gaseous, they mix more homogeneously with air and eliminate the distribution and starting problems that are encountered with liquid fuels. Even though the gaseous fuels are the most ideal for IC engines, storage and handling problems restrict their use in automobiles. Consequently, they are more commonly used for stationary power plants located near the source of availability of fuel. Some of the gaseous fuels can be liquefied under pressure for reducing the storage volume. But this arrangement is very expensive as well as risky. Because of the energy crisis in the recent years, considerable research efforts are being made to improve the design and performance of the gas engines, which became obsolete when liquid fuels came into use.

### **2.1.3 LIQUID FUELS**

In most of the modern IC engines, liquid fuels which are the derivatives of liquid petroleum are being used. The three principal commercial types of liquid fuels are: Benzyl, alcohol and petroleum products. However, petroleum products form the main fuels for IC engines as on today.

# Chapter 3

## ALTERNATIVE FUEL

### **3. ALTERNATIVE FUELS**

In this century, it is believed that the crude oil and petroleum products will become very scarce and costly. Day- to-day, fuel economy of engine is getting improved and will continue to improve. However, enormous increases in number of vehicles have started dictating the demand for fuel. Gasoline and diesel will become scarce and most costly in the near future. With increased use and the depletion of fossil fuels, alternative fuel technology will become more common in the coming decades.

All these years there have always been some IC engines fuelled with non-gasoline or diesel oil fuels .However; their numbers have been relatively very small. Because of the high cost of petroleum products, some developing countries are trying to use alternative fuels for their vehicles

Another reason motivating the development of alternative fuels for the IC engines is the concern over emission problems of gasoline and diesel engines. Combined with other air polluting systems, large number of automobiles is the major contributor to the air quality problem of the world. Quite a lot of improvements have been made in reducing emissions from automobile engines. If a 35% improvement made over a period of years, it is to be noticed that during the same time the number of automobiles in the world increases by 40%, thereby nullifying the improvement. Lot of efforts has gone into for achieving the net improvement in cleaning up automobiles exhaust. However, more improvements are needed to bring down the ever-increasing air pollution due to automobile population.

A third reason for alternative fuel development is the fact that a large percentage of crude oil must be imported from other countries which control larger oil fields. As of now many alternative fuels have been used in limited quantities in automobiles. Quite often, fleet vehicles have been used for testing. This paves way for comparison with similar gasoline-fuelled vehicles, and simplifies fuelling of these vehicles.

The engines used for alternative fuels are modified engines which were originally designed for gasoline fuelling. They are, therefore, not the optimum design for other fuels. Only when extensive research and development is done over a period of years, maximum performance and efficiency can be realized from these engines. However, the research and development is difficult to justify until the fuels are accepted as viable for large number of engines.

Some diesel engines have started appearing on market. They use methanol or natural gas and a small amount of diesel fuel that is injected at proper time to ignite both fuels. Most alternative fuels are costly now a day since the quantity used is very less. Many of these fuels will cost much less if the amount of their uses gets to the same order of magnitude as gasoline. The cost of manufacturing, distribution, and marketing would be less.

Another problem with alternative fuel is the lack of distribution points where the fuel is available to public. The public will be reluctant to purchase an automobile unless there is a large scale of network of service station available where fuel for that automobile can be purchased. On the other hand, it is difficult to justify building a network of these service networks until there are enough automobile to make them profitable.

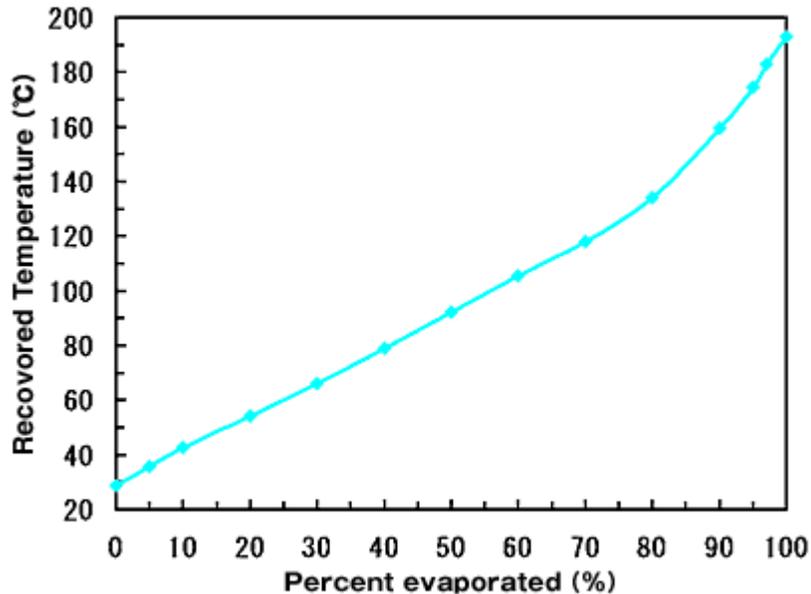
### **3.1 S.I ENGINE FUELS**

Fuels used in IC engines should possess certain basic qualities which are important for the smooth running of the engines .Gasoline which is mostly used in the present day SI engines is usually a blend of several low boiling paraffins, naphthalenes & aromatics in varying proportions. Some of the important qualities of gasoline are:-

#### **(i)Volatility:**

Volatility is one of the main characteristic properties of gasoline which determines its suitability for use in an SI engine. Since gasoline is a mixture of different hydrocarbons, volatility depends on the fractional composition of the fuel. The usual practice of measuring the fuel volatility is the distillation of the fuel in a special device at atmospheric pressure & in the presence of its own vapour. The fraction that boils off at a definite temperature is measured. The characteristic points are the temperatures at which 10, 40, 50 & 90% of the volume evaporates as well as the temperature at which boiling of the fuel terminates.

The more important aspects of volatility related to engine fuels are in conjunction with the



distillation curve:-

(ii) Starting & Warm up:

A certain part of the gasoline should vapourize at the room temperature for easy starting of the engine. Hence, the portion of the distillation curve between about 0 & 10 % boiled off have relatively low boiling temperatures. As the engine warms up, the temperature will gradually increase to the operating temperature. Low distillation temperatures are desirable throughout the range of the distillation curve for best warm-up.

(iii) Operating Range Performance:

In order to obtain good vapourization of the gasoline, low distillation temperatures are preferable in the engine operating range. Better vapourization tends to produce both more uniform

distribution of fuel to the cylinders as well as better acceleration characteristics by reducing the quantity of liquid droplets in the intake manifold.

iv)Crankcase Dilution:

Liquid fuel in the cylinder causes loss of lubricating oil (by washing away oil from cylinder walls) which deteriorates the quality of lubrication & tends to cause damage to the engine through increased friction. The liquid gasoline may also dilute the lubricating oil & weaken the oil film between rubbing surfaces. To prevent these possibilities, the upper portion of the distillation curve should exhibit sufficiently low distillation temperatures to ensure that all gasoline in the cylinder is vapourized by the time the combustion starts.

