`

EFFECT OF MUSTARD OIL BIODIESEL ON THE PERFORMANCE OF A DIESEL ENGINE

A Project report submitted

in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

In

MECHANICAL ENGINEERING

By

SVSS ANIL KUMAR	**(318126520111)**
VARANASI PAVAN	**(318126520114)**
G. PRAKASH	**(318126520079)**
CH. UMA MAYUKHA	**(318126520072)**

Under the esteemed guidance of

Mr. B. GEETA CHANDRA SEKHAR M.Tech(Ph.D.)

Assistant Professor

DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES

Autonomous status accorded by UGC and Andhra University (Approved by AICTE,
Permanently Affiliated to Andhra University, Accredited and reaccredited by NBA,
accredited by NAAC- ‘A’ Grade) Sanghivalasa,Bheemunipatnam Mandal.

Visakhapatnam (District) – 531162

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES
Autonomous status accorded by UGC and Andhra University (Approved by AICTE,
Permanently Affiliated to Andhra University, Accredited and reaccredited by NBA,
accredited by NAAC- ‘A’ Grade) Sanghivalasa,Bheemunipatnam Mandal.

Visakhapatnam (District) – 531162

CERTIFICATE

This is to certify that the Project Report entitled “EFFECT OF MUSTARD OIL BIODIESEL ON THE PERFORMANCE OF A DIESEL ENGINE” being submitted by SVSS ANIL KUMAR (318126520111), VARANASI PAVAN (318126520114), G. PRAKASH (318126520079), CH.UMA MAYUKHA (318126520072), in partial fulfilment for the award of degree of BACHELOR OF TECHNOLOGY in MECHANICAL ENGINEERING. It is the work of bonafide, carried out under the guidance and supervision of, Mr. B. GEETA CHANDRA SEKHAR.M.Tech(Ph.D.),Assistant Professor, DEPARTMENT OF MECHANICAL ENGINEERING during the academic year of 2018-2022.

APPROVED BY	**PROJECT GUIDE**
25.5.22	B.G.CH. Sekhar
(Dr.B.Naga Raju)	Mr.B.Geeta Chandra Sekhar M.Tech(Ph.D.)
Head of the Department	Assistant Professor
Dept. of Mechanical Engineering	Mechanical Department
ANITS, Visakhapatnam.	ANITS, Visakhapatnam.

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa-531 162 VISAKHAPATNAM Dist. A.P

THIS PROJECT WORK IS APPROVED BY THE FOLLOWING BOARDOF EXAMINERS

INTERNAL EXAMINER:

27.5.22

PROFESSOR & HEAD
Department of Mechanical Engineering
ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCE
Sangivalasa-531 162 VISAKHAPATNAM Dist A P

EXTERNAL EXAMINER:

27/5/22

ACKNOWLEDGMENT

We express immensely our deep sense of gratitude to **Mr. B. Geeta Chandra Sekhar**, Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalasa Bheemunipatnam Mandal, Visakhapatnam district for his valuable guidance and encouragement at every stage of work for the successful fulfilment of students.

We are very thankful to **Prof.T.V.Hanumantha Rao** ,Principal and **Prof. B.Nagaraju**, Head of the Department , Mechanical Engineering , Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We express our sincere thanks to the non-teaching staff of Mechanical Engineering for their kind co-operation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed directly or indirectly for the completion of our work.

SVSS ANIL KUMAR (318126520111)

VARANASI PAVAN (318126520114)

G. PRAKASH (318126520079)

CH. UMA MAYUKHA (318126520072)

`

ABSTRACT

Accessibility of energy sources and climate changes are the biggest challenges that mankind facing in this century. The fast-growing population and the increasing prosperity have led to rapid raise in the energy demand and also the world consumption of fuels is undoubtedly unstable causing world economic crisis, the worst compared to other economic recession that took place at different era. By using biodiesel, the problem could be tackled. Bio fuels, fuels derived from biomass have been gaining the attention as of highly renewable, biodegradable and locally available Biodiesel, obtained from vegetable oil or animal fats and Bio crude, synthetic oil. Bio fuels are carbon-neutral, nontoxic and reduce emission of volatile organic compounds. These fuels are not only green in nature but also help to reduce dependence on imported oil. Vegetable oil is a promising alternative fuel for CI engine because it is renewable, environment friendly and can be produced in rural areas. Thus, present study relates bio-diesel used in experimental work was prepared from Mustard oil by the process known as transesterification. The experiment is processed and the required observations are observed and analysed. Engine performance tests will be performed on a diesel engine at various loads to determine performance curves for the following will be plotted.

`

CONTENTS

PAGE NO.

`

PAGE NO.

`

PAGE NO.

`

LIST OF TABLES

PAGE NO.

LIST OF FIGURES

PAGE NO.

`

CHAPTER 1

INTRODUCTION

`

1.INTRODUCTION

1.1 Fossil Fuels:

Decomposing plants and other organisms, buried beneath layers of sediment and rock, have taken millennia to become the carbon-rich deposits we now call fossil fuels. These nonrenewable fuels, which include coal, oil, and natural gas, supply about 80 percent of the world’s energy. They provide electricity, heat, and transportation, while also feeding the processes that make a huge range of products, from steel to plastics.

When fossil fuels are burned, they release carbon dioxide and other greenhouse gases, which in turn trap heat in our atmosphere, making them the primary contributors to global warming and climate change.

Fossil fuels come in three main forms: petroleum, or crude oil, coal; and natural gas. All have many uses, but each serves one main purpose. In 2011, fossil fuels accounted for approximately 82 percent of world’s primary energy use but this is expected to fall to 78 percent by 2040, meaning that the use of fossil fuels is expected to be on a decline due to use of alternative fuels. Yet fossil fuels are finite resources and they can also irreparably harm the environment. According to Environmental Protection Agency, the burning of fossil fuels was responsible for 79 percent of U.S. greenhouse gas emissions in 2010. Oil is the world’s primary fuel source for transportation. Most oil is pumped out of underground reservoirs, but it can also be found imbedded in shale and tar sands. Once extracted, crude oil is processed in oil refineries to create fuel oil, gasoline, liquefied petroleum gas, and other non-fuel products such as pesticides, fertilizers, pharmaceuticals and plastics.

1.2 Alternative Fuels:

Alternative fuels include gaseous fuels such as hydrogen, natural gas, and propane; alcohols such as ethanol, methanol, and butanol; vegetable and waste-derived oils; and electricity. These fuels may be used in a dedicated system that burns a single fuel, or in a mixed system with other fuels including traditional gasoline or diesel, such as in hybrid-electric or flexible fuel vehicles.

`

Alcohol-based Ethanol derived from fermenting and distilling crops is already being blended with gasoline in India to increase renewable in nature, subsidies attached to it have a negative impact on food prices.

Natural Gas is already being used in homes and fertilizer plants successfully because of its lower emissions compared with gasoline or diesel. However, the methane created is far worse for global warming than carbon di-oxide.

Electricity is a feasible alternative to run vehicles and electric vehicles are getting a lot of attention from the Government. Electric vehicles no doubt will help reduce pollution levels dramatically, but as things stand today, a large amount of electricity is produced from fossil fuels such as coal, which adds to the bad carbon footprint.

Hydrogen as an additive to natural gas or its use in fuel-cell vehicles is yet another emerging alternative since it offers near zero emission problems. But it could be a costly alternative today. Technology enhancements in the future will help overcome its cost, and distribution infrastructure constraints.

Liquefied Petroleum Gas (LPG) or Propane, a by-product of natural gas processing has already entered our kitchens on commercial basis and is popular in the transportation sector primarily because of its lower emission properties. But its production, storage and distribution hamper its rapid acceptance as an alternative fuel. Biodiesel, based on vegetable oils and animal fats is an alternate fuel which is considered safe and biodegradable. It is, however, yet to be fully exploited commercially.

Alternative fuels have both advantages and disadvantages relating to their impact on the environment and society in general. But the time has come to increase the
utilization of alternative fuels to help create a better and cleaner world for everyone.

1.3 Need For Alternate Fuels:

Despite growing attention on clean energy, fossil fuels still account for 80 percent of global energy consumption and 75 percent of greenhouse gas emissions. Our fossil fuel-based energy system comes at a massive cost. Fossil fuels drive economic vulnerability, where countries and businesses are subject to volatile fuel prices; many are reliant on costly energy imports. Coal, oil and gas also increase human vulnerability: Dangerous outdoor air pollution due to fossil fuel burning kills 4.2 million people a year globally, according to the World Health Organization. Renewables have the potential to eliminate these risks while providing a range of economic opportunities for businesses and communities to thrive.

1.4 Biodiesel:

Biodiesel is a form of diesel fuel derived from plants or animals and consisting of long chain fatty acid esters. It is typically made by chemically reacting lipids such as animal fat (tallow), soybean oil, or some other vegetable oil with an alcohol, producing a methyl, ethyl or propyl ester. Unlike the vegetable and waste oils used to fuel converted diesel engines, biodiesel is a drop-in biofuel, meaning it is compatible with existing diesel engines and distribution infrastructure. Biodiesel can be used alone or blended with Petro diesel in any proportions. Biodiesel blends can also be used as heating oil.

1.5 Blends:

Blends of biodiesel and conventional hydrocarbon-based diesel are most commonly distributed for use in the retail diesel fuel marketplace. Much of the world uses a system known as the "B" factor to state the amount of biodiesel in any fuel mix:

Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, although certain manufacturers do not extend warranty coverage if equipment is damaged by these blends. The B6 to B20 blends are covered by the ASTM D7467 specification. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. Blending B100 with petroleum diesel may be accomplished by:

- Mixing in tanks at manufacturing point prior to delivery to tanker truck.

- Splash mixing in the tanker truck (adding specific percentages of biodiesel and petroleum diesel).

`

- In-line mixing, two components arrive at tanker truck simultaneously.

- Metered pump mixing, petroleum diesel and biodiesel meters are set to X total volume.

1.6 Properties:

Biodiesel has promising lubricating properties and cetane ratings compared to low sulfur diesel fuels. Fuels with higher lubricity may increase the usable life of high-pressure fuel injection equipment that relies on the fuel for its lubrication. Depending on the engine, this might include high pressure injection pumps, pump injectors (also called unit injectors) and fuel injectors.

The calorific value of biodiesel is about 37.27 MJ/kg. This is 9% lower than regular Number 2 Petro diesel. Variations in biodiesel energy density is more dependent on the feedstock used than the production process. Still, these variations are less than for Petro diesel. It has been claimed biodiesel gives better lubricity and more complete combustion thus increasing the engine energy output and partially compensating for the higher energy density of Petro diesel.

The color of biodiesel ranges from golden to dark brown, depending on the production method. It is slightly miscible with water, has a high boiling point and low vapor pressure. The flash point of biodiesel exceeds 130 °C (266 °F), significantly higher than that of petroleum diesel which may be as low as 52 °C
(126 °F). Biodiesel has a density of ~0.88 g/cm^3, higher than Petro diesel (~0.85 g/cm^3).

Biodiesel contains virtually no sulfur, and it is often used as an additive to ultra-low-sulfur diesel (ULSD) fuel to aid with lubrication, as the sulfur compounds in Petro diesel provide much of the lubricity.

`

1.7 Fuel efficiency:

The power output of biodiesel depends on its blend, quality, and load conditions under which the fuel is burnt. The thermal efficiency for example of B100 as compared to B20 will vary due to the differing energy content of the various blends. Thermal efficiency of a fuel is based in part on fuel characteristics such as: viscosity, specific density, and flash point; these characteristics will change as the blends as well as the quality of biodiesel varies.