(v) Vapour Lock Characteristics:

High rate of vapourization of gasoline can upset the carburetor metering or even stop the fuel flow to the engine by setting up a vapour lock in the fuel passages. This characteristic, demands the presence of relatively high boiling temperature hydrocarbons throughout the distillation range. Since this requirement is not consistent with the other requirements desired, a compromise must be made for the desired distillation temperatures.

(vi) Antiknock Quality:

Abnormal burning or detonation in an SI engine combustion chamber causes a very high rate of energy release, excessive temperature & pressure inside the cylinder adversely affects its thermal efficiency. Therefore, the characteristics of the fuel used should be such that it resists the

tendency to produce detonation & this property is called its antiknock property. The antiknock property of a fuel depends on the self-ignition characteristics of its mixture & varies largely with the chemical composition & molecular structure of the fuel. In general, the best SI engine fuel will be that having highest antiknock property, since this permits use of higher compression ratios & thus the engine thermal efficiency & the power output can be greatly increased.

(vii)Gum Deposits:

Reactive hydrocarbons & impurities in the fuel have a tendency to oxidize upon storage & form liquid & solid gummy substances. The gasoline containing hydrocarbons of the paraffin, naphthalene & aromatic families forms little gum while cracked gasoline containing unsaturated hydrocarbons is the worst offender. A gasoline with high gum content will cause operating difficulties such as sticking valves & piston rings carbon deposits in the engine, gum deposits in the manifold, clogging of carburetor jets & enlarging of the valve stems, cylinders & pistons. The amount of gum increases with increased concentrations of oxygen, with rise in temperature, with exposure to sunlight & also on contact with metals. Gasoline specifications therefore limit both the gum content of the fuel & its tendency to form gum during storage.

(viii)Sulphur Content:

Hydrocarbon fuels may contain free sulphur, hydrogen sulphide & other sulphur compounds which are objectionable for several reasons. The sulphur is a corrosive element of the fuel that can corrode fuel lines, carburetors & injection pumps & it will unite with oxygen to form sulphur dioxide that, in the presence of water at low temperatures, may form sulphurous acid. Since

sulphur has a low ignition temperature, the presence of sulphur can reduce the self-ignition temperature, then promoting knock in the SI engine.

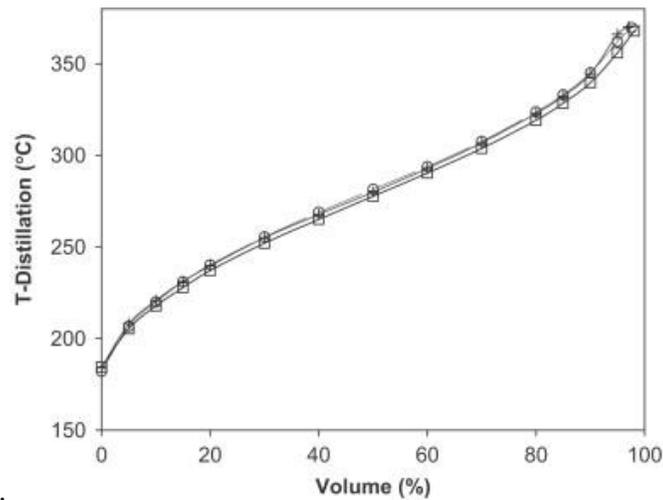
### **3.3 C.I ENGINE FUELS**

#### **(i)Knock Characteristics:**

Knock in the CI engine occurs because of an ignition lag in the combustion of the fuel between the time of injection & the time of actual burning. As the ignition lag increases, the amount of fuel accumulated in the combustion chamber increases & when combustion actually takes place, abnormal amount of energy is suddenly released causing an excessive rate of pressure rise which results in an audible knock. Hence, a good CI engine fuel should have a short ignition lag & will ignite more readily. Furthermore, ignition lag affects the starting, warmup, & leads to the production of exhaust smoke in CI engines. The present day measure in the cetane rating, the best fuel in general, will have a cetane rating sufficiently high to avoid objectionable knock.

#### **(ii)Volatility:**

The fuel should be sufficiently volatile in the operating range of temperature to produce good



mixing & combustion.

Figure above is a representative distillation curve of a typical diesel fuel.

(iii) Starting Characteristics:

The fuel should help in starting the engine easily. This requirement demands high enough volatility to form a combustible mixture readily & a high cetane rating in order that the self-ignition temperature is low.



# Chapter 4

## VEGETABLE OIL IN C.I ENGINE.

#### **4. VEGETABLE OIL IN C.I ENGINES**

Bio-diesel, an alternative diesel fuel, is made from renewable biodegradable sources such as vegetable oil and animal fats. It is biodegradable, non-toxic and possesses low emission profiles. Also, it is environmental friendly. It is named as bio-diesel in the United States during 1992 by the National Soy Diesel Development Board (presently National Bio-diesel Board) which has pioneered the commercialization of bio-diesel in the US.

Chemically, bio-diesel is mono-alkyl-esters of long-chain-fatty-acids derived from renewable lipid sources. Bio-diesel is the name for a variety of ester based oxygenated fuel from renewable biological sources. It can be used in compression ignition engines with little or no modifications.

One hundred years ago, Rudolf Diesel first tested vegetable oil as fuel for his engine. With the advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuel and diesel fuels and diesel engines started evolving together. Later in the 1940's, vegetable oils were used again as fuel in emergency situations, during the period of World War II. Because of the increase in crude oil prices, limited resources of fossil fuels and the environmental concern, there has been renewed focus on vegetable oils and animal fats for the production of bio-diesel fuel. Bio-diesel has the potential to reduce the level of pollution and the level of global warming.

The following are some of the advantages of using vegetable oil in I.C. engine :

- (i) Vegetable oil is produced domestically which helps to reduce costly petroleum imports;
- (ii) Development of the bio-diesel industry would strengthen the domestic, and particularly the rural, agricultural economy of agricultural based countries like India;
- (iii) It is biodegradable and non-toxic;
- (iv) It is a renewable fuel that can be made from agricultural crops and or other feed stocks that are considered as waste;
- (v) It has 80% heating value compared to that of diesel;
- (vi) It contains low aromatics;
- (vii) It has a reasonable cetane number and hence possesses less knocking tendency;
- (viii) Low sulphur content and hence environment friendly;
- (ix) Enhanced lubricity, thereby no major modification is required in the engine;
- (x) Personal safety is improved (flash point is 100 °C higher than that of diesel);
- (xi) It is usable within the existing petroleum diesel infrastructure (with minor or no modification in the engine) .