The American Society for Testing and Materials has set standards in order to judge the quality of a given fuel sample. One study found that the brake thermal efficiency of B40 was superior to traditional petroleum counterpart at higher compression ratios (this higher brake thermal efficiency was recorded at compression ratios of 21:1). It was noted that, as the compression ratios increased, the efficiency of all fuel types – as well as blends being tested – increased; though it was found that a blend of B40 was the most economical at a compression ratio of 21:1 over all other blends. The study implied that this increase in efficiency was due to fuel density, viscosity, and heating values of the fuels.

1.8 Emissions:

Emissions are inherent to the combustion of diesel fuels that are regulated by the U.S. Environmental Protection Agency (E.P.A.). As these emissions are a by-product of the combustion process, in order to ensure E.P.A. compliance a fuel system must be capable of controlling the combustion of fuels as well as the mitigation of emissions. There are a number of new technologies being phased in to control the production of diesel emissions. The exhaust gas recirculation system, E.G.R., and the diesel particulate filter, D.P.F., are both designed to mitigate the production of harmful emissions.

A study performed by the Chonbuk National University concluded that a B30 biodiesel blend reduced carbon monoxide emissions by approximately 83% and particulate matter emissions by roughly 33%. NOx emissions, however, were found to increase without the application of an E.G.R. system. The study also concluded that, with E.G.R, a B20 biodiesel blend considerably reduced the emissions of the engine. Additionally, analysis by the California Air Resources Board found that biodiesel had the lowest carbon emissions of the fuels tested, those being ultralow-sulfur diesel, gasoline, corn-based ethanol, compressed natural gas, and five types of Biodiesel from varying feedstocks. Their conclusions also showed great variance in carbon emissions of biodiesel based on the feedstock used. Of soy, tallow, canola, corn, and used cooking oil, soy showed the highest carbon emissions, while used cooking oil produced the lowest.

1.9 Feedstock:

The specifications for biodiesel allow a variety of feedstocks and processes to be used in it production. Biodiesel can be produced commercially from a variety of oils and fats:

- Animal fats: edible, inedible, and all other variations of tallow, lard, choice white grease, yellow grease, poultry fats, and fish oils;
- Plant oils: soy, corn, canola, sunflower, rapeseed, cottonseed;
- Recycled greases: used cooking oils and restaurant frying oils. Biodiesel can also be made from other oils, fats, and recycled oils such as mustard, palm, coconut, peanut, olive, sesame, and safflower oils, trap greases, and even oils produced from algae, fungi, bacteria, molds, and yeast. Some properties of finished biodiesel such as cetane number, cloud point, and stability depend heavily on the feedstock (US Department of Energy,2009). The words “oil” and “fats” designate substances with no solubility in water (hydrophobic) composed mainly by products of the condensation between glycerol and fatty acids, called triglycerides (Figure 1). In general fats have a high ratio of saturated fatty acids whereas oils contain more unsaturated fatty acids. The main distinction between them is in appearance: fats are solid whereas oils are liquid (Hartman, 1982).

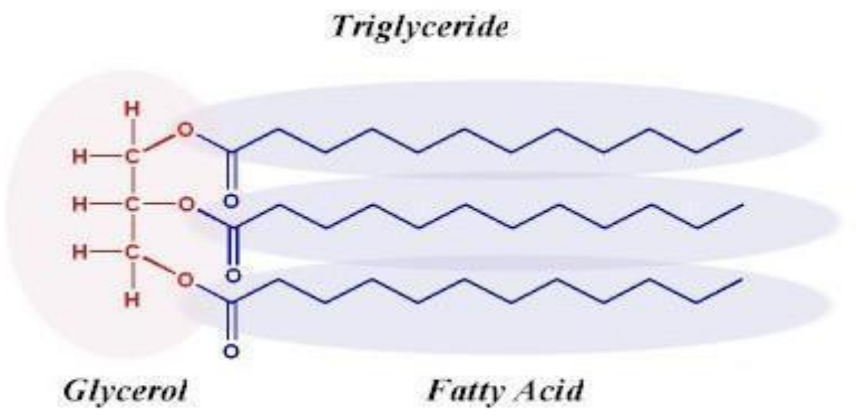


Fig 1.1 Triglyceride

`

Besides triglycerides, oils and fats contain a small amount of other compounds, such as free fatty acids, mono and diglycerides, phosphatides, alcohols, hydrocarbons and vitamins (Sonntag,1979). Compared with the chemistry of diesel fuel, which contains hundreds of compounds, the chemistries of different fats and oils typically used for biodiesel are very similar. Each fat or oil molecule is made up of a glycerin backbone of three carbons, and on each carbon is attached a long-chain fatty acid that reacts with methanol to make the methyl ester, or biodiesel. The glycerin backbone is turned into glycerin and sold as a by-product of biodiesel manufacturing. The fats and oils contain 10 common types of fatty acids that have 12 to 22 carbons, more than 90% of which are 16 to 18 carbons. Some of these chains are saturated, some are monounsaturated, and others are polyunsaturated. Within the limits of the specifications, the differing levels of saturation can affect some biodiesel fuel properties (US Department of Energy, 2009).

1.10 Mustard Oil:

Mustard oil can mean either the pressed oil used for cooking, or a pungent essential oil also known as volatile oil of mustard. The essential oil results from grinding mustard seed, mixing the grounds with water, and extracting the resulting volatile oil by distillation. It can also be produced by dry distillation of the seed. Pressed mustard oil is used as cooking oil in some cultures, but sale is restricted in some countries due to high levels of erucic acid. Varieties of mustard seed also exist that are low in erucic acid. This oil has a distinctive pungent taste, characteristic of all plants in the mustard family, Brassicaceae (for example, cabbage, cauliflower, turnip, radish, horseradish, or wasabi). It is often used for cooking in India, Pakistan, Nepal and Bangladesh.

Fig 1.2 Mustard oil

`

In Bengal, Odisha, Assam, Meghalaya, Manipur, and Nepal, it is the traditionally preferred oil for cooking. The oil makes up about 30% of the mustard seeds. It can be produced from black mustard (Brassica nigra), brown Indian mustard (B. juncea), and white mustard (B. hirta). The characteristic pungent flavour of mustard oil is due to allyl isothiocyanate. Mustard oil has about 60% monounsaturated fatty acids (42% erucic acid and 12% oleic acid); it has about 21% polyunsaturated fats (6% the omega-3 alpha- linolenic acid and 15% the omega-6 linoleic acid), and it has about 12% saturated fats.

1.11 Mustard Oil Production Process:

The oil is made by pressing of the seeds or by the process of grinding, whereby it is mixed with water and then further distilled. The black mustard yields a lighter colored and stronger tasting oil, while the white variety produces a yellowish colored, pungent oil. A simple mustard oil recipe is to directly press the seeds. This gives a strong tasting mustard oil. Another approach for making mustard oil is crushing the seeds, followed by separation of oil. Both the two extraction processes yield mustard oil and When the mustard seeds are processed in mustard oil plant, a by- product is produced which is seed's pressed cakes that have little amount of oil content in them. Oil cakes are made from these cakes from the process of distillation and these are used as animal feed. The production process yields 37% of oil and remaining is the oil cake.

1.12 Mustard Oil Extraction Process:

The extraction process of mustard oil involves removing impurities from the mustard seeds, then adjusting the mustard seeds to the optimal pressing state through a series of processes, and then extracting the oil from the mustard. For mustard oil mill plant, the most cost-effective and widely used method for mustard oil extraction process is mechanical extraction by mustard oil processing machines. Here, I will introduce you how to extract mustard oil step by step in large scale mustard oil mill Plant.

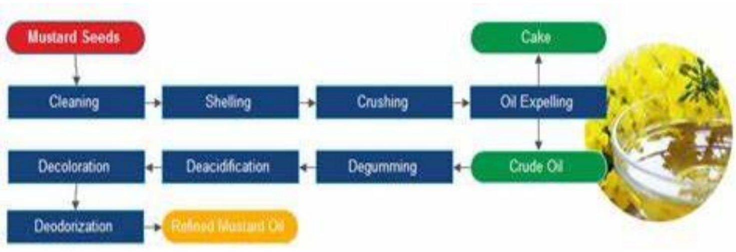


Fig 1.3 Extraction process of Mustard oil.

1.13 Biodiesel Production from Mustard Oil:

Biodiesel is produced from triglycerides in the presence of alcohol with catalyst through transesterification reaction. The biodiesel production from mustard oil with methanol in the presence of nano- sized calcium oxide nano-catalyst was done at a laboratory scale.

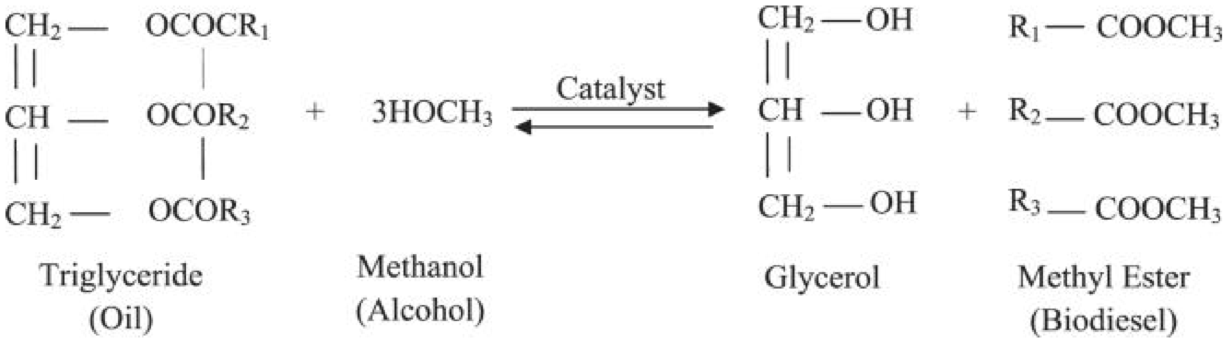


Fig 1.4 Trans esterification process

Transesterification reaction is carried out in a flask with overall volume of 300 ml flask was placed on a hot plate equipped with a controlled magnetic stirrer and temperature sensor.

Mustard oil was preheated to the required reaction temperature before methanol and the catalyst were added into the reaction flask. The calculated amount of methanol to oil ratio was poured into the reactor. Then the CaO catalyst was added in a range between 0.5 to 5% by weight with respect to mass of the mustard Oil, and then the formed reaction mixture was mixed for 10 minutes. 100 ml of waste cooking oil was added and temperature of the mixture was set from 30 to 70 °C, 5 °C interval.

Transesterification proceeded under continuous stirring of the reaction mixture for a desired duration. All transesterification reactions were carried-out at atmospheric pressure with stirring speed of 1500 rpm. Thermometer was inserted into the flask to monitor the reaction temperature. After the completion of the reaction, the mixture was transferred into a separating funnel and allowed to stand overnight. Three phases were formed due to the solid catalyst and glycerol is denser than biodiesel.

`

The separated biodiesel was heated above the boiling point of methanol (64.7 °C) to remove excess unreacted methanol. Moreover, very few suspended solid catalysts are removed by settling it for two to three days then the Biodiesel viscosity, specific gravity, water and sediment, total acidity, ash content, sulfur content, Flash Point and Cloud Point were checked according to the American Society for Testing and Materials (ASTM D 6751).