The major challenges that face the use of vegetable oil as I.C. engine fuels are listed below :

- (i) The price of vegetable oil is dependent on the feed stock price;
- (ii) Feed stock homogeneity, consistency and reliability are questionable;
- (iii) Homogeneity of the product depends on the supplier, feed stocks and production methods;
- (iv) Storage and handling is difficult (particularly stability in long term storage);
- (v) Flash point in blends is unreliable;

- (vi) Compatibility with I.C. engine material needs to be studied further;
- (vii) Cold weather operation of the engine is not easy with vegetable oils;
- (viii) Acceptance by engine manufacturers is another major difficulty;
- (ix) Continuous availability of the vegetable oils needs to be assured before embarking on the major use of it in I.C. engines.

The major technical areas (with respect to the use of vegetable oils as fuels in I.C. engines) , which need further attention are the following:

- (i) Development of less expensive quality tests;
- (ii) Study of the effects of oxidized fuel on engine performance and its durability;
- (iii) Emission testing with a wide range of feed stocks;
- (iv) Studies on developing specific markets such as mining, municipal water supplies etc. which can specify bio-diesel as the fuel choice for environmentally sensitive areas;
- (v) Co-product development like the recovery of glycerol at reduced cost;
- (vi) Efforts to be focused on responding to fuel system performance, material compatibility, petroleum additive compatibility and low fuel stability under long term storage;
- (vii) Continued engine performance, emissions and durability testing in a variety of engine types and sizes need to be developed to increase consumer and manufacturer confidence;
- (viii) Environmental benefits offered by vegetable oil over diesel fuel needs to be popularized;
- (ix) Studies are needed to reduce the production cost, develop low cost feed stocks and identify potential markets in order to balance cost and availability;

(x)Research on the effect of glycerol on engine durability, emission and material compatibility;

(xi)Development of additives for improving cold flow properties, material compatibility and prevention of oxidation in storage, etc.

#### **4.1 CASTOR SEED OIL**

Castor oil is non-volatile fatty oil taken from beans of the plants. It ranges in color from colorless to greenish. It has two derivatives such as blown castor and hydrogenated oil. Castor oil used in textiles, paints, varnishes, plastics, cosmetics, fibers, hair oils and drying oils. It is also used for traditional and medical treatment purposes. Table 1 shows the comparison of properties of castor oil with diesel.

| Property                             | Diesel oil | Castor oil |
|--------------------------------------|------------|------------|
| Density (g/ml) at 30 <sup>0</sup> C  | 0.84       | 0.956      |
| Calorific value (kj/kg)              | 42000      | 36000      |
| Viscosity (cst) at 30 <sup>0</sup> C | 5.0        | 78         |
| Flash point ( <sup>0</sup> C)        | 57         | 320        |
| Fire point ( <sup>0</sup> C)         | 65         | 345        |

## **4.2 MUSTARD SEED OIL**

Monterey County transit officials are in the midst of an experiment to put biofuel from locally grown mustard plants into the fuel tanks of buses.

By December, Monterey-Salinas Transit officials hope to have refined mustard-seed oil — which will be mixed with regular diesel fuel — from about 3,000 pounds of seeds harvested in August from a 10-acre field in the King City area.

"We're going to be using our oil late this year," said Hunter Harvath, assistant general manager of the transit agency.

The timing depends on when the seed can be pressed and refined. Presses are in short supply this time of year because the wine grape crush is under way, he said.

The mustard seed experiment began in February on 20 acres owned by San Bernabe Vineyards near King City. Pacific gold and wild California mustards were planted to determine which variety of the plant would produce the most seed oil.

The idea is to determine whether mustard could be a sustainable, home-grown substitute for corn and soy, the primary sources of biodiesel fuel. Buses on the Monterey-Salinas Transit line already burn fuel with 20 percent biodiesel from soy beans, Harvath said.

Of the two varieties, only the Pacific gold was harvested because turnips overran the other field, making it impossible to use a combine to collect the wild California seed, Harvath said. The ton and a half of seed will produce about 750 to 800 gallons of biodiesel. Like other biodiesel, the mustard oil will constitute 20 percent of the fuel mixture that powers the buses, he said.

MST officials are already talking about the next round of biofuel experimentation. More acreage might be planted later this fall to take advantage of winter rains for natural irrigation. Mustard likely will be examined along with other plants for biofuel potential.

Hoover is uncertain about the economics of growing a lot of biofuel mustard in Monterey County. Land costs and arid conditions in the southern part of the county don't lend themselves to the crop, he said.

| <b>PROPERTIES</b>            | <b>MUSTARD OIL</b> | <b>DIESEL</b> |
|------------------------------|--------------------|---------------|
| SPECIFIC GRAVITY             | 0.672              | 0.83          |
| CALORIFIC<br>VALUE(MJ/KG)    | 42.1               | 43.22         |
| FLASH POINT(K)               | 518                | 47            |
| VISCOSITY                    | 33.8               | 5.8           |
| SULPHUR<br>CONTENT(MGS/100G) | 170.5              | 10            |
| ACID VALUE                   | 1.5                | 0             |
| FIRE POINT(C)                | 90                 | 64            |
| CETANE NO.                   | 47                 | 49            |

|                     |       |     |
|---------------------|-------|-----|
| MOLECULAR WEIGHT(G) | 99.15 | 233 |
|---------------------|-------|-----|

#### 4.3 PROPERTIES OF CASTOR AND MUSTARD SEED OIL MIXTURE AND DIESEL

| PROPERTIES                | CASTOR OIL | MUSTARD OIL | MIXTURE | DIESEL |
|---------------------------|------------|-------------|---------|--------|
| SPECIFIC GRAVITY          | 0.96       | 0.672       | 0.816   | 0.83   |
| CALORIFIC VALUE(MJ/KG)    | 36.2       | 42.1        | 37.85   | 43.22  |
| FLASH POINT(K)            | 317        | 518         | 417.5   | 47     |
| VISCOSITY                 | 226.82     | 33.8        | 130.31  | 5.8    |
| SULPHUR CONTENT(MGS/100G) | 20         | 170.5       | 95.25   | 10     |
| ACID VALUE                | 1.642      | 1.5         | 1.57    | 0      |
| FIRE POINT(C)             | 345        | 90          | 217.5   | 64     |
| CETANE NO                 | 40         | 47          | 43.5    | 49     |
| MOLECULAR WEIGHT(GM)      | 932        | 99.15       | 515.575 | 233    |

# Chapter 5

## **EXPERIMENTAL SETUP AND PROCEDURE**



## 5.2 ENGINE SPECIFICATION

|                   |  |
|-------------------|--|
| ENGINE            | 4S TWIN CYLINDER,WATER COOLED,DIRECT INJECTING,VERTICAL,3.7 KW POWER |
| MAKE/MODEL        | KIRLOSKAR TV 1   |
| BHP AND RPM       | 10 BHP @ 1500 RPM  |
| BORE*STROKE       | 80mm*110mm   |
| COMPRESSION RATIO | 17.5:1   |

## 5.3 PROCEDURE

The castor oil and mustard oil are mixed together to prepare a mixture. The proportion of mixing the two oils are 50% and 50%.then 10% of the mixture is taken and 90% of diesel is taken to prepare the blend. This is the first fuel to be tested.

Then 20% of the mixture is taken and 80%diesel is mixed to prepare the second blending .likewise 30% blend is taken and tested.

The blend oil is put in the fuel tank, the engine is started first we have to take the reading for 0 load and time taken to consume 20ml of oil is noted down. Afterwards load is increased gradually as 0, 5,10,15,20 and 25Kg.

## Diesel

| Load (Kgf) | Engine speed (rpm) | Time (sec.) | Ex. temp. (°c) | Fuel consumption (Kg/hr.) | Brake power (Kw) | Brake sp. Fuel consumption (Kg/Kw hr.) | $\eta_{\text{thermal}}$ (%) |
|------------|--------------------|-------------|----------------|---------------------------|------------------|--|-----------------------------|
| 0          | 1500               | 74          | 260            | 0.81                      | 0                | 0                                      | 0                           |
| 5          | 1500               | 54          | 310            | 1.11                      | 1.34             | 0.828                                  | 9.3                         |
| 10         | 1500               | 45          | 340            | 1.33                      | 2.7              | 0.492                                  | 15.7                        |
| 15         | 1500               | 39          | 390            | 1.53                      | 4.04             | 0.379                                  | 20.4                        |
| 20         | 1500               | 33          | 420            | 1.81                      | 5.39             | 0.336                                  | 23                          |
| 25         | 1500               | 27          | 450            | 2.21                      | 6.74             | 0.328                                  | 23.6                        |

### 10% blending

|    | Engine speed (rpm) | Time (sec.) | Ex. temp. (°c) | Fuel consumption (Kg/hr.) | Brake power (Kw) | Brake sp. Fuel consumption (Kg/Kw hr.) | $\eta_{\text{thermal}}$ (%) |
|----|--------------------|-------------|----------------|---------------------------|------------------|--|-----------------------------|
| 0  | 1500               | 69.52       | 270            | 0.85                      | 0                | 0                                      | 0                           |
| 5  | 1500               | 52.9        | 315            | 1.12                      | 1.347            | 0.8314                                 | 10.14                       |
| 10 | 1500               | 42.71       | 360            | 1.39                      | 2.695            | 0.519                                  | 16.32                       |
| 15 | 1500               | 37.31       | 400            | 1.59                      | 4.04             | 0.398                                  | 21.40                       |
| 20 | 1500               | 31.46       | 450            | 1.89                      | 5.39             | 0.35                                   | 24.05                       |
| 25 | 1500               | 25.87       | 470            | 2.30                      | 6.738            | 0.34                                   | 24.71                       |

|    | Engine speed (rpm) | Time (sec.) | Ex. temp. (°c) | Fuel consumption (Kg/hr.) | Brake power (Kw) | Brake sp. Fuel consumption (Kg/Kw hr.) | $\eta_{\text{thermal}}$ (%) |
|----|--------------------|-------------|----------------|---------------------------|------------------|--|-----------------------------|
| 0  | 1500               | 67.80       | 275            | 0.87                      | 0                | 0                                      | 0                           |
| 5  | 1500               | 48.4        | 320            | 1.23                      | 1.347            | 0.91                                   | 9.26                        |
| 10 | 1500               | 40.23       | 365            | 1.48                      | 2.695            | 0.549                                  | 15.4                        |
| 15 | 1500               | 34.23       | 410            | 1.74                      | 4.04             | 0.43                                   | 19.64                       |
| 20 | 1500               | 28.67       | 460            | 2.07                      | 5.39             | 0.384                                  | 21.8                        |
| 25 | 1500               | 23.53       | 475            | 2.53                      | 6.738            | 0.375                                  | 22.51                       |

**20% blending**

**30% blending**

## Emission characteristics:

### Diesel

| LOAD | HC | CO   | NO <sub>x</sub> |
|------|----|------|-----------------|
| 0    | 22 | 0.01 | 3               |
| 5    | 18 | 0.05 | 3               |
| 10   | 13 | 0.1  | 4               |
| 15   | 11 | 0.17 | 7               |
| 20   | 8  | 0.22 | 15              |
| 25   | 6  | 1.6  | 38              |

|    | Engine speed (rpm) | Time (sec.) | Ex. temp. (°c) | Fuel consumption (Kg/hr.) | Brake power (Kw) | Brake sp. Fuel consumption (Kg/Kw hr.) | $\eta_{\text{thermal}}$ (%) |
|----|--------------------|-------------|----------------|---------------------------|------------------|--|-----------------------------|
| 0  | 1500               | 65.33       | 280            | 0.91                      | 0                | 0                                      | 0                           |
| 5  | 1500               | 46.6        | 330            | 1.287                     | 1.347            | 0.95                                   | 8.92                        |
| 10 | 1500               | 38.10       | 375            | 1.56                      | 2.695            | 0.57                                   | 14.72                       |
| 15 | 1500               | 32.05       | 420            | 1.83                      | 4.04             | 0.45                                   | 18.82                       |
| 20 | 1500               | 27.78       | 465            | 2.14                      | 5.39             | 0.39                                   | 21.41                       |
| 25 | 1500               | 22.69       | 490            | 2.62                      | 6.738            | 0.38                                   | 21.91                       |

### 10% blending

### 20% blending

| LOAD | HC | CO | NO <sub>x</sub> |
|------|----|----|-----------------|
|------|----|----|-----------------|

| LOAD | HC | CO   | NO <sub>x</sub> |
|------|----|------|-----------------|
| 0    | 19 | 0.01 | 4               |
| 5    | 17 | 0.06 | 5               |
| 10   | 11 | 0.11 | 7               |
| 15   | 9  | 0.18 | 11              |
| 20   | 7  | 0.24 | 17              |
| 25   | 5  | 1.8  | 40              |
| 0    | 18 | 0.05 | 6               |

|    |    |      |    |
|----|----|------|----|
| 5  | 15 | 0.09 | 8  |
| 10 | 11 | 0.15 | 12 |
| 15 | 9  | 0.21 | 19 |
| 20 | 7  | 0.28 | 27 |
| 25 | 5  | 2.3  | 43 |