Fig 1.5 Raw mustard oil

Fig 1.6 Heat treatment to remove free fatty acids

Fig 1.7 Preparation of potassium hydroxide

`

Fig 1.8 Base treatment

*Fig 1.9 Removal of glycerin*e

1.14 Purification:

After the reaction of transesterification, there is the separation of glycerol and ethyl or methyl esters, which are only called biodiesel after reaching the appropriate specifications, that is, after the removal of contaminants such as free glycerol, soaps, metals, excess alcohol, catalyst, and others (Cooke, 2007). Among the most widely used treatments for the purification of biodiesel are washing it with water and acidified water. The great advantage of washing is the efficient removal of glycerol and ethanol, and residues of sodium salts and soaps, the latter dependent on the amount of free fatty acids present in the original raw material.

`

CHAPTER 2

LITERATURE REVIEW

`

2. LITERATURE REVIEW

Before going with the project, a brief study on papers related to Performance Analysis of Compression Ignition Engine using Biodiesel was done. Many authors portrayed different ideas related to their works on Biodiesel. The different papers reviewed are listed below:

YedilfanaSetargeMekonnen [1], investigated the production of biodiesel from three mixtures of vegetable oil and used cooking oil by alkali catalysed transesterification. Three kinds of vegetable oils, including jatropha, roselle and coconut oils were tested. The effect of used cooking oil content in oil feedstock (used cooking oil/vegetable oil ratios of 0.03-0.2 v/v) on methyl ester formation was investigated and optimized. The methyl ester content from each reaction condition was determined by gas chromatography (GC). The optimum used cooking oil/vegetable oil ratio was 0.03 v/v for all three kinds of oil feedstock.

Murat Kadir Yesilyurt, Mevlüt Arslan & Tanzer Eryilmaz [2],in the present study, response surface methodology (RSM) involving central composite design (CCD) was applied to optimize the reaction parameters of biodiesel production from yellow mustard (Sinapisalba L.) seed oil during the single-step transesterification process. A total of 30 experiments were designed and performed to determine under the effects of variables on the biodiesel yield such as methanol to oil molar ratio (2:1–10:1), catalyst concentration (0.2–1.0 wt.% NaOH), reaction temperature (50–70°C), and reaction time (30–90 min). The second order polynomial model was used to predict the biodiesel yield and coefficient of determination (R2) was found to be at 0.9818. The optimum biodiesel yield was calculated as 96.695% from the model with the following reaction conditions: 7.41:1 of methanol to oil molar ratio, 0.63 wt. % NaOH of catalyst concentration, 61.84°C of reaction temperature, and 62.12 min of reaction time. It is seen that the regression model results were in agreement with the experimental data. The results showed that RSM is a suitable statistical technique for optimizing the reaction parameters in the transesterification process in order to maximize the biodiesel yield.

Chatpalliwarl et al. [3], described the brief overview of the Biodiesel production plant. Various issues- sources, opportunities, challenges, plant design, and evaluation etc, are discussed related to the Biodiesel production. The contribution of the work is that it discusses the important issues concerned with the Biodiesel production plant design, the fundamental

`

details required for the formulation of Biodiesel plant and also it presents possible approach for the mathematical model to evaluate the Biodiesel plant design.

Avinash Kumar Agarwal [4], reported the technical feasibility of using straight vegetable oils (Jatropha oil), into a constant speed direct injection compression ignition engine. Vegetable oils have very high viscosity, which make their direct usability in engines questionable. In this investigation, SVO's were preheated by using waste heat from engine exhaust, in order to reduce their viscosity. The effect of using these oils on typical engine problems such as injector coking, piston ring sticking, lube oil dilution etc. was investigated in detail. Long-term endurance test (For a duration of 512 hours) of SVO fueled engine vis-à-vis mineral diesel fueled engine was executed and the results are compared.

Abuhabaya, A., J. Fieldhouse, and D. Brown [5], bio-fuel production provides an alternative non-fossil fuel without the need to redesign current engine technology. This study presents an experimental investigation into the effects of using biodiesel blends on diesel engine performance and its emissions. The biodiesel fuels were produced from sunflower oil using the transesterification process with low molecular weight alcohols and sodium hydroxide then tested on a steady state engine test rig using a Euro 4 four cylinder compression ignition (CI) engine. This study also shows how by blending biodiesel with diesel fuel at intervals of B5, B10, B15, and B20 can decrease harmful gas emissions significantly while maintaining similar performance output and efficiency. Production optimization was achieved by changing the variables which included methanol/oil molar ratio, NaOH catalyst concentration, reaction time, reaction temperature, and the rate of mixing to maximize biodiesel yield. The technique used was the response surface methodology (RSM). In addition, a second-order model was developed to predict the biodiesel yield if the production criteria is known. The model was validated using additional experimental testing. It was determined that the catalyst concentration and molar ratio of methanol to sunflower oil were the most influential variables affecting percentage conversion to fuel and percentage initial absorbance.

Ahmad, M., M. Zafar, S. Sultana, A. Azam, and M. A. khan[6], this study is confined to optimization of biodiesel production from a non-edible oil yielding plant milk thistle (Silybum arianum) of Mediterranean origin is reported as a new source used as raw material

`

for biodiesel production. This study explains optimization analysis of biodiesel production through base catalyzed transesterification. Effects of four different variables includes the reactant ratio, catalyst concentration, reaction temperature and time were studied. It is found that 80% fatty acids were converted into fatty acid methyl esters within 75 min at 60°C by using 5:1 molar ratio (methanol to oil). The study stated that the order of significant factors effecting biodiesel yield was catalyst concentration > reaction time > reaction temperature > methanol to oil ratio. The fuel properties of milk thistle FAMEs including color, density, kinematic viscosity, sulfur content, total acid number, flash point, pour point, distillation, cloud point, calorific value, and cetane index were determined and compared with ASTM standards.

Rashid, U., F. Anwar, M. Ashraf, M. Saleem, and S. Yusup[7], Response surface methodology (RSM), with central composite rotatable design (CCRD), was used to explore optimum conditions for the transesterification of Moringa oleifera oil. Effects of four variables, reaction temperature (25–65 °C), reaction time (20–90 min), methanol/oil molar ratio (3:1–12:1) and catalyst concentration (0.25–1.25 wt.% KOH) were appraised. The quadratic term of methanol/oil molar ratio, catalyst concentration and reaction time while the interaction terms of methanol/oil molar ratio with reaction temperature and catalyst concentration, reaction time with catalyst concentration exhibited significant effects on the yield of Moringa oil methyl esters (MOMEs)/biodiesel, $p < 0.0001$ and $p < 0.05$, respectively. Transesterification under the optimum conditions ascertained presently by RSM: 6.4:1 methanol/oil molar ratio, 0.80% catalyst concentration, 55 °C reaction temperature and 71.08 min reaction time offered 94.30% MOMEs yield. The observed and predicted values of MOMEs yield showed a linear relationship. GLC analysis of MOMEs revealed oleic acid methyl ester, with contribution of 73.22%, as the principal component. Other methyl esters detected were of palmitic, stearic, behenic and arachidic acids. Thermal stability of MOMEs produced was evaluated by thermogravimetric curve. The fuel properties such as density, kinematic viscosity, lubricity, oxidative stability, higher heating value, cetane number and cloud point etc., of MOMEs were found to be within the ASTM D6751 and EN 14214 biodiesel standards.

`

Meher, L. C., D. V. Sagar, and S. N. Naik[8], biodiesel is gaining more and more importance as an attractive fuel due to the depleting fossil fuel resources. Chemically biodiesel is monoalkyl esters of long chain fatty acids derived from renewable feed stock like vegetable oils and animal fats. It is produced by transesterification in which, oil or fat is reacted with a monohydric alcohol in presence of a catalyst. The process of transesterification is affected by the mode of reaction condition, molar ratio of alcohol to oil, type of alcohol, type and amount of catalysts, reaction time and temperature and purity of reactants. In the present paper various methods of preparation of biodiesel with different combination of oil and catalysts have been described. The technical tools and processes for monitoring the transesterification reactions like TLC, GC, HPLC, GPC, 1H NMR and NIR have also been summarized. In addition, fuel properties and specifications provided by different countries are discussed.

Moser, B. R., R. Q. Evangelista, and G. Jham[9], Brassica juncea is a drought-tolerant member of the Brassicaceae plant family with high oil content and a short growing season that is tolerant of low quality soils. It was investigated as a feedstock for production of biodiesel along with evaluation of subsequent fuel properties, both neat and in blends with petroleum diesel fuel. These results were compared against relevant fuel standards such as ASTM D6751, EN 14214, ASTM D975, EN 590, and ASTM D7467. Crude B. juncea oil was extracted from unconditioned seeds utilizing a continuous tubular radial expeller. The oil was then chemically refined via degumming, neutralization and bleaching to render it amenable to direct homogeneous sodium methoxide-catalyzed transesterification. The principal fatty acid detected in B. juncea oil was erucic acid (44.1%). The resulting biodiesel yielded fuel properties compliant with the biodiesel standards with the exception of oxidative stability and kinematic viscosity in the case of EN 14214. Addition of tert-butylhydroquinone and blending with soybean oil-derived biodiesel ameliorated these deficiencies. The fuel properties of B5 and B20 blends of B. juncea oil methyl esters (BJME) in ultra-low sulfur (<15 ppm S) diesel (ULSD) fuel were within the ranges specified in the petrodiesel standards ASTM D975, EN 590 and ASTM D7467 with the exception of derived cetane number in the case of EN 590. This deficiency was attributed to the inherently low cetane number of the certification-grade ULSD, as it did not contain performance-enhancing additives. In summary, this study reports new fuel property data for BJME along with

`

properties of B5 and B20 blends in ULSD. Such results will be useful for the development of B. juncea as an alternative source of biodiesel fuel.

Lin, B. F., J. H. Huang, and D. Y. Huang[10], Vegetable oil methyl ester (VOME) is produced through the transesterification of vegetable oil and can be used as biodiesel in diesel engines as a renewable, nontoxic, and potentially environmentally friendly fossil fuel alternative in light of growing concerns regarding global warming and increasing oil prices. This study used VOME fuels produced from eight commonly seen oil bases to conduct a series of engine tests to investigate the effects of VOME on the engine performance, exhaust emissions, and combustion characteristics. The experimental results showed that using VOME in an unmodified direct injection (DI) diesel engine yielded a higher brake specific fuel consumption (BSFC) due to the VOME fuel's lower calorific value. The high cetane number of VOME also imparted a better ignition quality and the high intrinsic oxygen content advanced the combustion process. The earlier start of combustion and the rapid combustion rate led to a drastic increase in the heat release rate (HRR) and the in-cylinder combustion pressure (ICCP) during the premixed combustion phase. A higher combustion rate resulted in higher peaks of HRR and ICCP as well as near the top dead center (TDC) position. Thus, it was found that a diesel engine fueled with VOME could potentially produce the same engine power as one fueled with petroleum diesel (PD), but with a reduction in the exhaust gas temperature (EGT), smoke and total hydrocarbon (THC) emissions, albeit with a slight increase in nitrogen oxides (NOx) emissions. In addition, the VOME which possesses shorter carbon chains, more saturated bonds, and a higher oxygen content also yields a lower EGT as well as reduced smoke, NOx, and THC emissions. However, this is obtained at the detriment of an increased BSFC.