**30% blending**

| <b>LOAD</b> | <b>HC</b> | <b>CO</b> | <b>NO<sub>x</sub></b> |
|-------------|-----------|-----------|-----------------------|
| 0           | 16        | 0.07      | 9                     |
| 5           | 14        | 0.12      | 11                    |
| 10          | 7         | 0.18      | 16                    |
| 15          | 5         | 0.23      | 20                    |
| 20          | 4         | 0.31      | 32                    |
| 25          | 2         | 2.9       | 48                    |

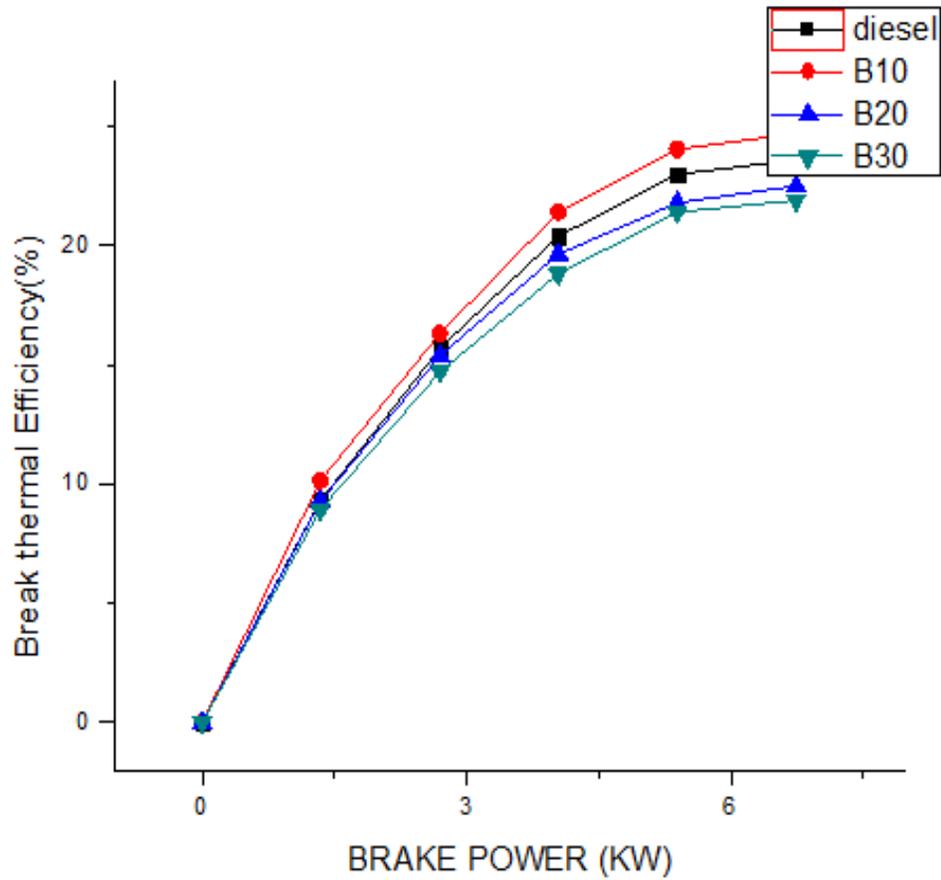
# Chapter 6

## RESULTS AND DISCUSSION

## 6. RESULTS AND DISCUSSION

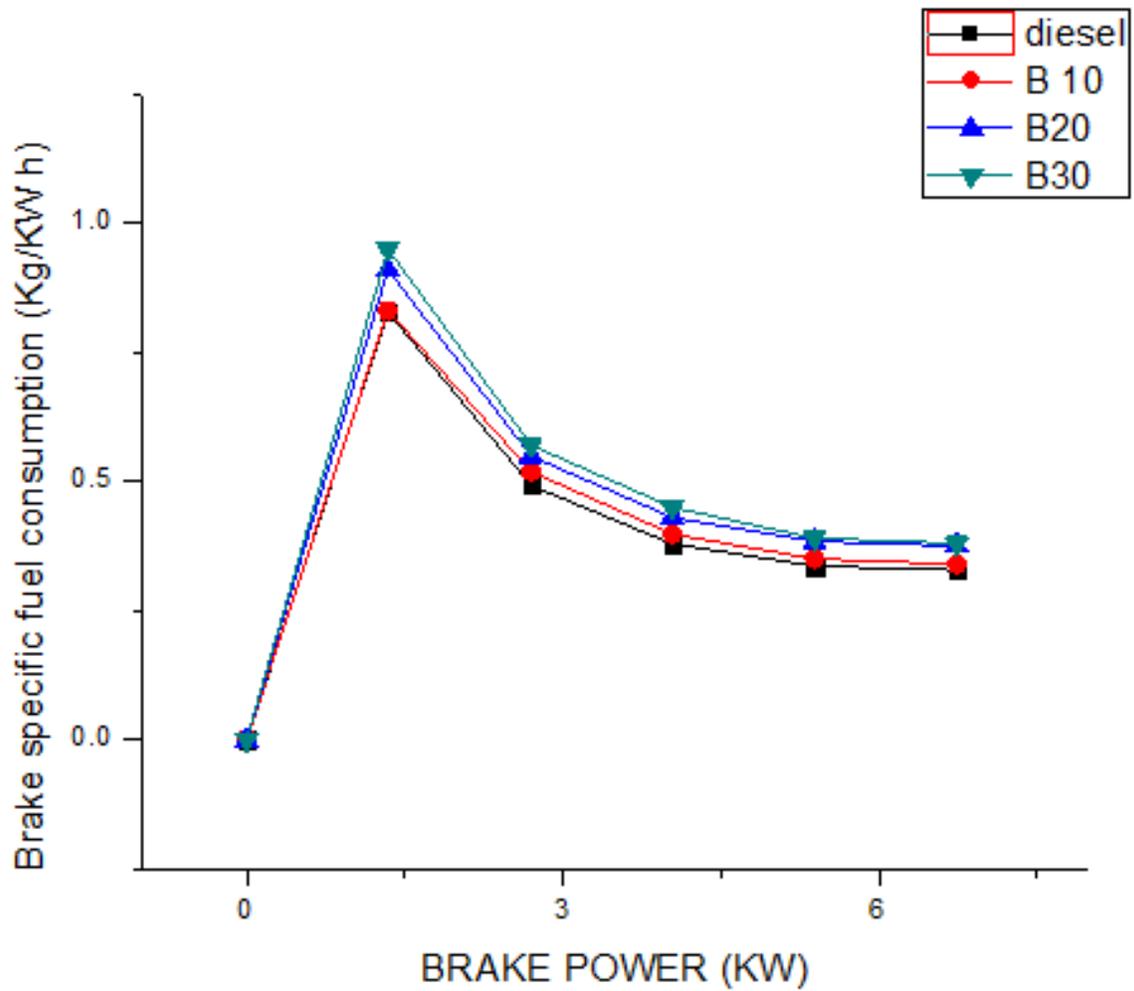
### 6.1 Performance characteristics

#### 6.1.1. Break thermal efficiency v/s Brake power



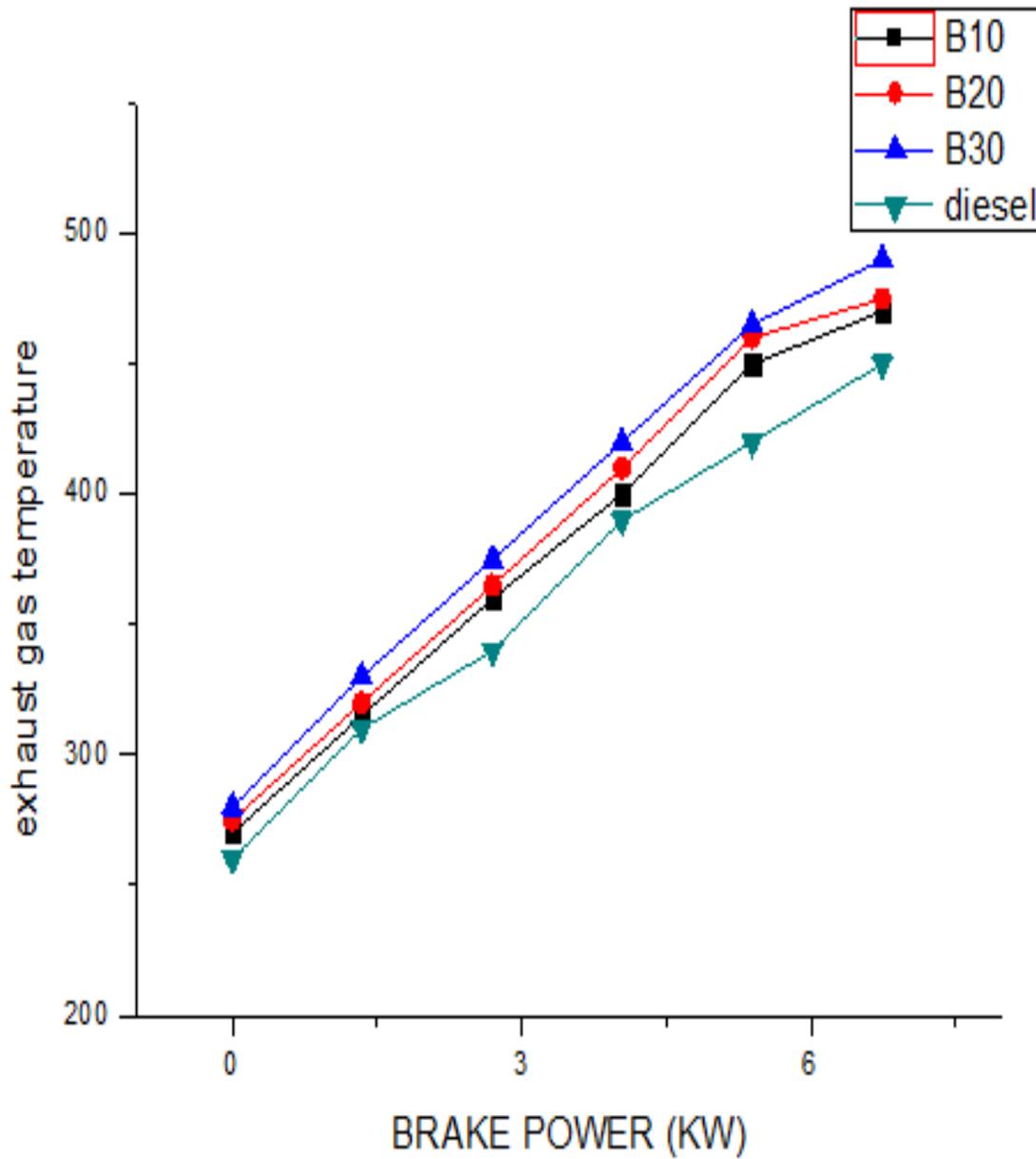
Break thermal efficiency in case of blending 10% is highest in comparison to 20% blending, 30% blending and pure diesel. We get optimum value in case of 10% blending.

### 6.1.2. Brake specific Fuel Consumption V/S Brake Power



Brake specific Fuel consumption in case of pure diesel is the lowest than 10,20 and 30% blending.

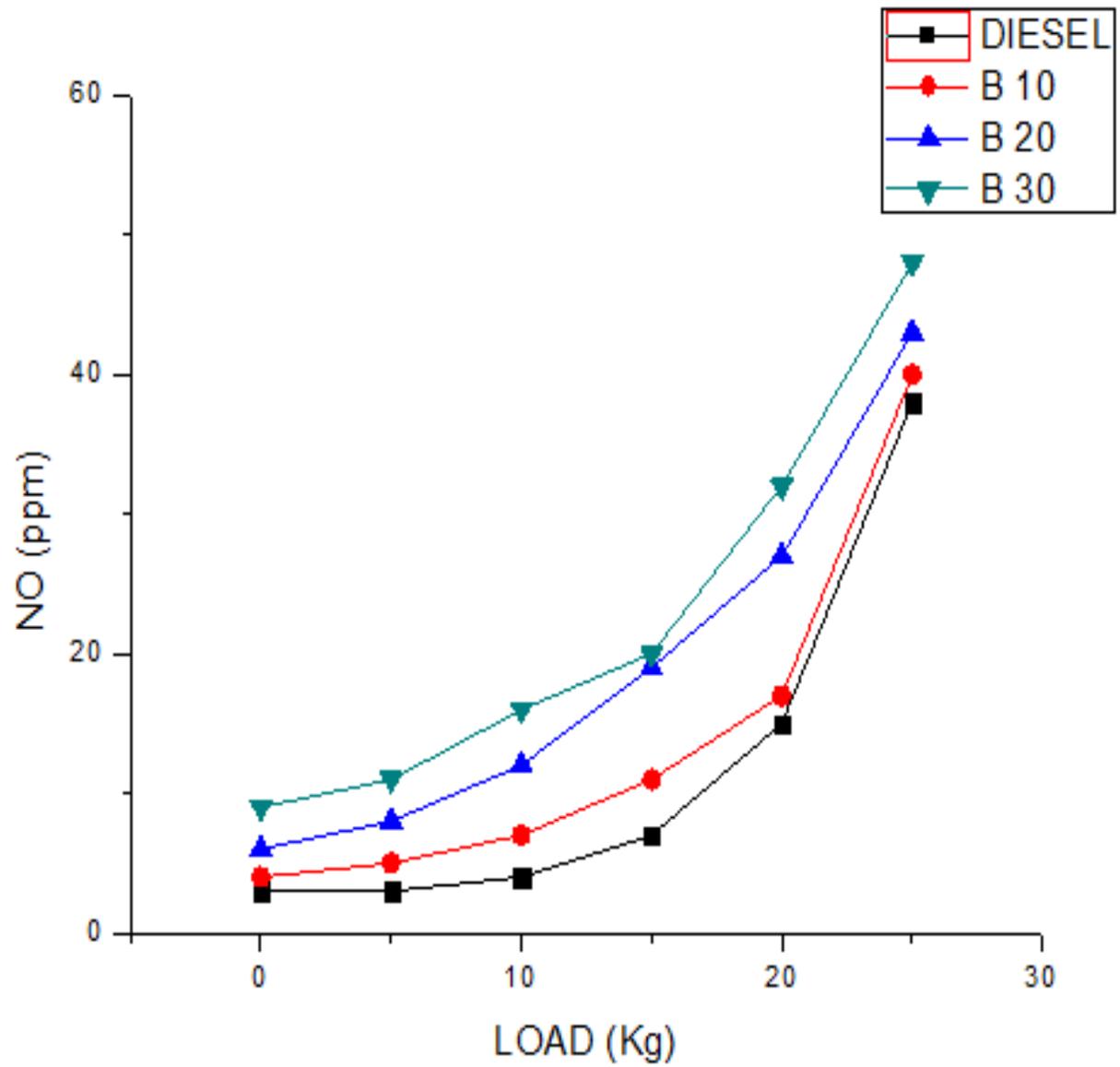
### 6.1.3. Exhaust Gas Temperature V/S Brake Power