A. Srivasata and R. Prasad[11], efforts are under way in many countries, including India, to search for suitable alternative diesel fuels that are environment friendly. The need to search for these fuels arises mainly from the standpoint of preserving the global environment and the concern about long-term supplies of conventional hydrocarbon-based diesel fuels. Among the different possible sources, diesel fuels derived from triglycerides (vegetable oils/animal fats) present a promising alternative to substitute diesel fuels. Although triglycerides can fuel diesel engines, their high viscosities, low volatilities and poor cold flow properties have led to the investigation of various derivatives. Fatty acid methyl esters, known as biodiesel, derived from triglycerides by transesterification with methanol have received the most attention. The main advantages of using biodiesel are its renewability, better-quality exhaust gas emissions, its biodegradability and given that all the organic carbon present is photosynthetic in origin, it does not contribute to a rise in the level of carbon dioxide in the atmosphere and consequently to the greenhouse effect**.**

M. Stumborg, A. Wong and E. Hogan[12], the Saskatchewan Research Council (SRC), in cooperation with Natural Resources Canada and Agriculture and Agri-Food Canada, investigated the use of conventional refinery technology to convert vegetable oils into a product resembling diesel fuel. SRC found that the use of a medium severity refinery hydro process yielded a product ('super cetane') in the diesel boiling range with a high cetane value (55–90). Preliminary engine testing by ORTECH has shown that the impact of the 'super cetane'/diesel mixture ('green diesel') on engine emissions is similar to the impact cetane enhancement via a nitrate additive has when added to conventional diesel fuel. Advantages of hydro processing over esterification in the Canadian context include lower processing cost, compatibility with infrastructure, engines and fuel standards, and feed stock flexibility. Further research in the areas of process optimization, alternative feed stock selection, cold flow properties, and multi-cylinder emission testing is planned. In cooperation with a commercialization partner, Arbokem Inc., pilot testing of the hydro process was done and was proven successful. A fleet demonstration and evaluation is currently underway.

Ong, H. C., H. H. Masjuki, T. M. I. Mahlia, A. S. Silitonga, W. T. Chong, and K. Y. Leong[13], in the present study, crude Calophyllum inophyllum oil (CCIO) has been evaluated as a potential feedstock for biodiesel production. C. inophyllum oil has high acid value which is 59.30 mg KOH/g. Therefore, the degumming, esterification, neutralization and transesterification process are carried out to reduce the acid value to 0.34 mg KOH/g. The optimum yield was obtained at 9:1 methanol to oil ratio with 1 wt.%. NaOH catalyst at 50 °C for 2 h. On the other hand, the C. inophyllum biodiesel properties fulfilled the specification of ASTM D6751 and EN 14214 biodiesel standards. After that, the C. inophyllum biodiesel diesel blends were tested to evaluate the engine performance and emission characteristic. The performance and emission of 10% C. inophyllum biodiesel blends (CIB10) give a satisfactory result in diesel engines as the brake thermal increase 2.30% and fuel consumption decrease 3.06% compared to diesel. Besides, CIB10 reduces

`

CO and smoke opacity compared to diesel. In short, C. inophyllum biodiesel can become an alternative fuel in the future.

Helwani, Z., M. R. Othman, N. Aziz, W. J. N. Fernando, and J. Kim[14], biodiesel production is undergoing rapid technological reforms in industries and academia. This has become more obvious and relevant since the recent increase in the petroleum prices and the growing awareness relating to the environmental consequences of the fuel overdependency. In this paper, various technological methods to produce biodiesel being used in industries and academia are reviewed Catalytic transesterification, the most common method in the production of biofuel, is emphasized in the review. The two most common types of catalysts; homogeneous liquids and heterogeneous solids, are discussed at length in the paper. Two types of processes; batch and continuous processes, are also presented. Although batch production of biodiesel is favoured over continuous process in many laboratory and larger scale efforts, the latter is expected to gain wider acceptance in the near future, considering its added advantages associated with higher production capacity and lower operating costs to ensure long term supply of biodiesel.

`

CHAPTER 3

PROBLEM STATEMENT

`

3.PROBLEM STATEMENTS

There are two problem statement in that has to be solved in this research. First is the prediction of the engine performance and exhaust emissions of diesel engine using biodiesel fuel and second is how the inputs affect the outputs of engine.

3.1 PROJECT OBJECTIVES:

There are two main objectives in that has to be achieved in this research. First is to investigate the performance characteristics of a diesel engine operating with biodiesel and second is to investigate the different performance of biodiesel and diesel fuel blends.

3.2 PROJECT SCOPES:

There are two main scopes in this research. First is diesel engine testing at various engine speeds and second is collect all the performance characteristics

`

CHAPTER 4

EXPERIMENTAL SETUP

4.EXPERIMENTAL SETUP

4.1 Diesel engine:

A diesel engine also known as a compression-ignition engine. It is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel that has been injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine, gasoline engine or gas engine using a gaseous fuel as opposed to gasoline, which uses a spark plug to ignite an air-fuel mixture. The engine was developed by German inventor Rudolf Diesel in 1893.

The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines are used in ships and for other applications where overall engine weight is relatively unimportant, can have a thermal efficiency that exceeds 50%.

Diesel engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Its use in locomotives, trucks, heavy equipment and electric generating plants followed later. In the 1930s, they slowly began to be used in a few automobiles. Since the 1970s, the use of diesel engines in larger on-road and off-road vehicles in the USA increased. As of 2007, about 50% of all new car sales in Europe are diesel.

The world's largest diesel engine is currently a Wartsila-Sulzer RTA96-C Common Rail marine diesel of about 84,420 kW (113,210 HP) @ 102 rpm output. According to the British Society of Motor Manufacturing and Traders, the EU average for diesel cars account for 50% of the total sold, including in France 70%, and in the UK - 38%.

4.2 Size Groups:

There are three size groups of Diesel engines.

- Small -Under 188 kW (252 HP) output
- Medium
- Large

`

4.3 Engine speeds:

Within the diesel engine industry, engines are often categorized by their rotational speeds into three groups:

- High-speed engines (>1,000 rpm),
- Medium-speed engines (300 - 1,000 rpm), and
- Slow-speed engines (<300 rpm).

High-speed and Medium-speed engines are predominantly four-stroke engines; except for the Detroit Diesel two-stroke range. Medium-speed engines are physically larger than high-speed engines and can burn lower-grade (slower-burning) fuel than high-speed engines.

Slow-speed engines are predominantly large two-stroke crosshead engines, hence very different from high- and medium-speed engines. Due to the lower rotational speed of slow speed and medium-speed engines, there is more time for combustion during the power stroke of the cycle.

4.4 Major Advantages:

Diesel engines have several advantages over other internal combustion engines:

- They burn less fuel than a petrol engine performing the same work, due to the engine's higher temperature of combustion and greater expansion ratio. Gasoline engines are typically 30% efficient while diesel engines can convert over 45% of the fuel energy into mechanical energy.

- They have no high voltage electrical ignition system, resulting in high reliability and easy adaptation to damp environments. The absence of coils, spark plug wires, etc., also eliminates a source of radio frequency emissions which can interfere with navigation and communication equipment, which is especially important in marine and aircraft applications.

- The life of a diesel engine is generally about twice as long as that of petrol engine due to the increased strength of parts used. Diesel fuel has better lubrication properties than petrol as well.

- Diesel fuel is distilled directly from petroleum. Distillation yields some gasoline, but the yield would be inadequate without catalytic reforming, which is a more costly process. Diesel fuel is considered safer than petrol in many applications. Although diesel fuel will burn in open air using a wick, it will not explode and does not release a large amount of flammable vapour. The low vapour pressure of diesel is especially advantageous in marine applications, where the accumulation of explosive fuel-air mixtures is a particular hazard. For the same reason, diesel engines are immune to vapour lock.
- For any given Partial load, the fuel efficiency (mass burned per energy produced) of a diesel engine remains nearly constant, as opposed to petrol and turbine engines which use proportionally more fuel with partial power outputs. They generate less waste heat in cooling and exhaust.
- Diesel engines can accept super- or turbo-charging pressure without any natural limit, constrained only by the strength of engine components. This is unlike petrol engines, which inevitably suffer detonation at higher pressure.
- The carbon monoxide content of the exhaust is minimum; therefore diesel engines are used in underground mines. Biodiesel is easily synthesized, non-petroleum-based fuel (through transesterification) which can run directly in many diesel engines, while gasoline engines either need adaptation to run synthetic fuels or else use them as an additive to gasoline (e.g., ethanol added to gasohol).

`

4.5 Engine Description:

Single Cylinder Four Stroke Diesel Engine Test Rig:	
Engine Make	M/S Kirloskar
Cylinder Position	Vertical
Brake Power	5 HP
Speed	1500 RPM
Bore	80 mm
Stroke	110 mm
Compression Ratio	17.5:1
Orifice Diameter	20 mm
Cooling	Water Cooled
Starting	Hand Cranking
Dynamometer	Rope Brake

Table 4.1: Engine Description

The prepared fuel blends are used in Kirloskar made Four stroke, single cylinder diesel engine- test rig in the laboratory and load test is held with additional attachment of muffler to the exhaust smoke pipe. By the load test, the performance characteristics and from smoke analysis, combustion analysis of fuel is obtained. The given I.C engine is a vertical, single cylinder, 4-stroke, and water-cooled constant speed diesel engine. It is fitted with a flywheel sufficient enough to give momentum to absorb energy when in power stroke and release during the other three strokes to get a uniform speed. Provision is made to measure the exhaust heat with the help of a calorimeter and thermocouples fixed at salient points. This engine is provided with a crank handle for starting. The engine is mounted with an absorption thermometer of brake drum type. The engine set up is also provided with burette, graduations duly marked and a three way to measure the fuel flow rate.

Fig 4.1 Diesel engine

`

CHAPTER 5

EXPERIMENTAL PROCEDURE

`

5.EXPERIMENTAL PROCEDURE

5.1Blending:

It is the main process involved for making biodiesels. It is nothing but mixing of trans-esterified oil in certain proportions to obtain the required properties. This process involves: Taking proportions of the trans-esterified oil. Mixing of biodiesel and diesel in the mixture up to the foam arises.

5.2Blending of oil:

In this process, the conventional diesel fuel is mixed with trans-esterified mustard oil and Methanol in required proportions to obtain the required blends.

Following are the blends obtained in this process:

D100- DIESEL 100%
D95 - MUSTARD OIL 5%, DIESEL 95 %
D90 - MUSTARD OIL 10%, DIESEL 90%
D85 - MUSTARD OIL 15%, DIESEL 85%
D80 - MUSTARD OIL 20%, DIESEL 80%

When biodiesel is blended with petroleum diesel, the cloud point of the diesel fuel and bio fuel are the two most important properties. The blended fuel must still need the seasonal temperature for cloud point for the region the fuel is being used. If blending is done into seasonal diesel, it must be done such that the seasonal cloud point temperatures are maintained. Therefore, the cloud point of biodiesel and petroleum diesel must be known. In some cases, this may govern the blend level of the biodiesel blend. Operators that blend even low percentages of biodiesel with seasonal diesel in the winter or shoulder seasons, risk having operational issues due to the raised cloud point. Therefore, it is important to know the cloud point of diesel used for blending, the biodiesel intended for blending and regional seasonal cloud point for the biodiesel blend. Blending of biodiesel blends without knowing the cloud points of the fuels being blended is not recommended.

5.3 Performance Characteristics of the Diesel Engine:

Engine performance is an indication of the degree of success with which it is doing its assigned job, i.e., the conversion of the chemical energy contained in the fuel into the useful mechanical work.

`

The degree of success is compared on the basis of the following:

1. Specific fuel consumption
2. Brake mean effective pressure
3. Brake thermal efficiency
4. Indicated thermal efficiency
5. Mechanical efficiency

Indicated thermal efficiency is the ratio of energy in the indicated power (IP) to the input fuel energy.