Exhaust gas temperature in case of diesel is the lowest compared to other blending.

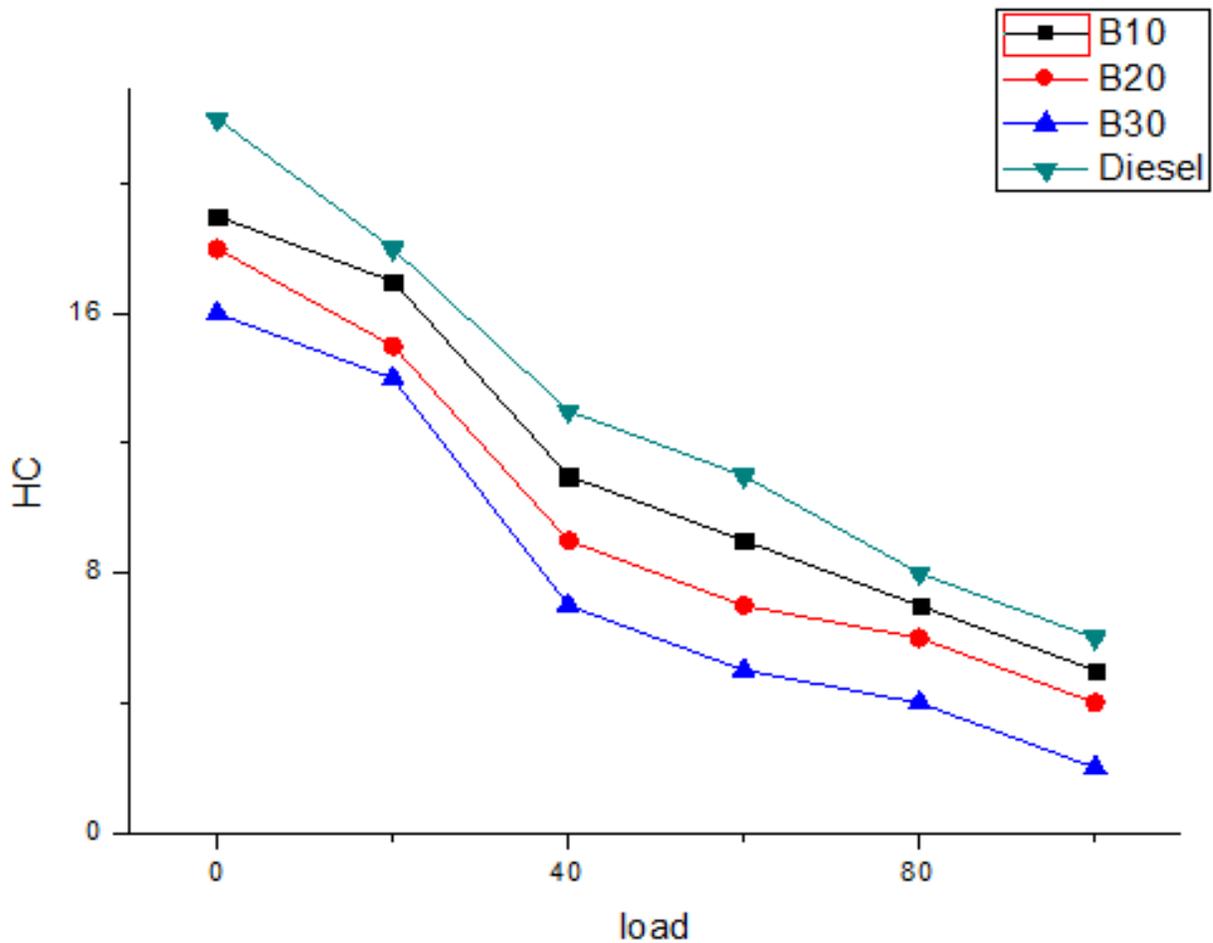
## 6.2 EMISSION TESTS

### 6.2.1. NO (ppm)V/S LOAD(%)



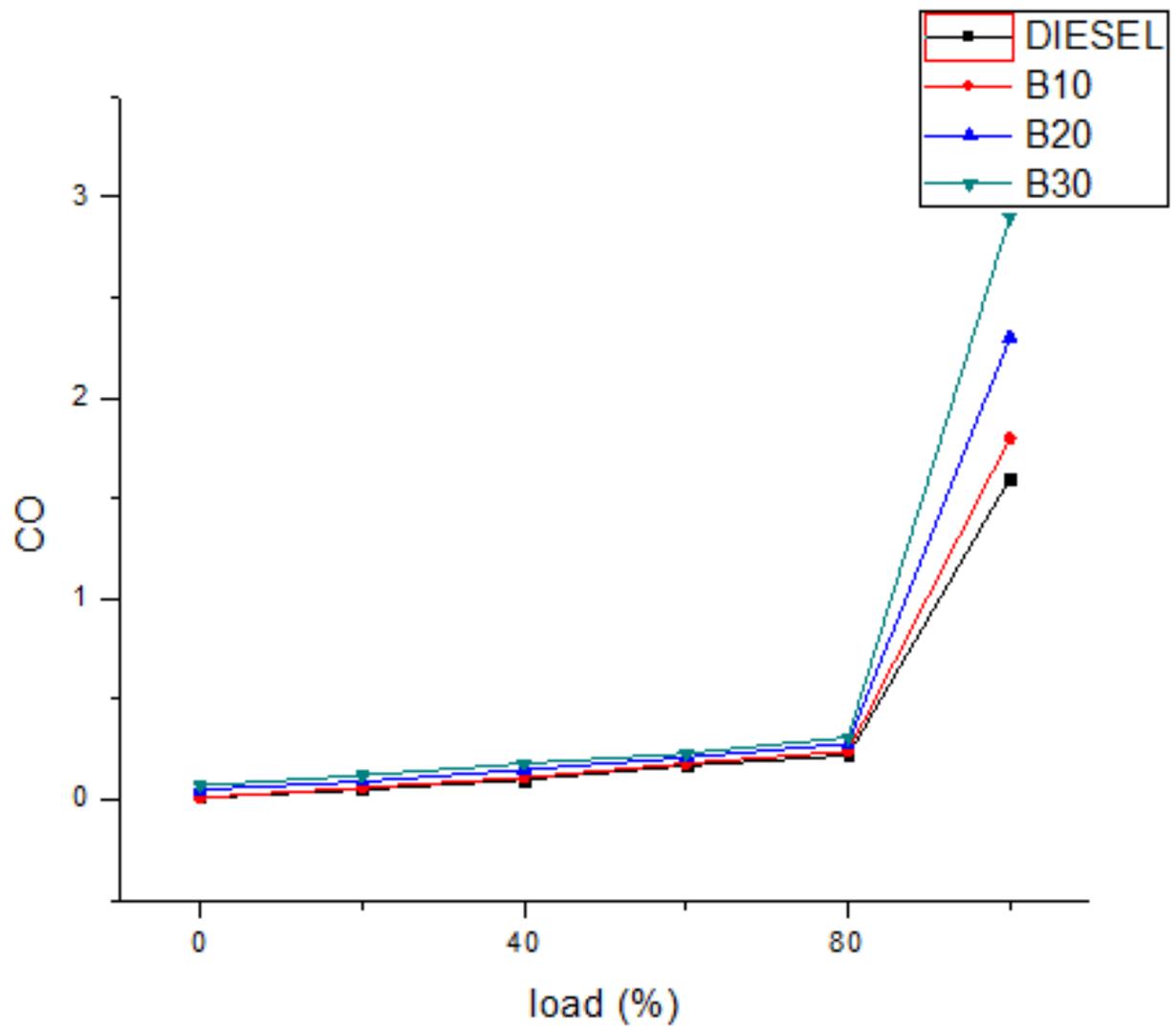
As vegetable oils have larger value of O<sub>2</sub> than diesel so oil burns more inside the cylinder which leads larger value of temperature inside the cylinder which is the main cause of the larger value of NO<sub>x</sub>.

### 6.2.2. HC V/S LOAD (%)



Larger the value of oxygen, lesser will be the HC percentage. As the vegetable oil contents larger oxygen amount, so they emit less hydrocarbon. Growing percentage of blend leads to decrease in hydrocarbon.

### 6.2.3 CO V/S LOAD



Vegetable oil contains larger value of oxygen than diesel, which acts as a combustion promoter in the cylinder. This results in better combustion than diesel. Hence CO, which is due to incomplete combustion, is lower in these oils compared to diesel.

# Chapter 7

## CONCLUSION

## 7. CONCLUSION

- As the above graphs shows that 10% blending gives us optimum values of performance and emission characteristics
- Blends have lower value of Co, Un burnt hydrocarbon than diesel. This is due to better combustion of fuel inside the cylinder than diesel.
- The Brake thermal efficiency, brake specific fuel consumption of blends is lower and higher (except 10% blending) respectively than diesel, this is due to higher viscosity and lower calorific value of the fuel.
- The properties like density, viscosity ,flash point of blends is higher and calorific value is almost 0.8 to 0.9 times that of diesel.