Brake thermal efficiency is the ratio of energy in the brake power (BP), to the input fuel energy. Brake thermal efficiency is the true indication of the efficiency with which the thermodynamic input is converted into mechanical work. It also accounts for combustion efficiency.

Mechanical efficiency is defined as the ratio brake power to the indicated power.

Mean effective pressure is the average pressure inside the cylinders of an internal combustion engine based on the calculated or measured power output. Mean effective pressure, gives an indication of engine displacement utilization higher the mean effective pressure higher will be power developed by the engine for a given displacement.

Specific fuel consumption is an important parameter that reflects how good the engine performance is. It is the reciprocal of thermal efficiency. Specific fuel consumption is widely used to compare the performance of different engine.

5.4Procedure:

1.Check the fuel and lubricating oil systems before starting the engine. 2.Connect water supply to the engine and brake drum and remove all load on the brake drum.

3. Keep 3way cock in horizontal position so that fuel flows from the tank to engine filling burette.

4. Start the engine by hand cranking and allow the engine to pick up rated speed.

5.Allow the engine to run for some time in idle condition.

`

6.Put the 3-way cock on vertical position and measure the fuel consumption rate by noting the time taken for 10 cc of fuel flow.

7.Experiment repeated at different loads.

8. Engine is stopped after detaching load from the engine.

5.5 Basic Data:

1.Rated brake power of engine "BP"—5HP

2.Speed of the engine— 1500RPM

3.Effective radius of break drum "R" —0.12 meter.

4.Stroke length —$110*10^{-3}$ meter

5.Diameter of cylinder bore —0.08 meter

5.6 Variables to be considered:

1.Specific Gravity of fuel.

2.Dead load applied on break drum "W "(Kg).

3.Spring balance reading "S”. (Kg)

4.Calorific value of fuel.

5.Time taken for 10 cc fuel consumption.

5.6.1 Calculations:

Fuel consumption (F.C) = (10*SP. Gravity*3600)/(t*1000)

Brake power (B.P) = (2πN(W-S) *9.81*r)/60000

Friction power (F.P) = (from graph)

Indicated power (I.P) = B.P.+F.P

Specific fuel consumption (S.F.C) = F.C/B. P

Brake thermal efficiency (η_{Bth}) = (B.P*3600)/ (F.C*C. V)

Indicated thermal efficiency (η_{Ith}) = (I.P*3600)/(F.C*C. V)

Mechanical efficiency (η_{mech}) = B.P/ I.P

Brake mean effective pressure (B.M.E.P) = (B.P*60000)/(L*(π/4)d^2*(N/2))

Indicated mean effective pressure (I.M.E.P) = (I.P*60000)/(L*(π/4) d^2*(N/2))

`

5.7 Redwood Viscometer Procedure:

The common procedure followed in Redwood Viscometer experiment is as follows,

1. Neatly clean the oil cup.
2. Keep the orifice close with the ball valve.
3. Fill the oil cup with oil to the required oil level.
4. Heat the water bath to heat water filled in it.
5. Lift the ball valve after getting the required temperature.
6. Use a thermometer for this purpose. Note down the temperature.
7. Let the oil flow through the orifice and collect 50ml of oil in the flask. Note the time taken in seconds. For this use a stop-watch.
8. This time is called redwood seconds.
9. Repeat the above procedure at different temperatures and note down the time.

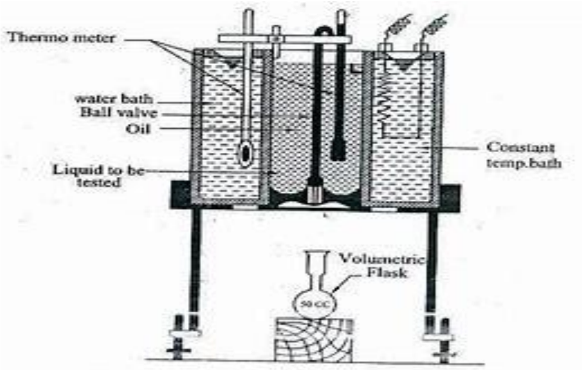


Fig 5.1 Detailed diagram of redwood viscometer

Fig 5.2 Redwood viscometer

`

5.8 Formulae used:

Kinematic Viscosity = At_r – B/t_r in stokes or t in centi stokes

A = 0.0026 B = 1.72

A = 0.26 B = 172

T = time in second

Dynamic viscosity µ= ρ_r- 0.00065 (t - t_r) centipoise.

t = Temperature at which the density is required

t_r= Room Temperature

ρ_r = Density of oil at room temperature in gm / cm3 = 0.84 (or) 0.85 gm/cm3.

5.9 Flash point and Fire point:

FLASH POINT**:** it is defined as a minimum temperature at which the oil gives the sufficient vapours to ignite momentarily a flame of standard dimension is brought near the surface of the oil.

FIRE POINT**:** the fire point is the lowest temperature at which the vapours of oil burn continuously for at least for 5 seconds when standard flame is brought near the surface of coil.

Significance:

1.This ensure safely against risk of fire a good lubricating oil should have flash point reasonably above the working temperature.

2. It helps in proper storage, transportation and handling.

3. Used for identification of oil.

4. To get idea about contamination in oil.

5. If flash point is high then oil is thermally stable and will not degrade and evaporate at high temperature.

5.10 Flash point and fire point procedure:

Procedure:

1. Clean the cup and fill it with the given sample of oil up to the filling mark.

2. Insert the thermometer in the holder. Make sure that the thermometer should not touch the metallic cup.

3. Heat the oil by the means of electric heater so that the sample of oil gives out vapour at the rate of 10°C per minute.

4. When the oil gives out vapour, introduce the test flame above the oil, without

touching the surface of the oil and watch for flash with flickering sound.

5. Introducing the test flame should not continued at regular intervals until the flash is observed with peak flickering sound. The temperature corresponding to this flickering sound is noticed and it is the flash point temperature of the given sample of oil.

6. Continue the process of heating and introducing the test flame until the oil will begins to burn continuously and observe the temperature. This is the fire pint temperature of the given sample of oil.

7. Repeat the test twice or thrice with fresh sample of oil and observe the results.

8. The observations are tabulated.

Fig 5.3 Clevelands Appartus

`

CHAPTER 6

CALCULATION AND ANALYSIS

`

6. CALCULATION AND ANALYSIS

6.1 Basic Data:

4-Stroke single cylinder vertical diesel engine

Rated brake power of engine B.P = 5 H.P = 3.7KW

Speed of engine N = 1500rpm

Effective radius of the brake drum R = 0.213 m

Specific gravity of fuel = 0.853 gm/cc

Load on brake drum =(W-S)

Stroke length L =110×10−3 m

Diameter of cylinder bore D =80×10−3 m

Calorific Value of fuel CV = 42000 kJ/kg

Time taken for 10cc consumption of fuel is ‘T’ sec

`

6.2 Calculation: 6.2.1 D100: Table 6.1 D100 Load test:

W-S (kg)	**T Sec**	**BP (kW)**	**FC (kJ/hr)**	**IP (kW)**	**SFC (kJ/kW hr)**	**BTE %**	**ITE %**	**ME %**	**IMEP**	**BMEP**
0	74	0	0.389	2..75	0	0	60.6	0	3.98	0
1.7	62	0.558	0.464	3.308	0.831	10.3	61.1	16.86	4.78	0.8
3.3	55	1.083	0.524	3.833	0.483	17.8	62.7	28.25	5.54	1.56
5.1	49	1.674	0.588	4.424	0.351	24.4	64.5	37.84	6.4	2.42
6.8	42	2.232	0.686	4.982	0.307	27.9	62.2	44.8	7.2	3.22
8.4	37	2.751	0.778	5.501	0.282	30.4	60.6	50	7.96	3.98

Table 6.2 D100 Viscosity:

S. No	**Temperature (°C)**	**Time for 50cc of oil in sec**	**A*Time**	**B/Time**	**Kinematic Viscosity (V) Centistokes**	**Ln(v)**	**Absolute Viscosity (μ) Centipoise**
1	29	42	0.11088	0.04523	0.06565	-2.723	0.84
2	36	38	0.10032	0.05	0.05032	-2.989	0.83545
3	44	35	0.0924	0.05428	0.03812	-3.267	0.83025

Table 6.3 D100 Flash and Fire Point:

S. No	**Flash point °c**	**Fire point °c**
1	51	55

`

Calculations:

Load test:

Maximum load $=\frac{Rated\ B.P\ \times 60000}{2\pi NR\times 9.81}$

$= \frac{3.7\ \times 60000}{2\pi\times 1500\times 0.213\times 9.81}$

= 11.27 kg

Brake power (B.P) = $\frac{2\pi N(W-S)\times 9.81\times R}{60000}$

$= \frac{2\pi\times 1500\times 1.7\times 9.81\times 0.213}{60000}$

= 0.558kW

Fuel consumption (F.C) = $\frac{10}{t}\times\frac{specific\ gravity\ \times 3600}{1000}\ kJ$/hr

$=\frac{10}{62}\times\frac{0.853\times 3600}{1000}\ kJ/hr$

= 0.464 kJ/hr

Frictional power from graph (F.P) = 2.75 kW

Indicated power (I.P) = B.P + F.P =0.558+2.75

=3.308 kW

Specific fuel consumption (S.F.C) = $\frac{F.C}{B.P}\ kJ/kW.hr$

$=\frac{0.464}{0.558}$

= 0.831 $kJ/kW.hr$

Brake thermal efficiency $\eta_{Bth} =\frac{B.P\times 3600}{FC\times CV}$

$=\frac{0.558\times 3600}{0.464\times 42000}$

= 10.3%

Indicated thermal efficiency $\eta_{Ith} = \frac{I.P\times 3600}{FC\times CV}$

`

$$= \frac{3.308\times3600}{0.464\times42000} = 61.1\ \%$$

Mechanical efficiency $\eta_{\text{mech}} = \frac{B.p}{I.p}$

$$= \frac{0.558}{3.308}$$

$$= 16.86\ \%$$

Indicated mean effective pressure (IMEP)= $\frac{I.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

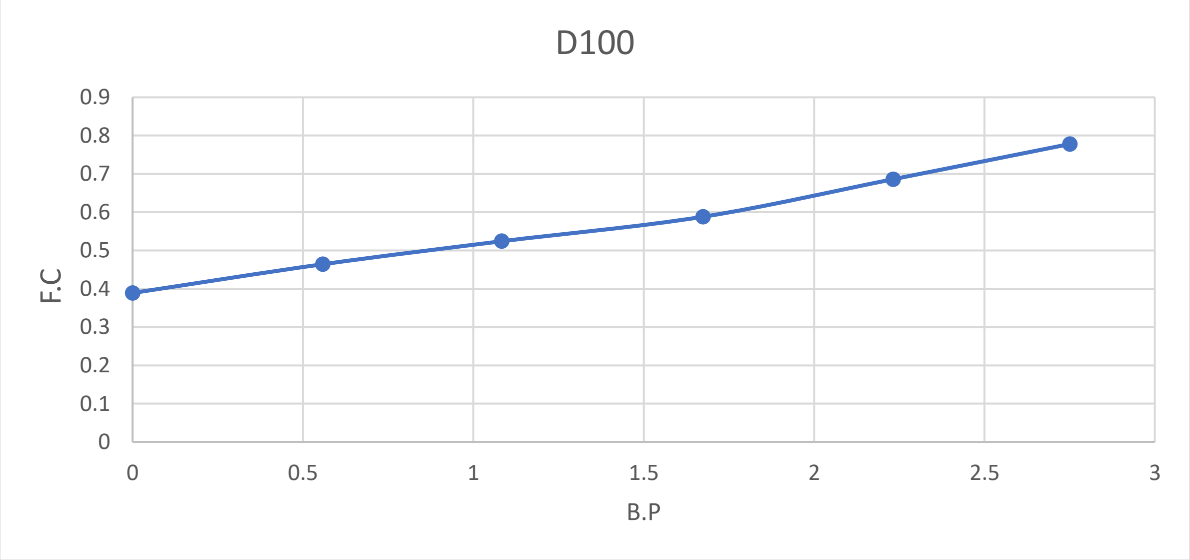
$$= \frac{3.308\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