# Chapter 7

## REFERENCE

## Reference :

- [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6V4S-4B0X421-2&\\_user=1657113&\\_coverDate=04%2F30%2F2004&\\_alid=1327933290&\\_rdoc=15&\\_fmt=high&\\_orig=search&\\_cdi=5766&\\_sort=r&\\_docanchor=&view=c&\\_ct=561&\\_acct=C000053917&\\_version=1&\\_urlVersion=0&\\_userid=1657113&md5=5014aa2fa8a7f2a5e5767916cf61c579](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V4S-4B0X421-2&_user=1657113&_coverDate=04%2F30%2F2004&_alid=1327933290&_rdoc=15&_fmt=high&_orig=search&_cdi=5766&_sort=r&_docanchor=&view=c&_ct=561&_acct=C000053917&_version=1&_urlVersion=0&_userid=1657113&md5=5014aa2fa8a7f2a5e5767916cf61c579)
- [http://www.biodieselnw.com/general\\_biodiesel\\_21/f/14/p/23274/160143](http://www.biodieselnw.com/general_biodiesel_21/f/14/p/23274/160143).
- <http://domesticfuel.com/2008/10/24/mustard-seed-biodiesel-for-some-ca-buses/>
- <http://www.techlearning.com/article/18846>
- [http://fbae.org/2009/FBAE/website/our-position-biofuel\\_potential-future-crop-of-farmers.html](http://fbae.org/2009/FBAE/website/our-position-biofuel_potential-future-crop-of-farmers.html)
- **Internal combustion engine by V Ganesan**
- **Internal combustion engine by G D Rai**
- [http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6V3F-4NT57JD-2&\\_user=1657113&\\_coverDate=09%2F30%2F2007&\\_rdoc=1&\\_fmt=high&\\_orig=search&\\_sort=d&\\_docanchor=&view=c&\\_searchStrId=1327285628&\\_rerunOrigin=google&\\_acct=C000053917&\\_version=1&\\_urlVersion=0&\\_userid=1657113&md5=363e6b3bbca08e17000834e75ee5fa42\]](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V3F-4NT57JD-2&_user=1657113&_coverDate=09%2F30%2F2007&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1327285628&_rerunOrigin=google&_acct=C000053917&_version=1&_urlVersion=0&_userid=1657113&md5=363e6b3bbca08e17000834e75ee5fa42)