= 4.78bar

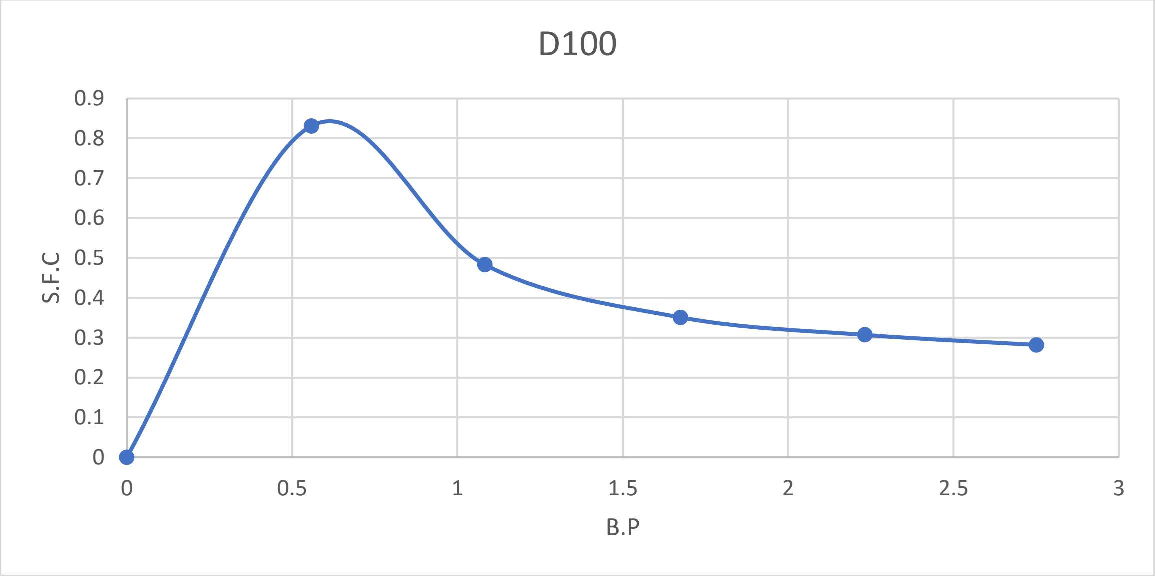
Break mean effective pressure (BMEP) = $\frac{B.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

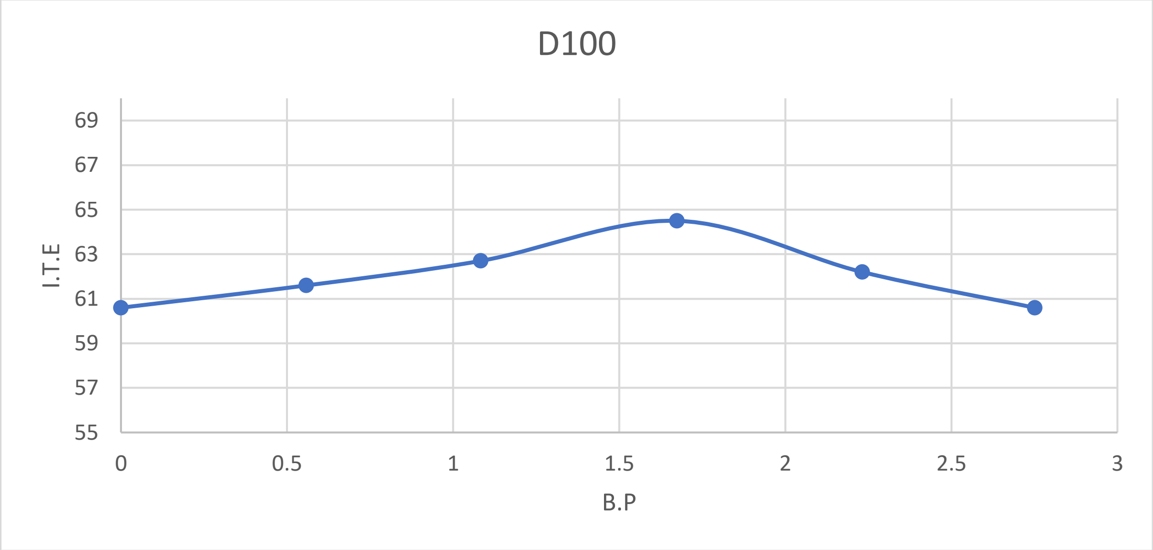
$$= \frac{0.558\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

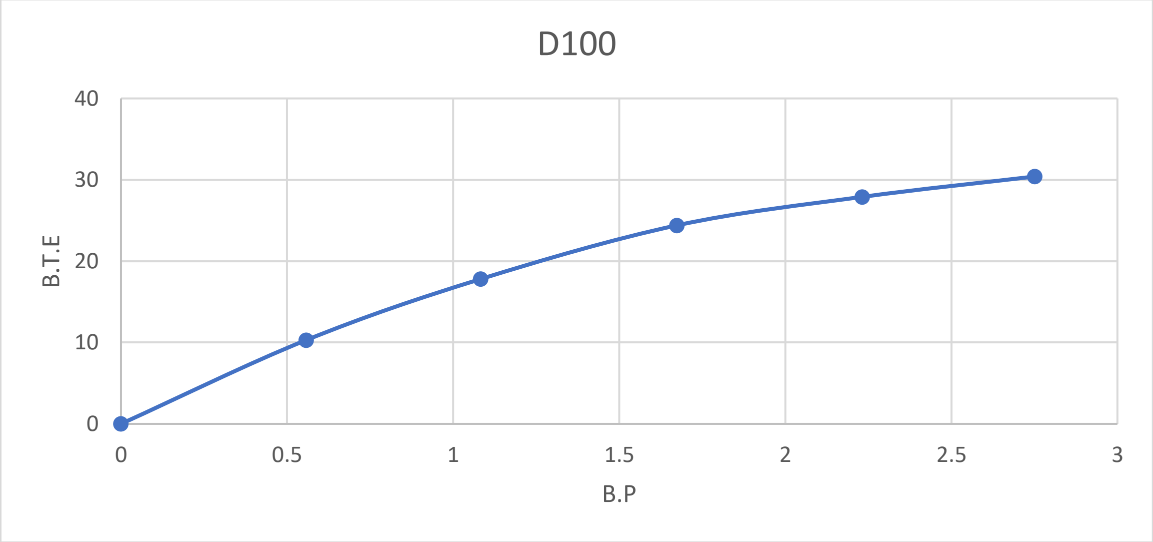
= 0.8 bar



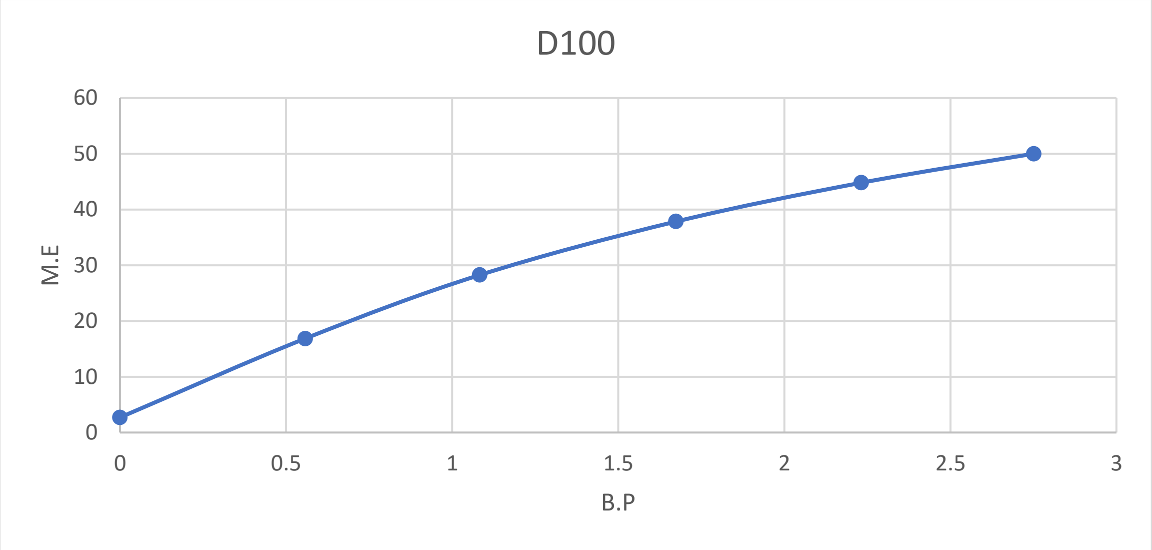
`

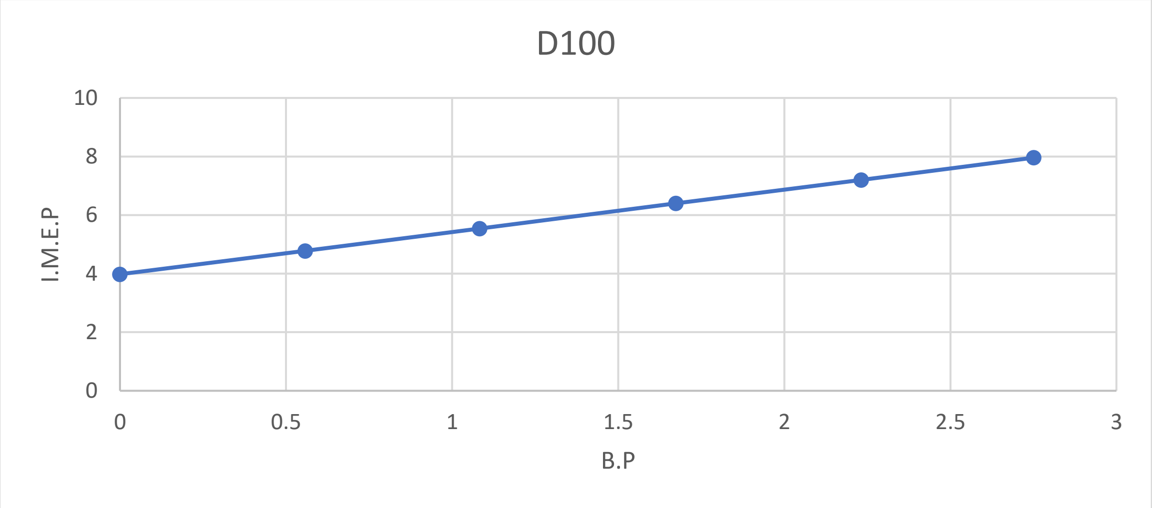

D100
S.F.C
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
B.P

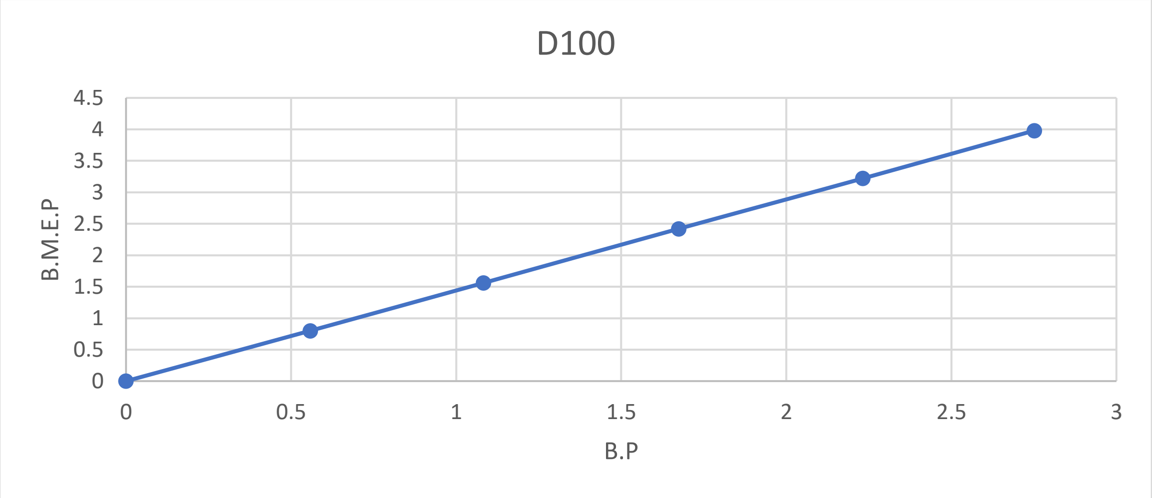

D100
I.T.E
69
67
65
63
61
59
57
55
0
0.5
1
1.5
2
2.5
3
B.P


D100
B.T.E
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P

`


D100
M.E
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D100
I.M.E.P
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
B.P


D100
B.M.E.P
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
B.P

`

Viscosity:

Temp=29 ℃ , Time(t_r)=42 sec

A=0.00264, B=1.9

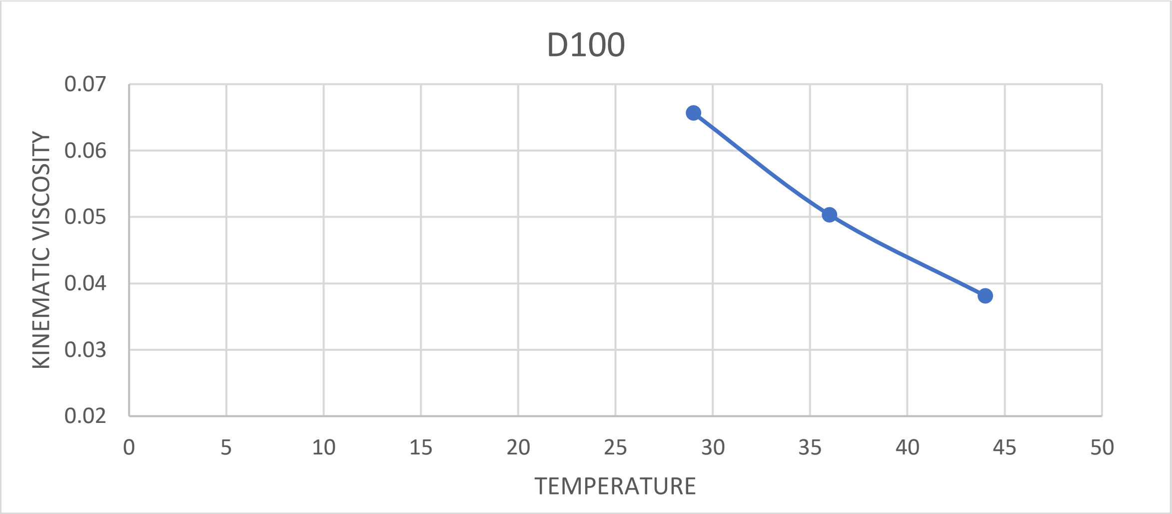
Kinematic(v)=At_r- B/t_r=0.11088-0.04523=0.06565 Centistokes

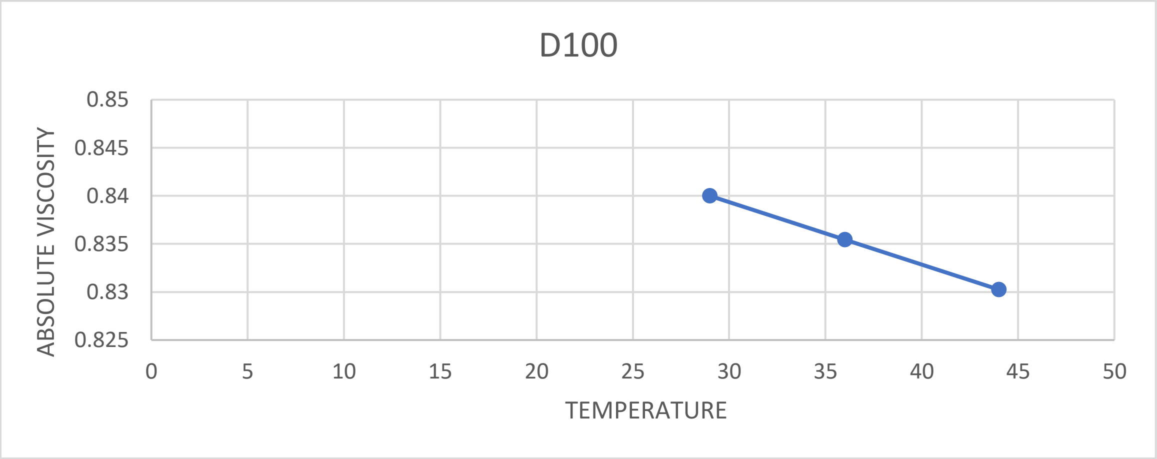
ln(v)=-2.723,

absolute viscosity(µ)=0.84-(0.0065) ×(temp-29)

=0.84-(0.0065) × (29-29)

=0.84 Centipoise.





`

6.2.2. D95:

Table 6.4 D95 Load test:

W-S (kg)	T (Sec)	BP (kW)	FC (kJ/hr)	IP (kW)	SFC (KJ/kW hr)	BTE %	ITE %	ME %	IMEP	BMEP
0	80	0	0.384	2.25	0	0	50.2	0	3.25	0
1.8	64	0.59	0.48	2.84	0.813	11.09	50.7	20.77	4.11	0.85
3.5	55	1.149	0.558	3.4	0.486	17.6	52.2	33.8	4.92	1.66
5.2	49	1.707	0.627	3.957	0.367	23.35	54.1	43.14	5.72	2.47
6.9	44	2.265	0.698	4.515	0.308	27.8	55.4	50.16	6.53	3.28
8.6	37	2.823	0.83	5.073	0.294	29.15	52.4	55.65	7.34	4.08

Table 6.5 D100 Viscosity:

S. No	Temperature (°C)	Time for 50cc of oil in sec	A*Time	B/Time	Kinematic Viscosity (V) Centistokes	Ln(v)	Absolute Viscosity (μ) centipoise
1	38	36	0.09504	0.0527	0.04234	-3.162	0.83415
2	43	34	0.08976	0.05588	0.03388	-3.385	0.8309
3	48	32	0.08448	0.05937	0.02511	-3.684	0.82765

Table 6.6 D100 Flash and Fire Point:

S. No	Flash point °c	Fire point °c
1	49	53

`

Load test:

Maximum load $=\frac{Rated\ B.P\times 60000}{2\pi NR\times 9.81}$

$=\frac{3.7\times 60000}{2\pi\times 1500\times 0.213\times 9.81}$

= 11.27 kg

Brake power (B.P) = $\frac{2\pi N(W-S)\times 9.81\times R}{60000}$

$=\frac{2\pi\times 1500\times 1.8\times 9.81\times 0.213}{60000}$

= 0.59 kW

Fuel consumption (F.C) = $\frac{10}{t}\times\frac{specific\ gravity\times 3600}{1000}\ kJ$/hr

$=\frac{10}{64}\times\frac{0.853\times 3600}{1000}\ kJ/hr$

= 0.48 kJ/hr

Frictional power from graph (F.P) = 2.25kW

Indicated power (I.P) = B.P + F.P =0.59+2.25

=2.84 kW

Specific fuel consumption (S.F.C) = $\frac{F.C}{B.P}\ kJ/kW.hr$

$=\frac{0.48}{0.59}$

= 0.813 $kJ/kW.hr$

Brake thermal efficiency $\eta_{Bth}=\frac{B.P\times 3600}{FC\times CV}$

$=\frac{0.59\times 3600}{0.48\times 39900}$

= 11.09 %

`

Indicated thermal efficiency η $_{\text{Ith}}$ $=\frac{I.P\times3600}{FC\times CV}$

$$=\frac{2.84\times3600}{0.48\times39900}$$

= 50.7 %

Mechanical efficiency η $_{\text{mech}}$ $=\frac{B.p}{I.p}$

$$=\frac{0.59}{2.84}$$

= 20.77 %

Indicated mean effective pressure (IMEP)= $\frac{I.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

$$=\ \frac{2.84\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

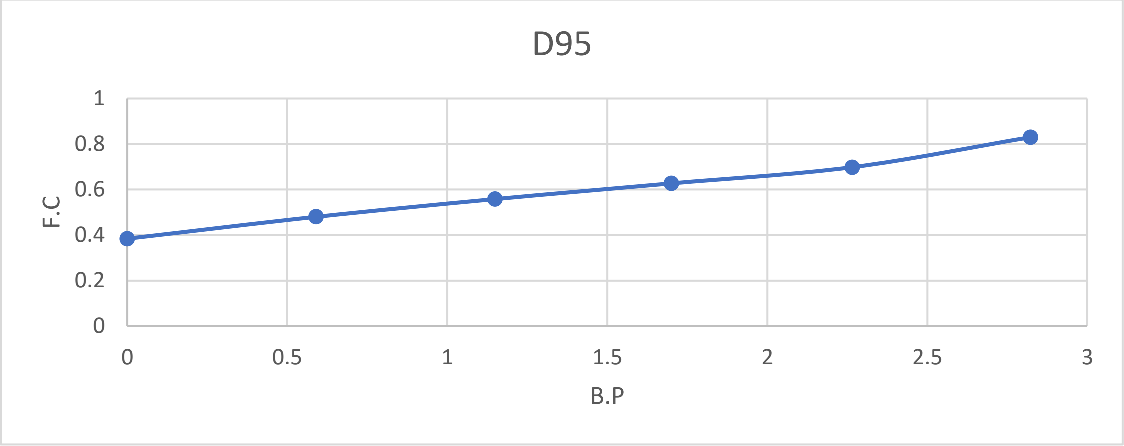
= 4.11bar

Break mean effective pressure (BMEP) = $\frac{B.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

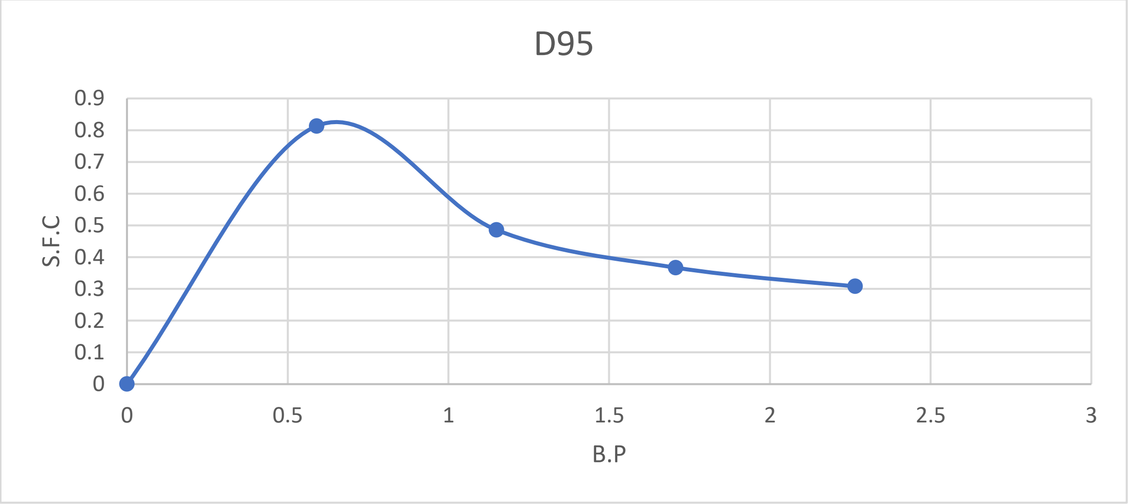
$$=\ \frac{0.59\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

= 0.85 bar

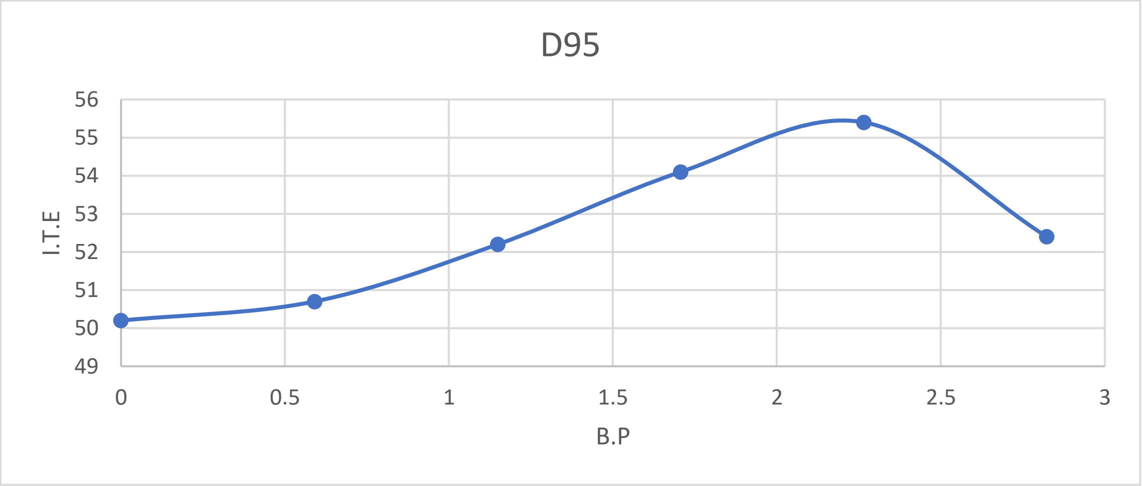
`



D95
F.C
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
B.P

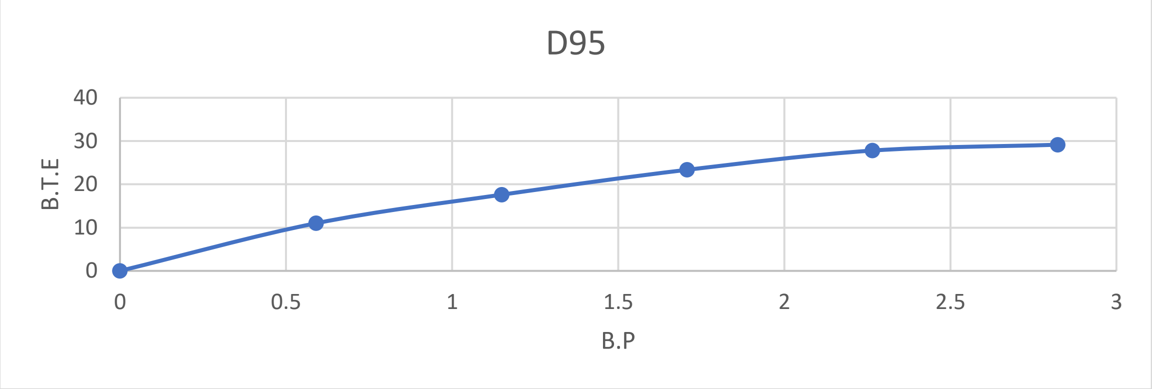


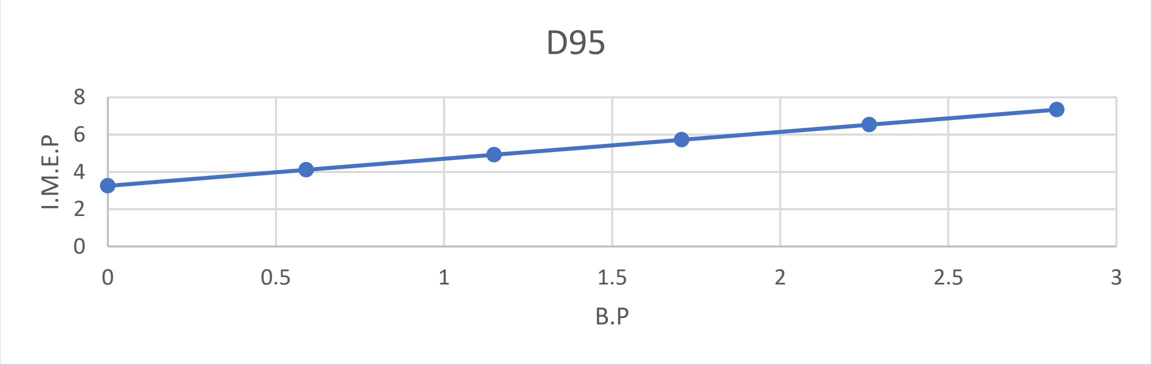
D95
S.F.C
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
B.P

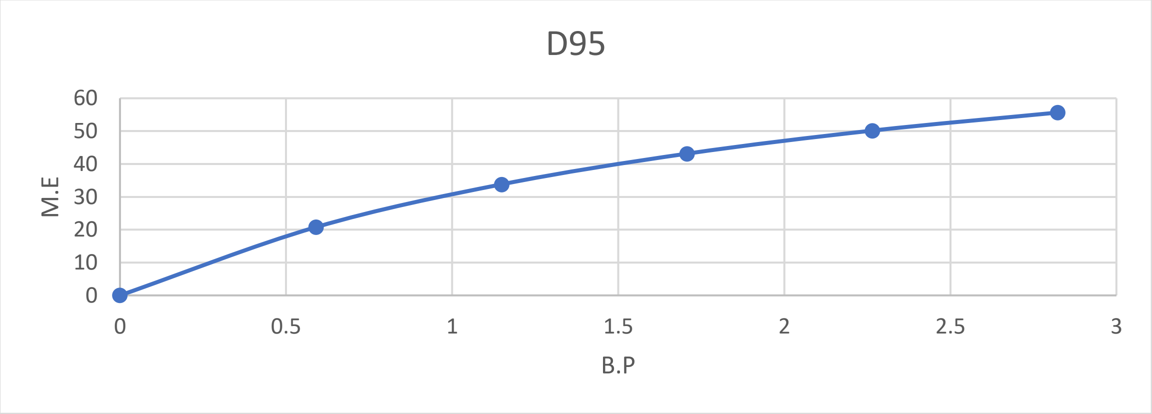


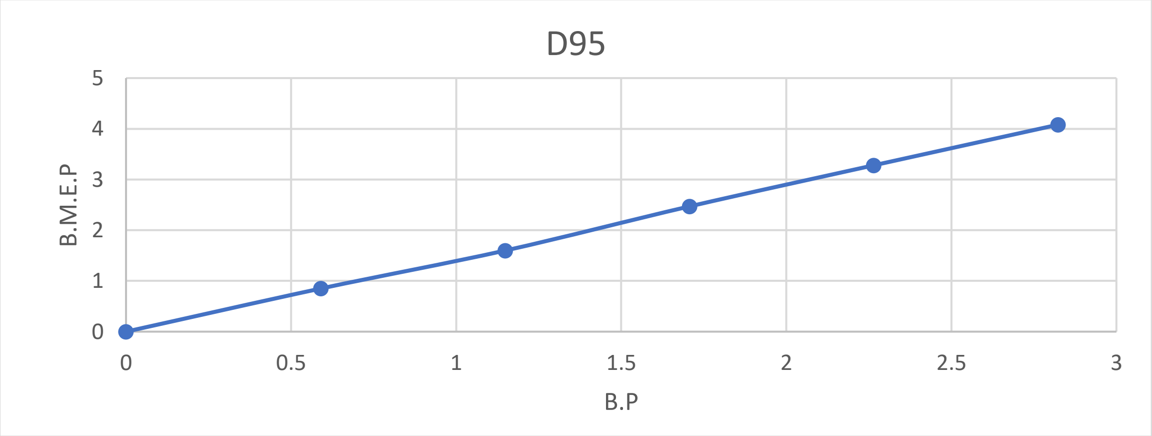
D95
I.T.E
56
55
54
53
52
51
50
49
0
0.5
1
1.5
2
2.5
3
B.P

`


D95
B.T.E
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D95
I.M.E.P
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
B.P


D95
M.E
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D95
B.M.E.P
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
B.P

`

Viscosity:

Temp=38℃ ,   Time(t_r)=36 sec

A=0.00264, B=1.9

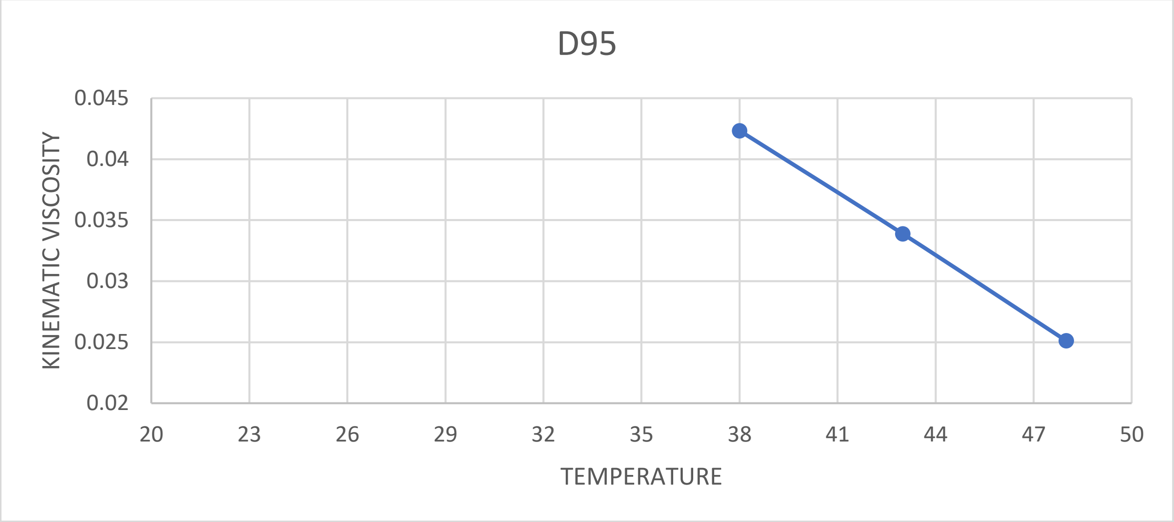
Kinematic(v)=At_r- B/t_r=0.09504-0.0527=0.04234 Centistokes

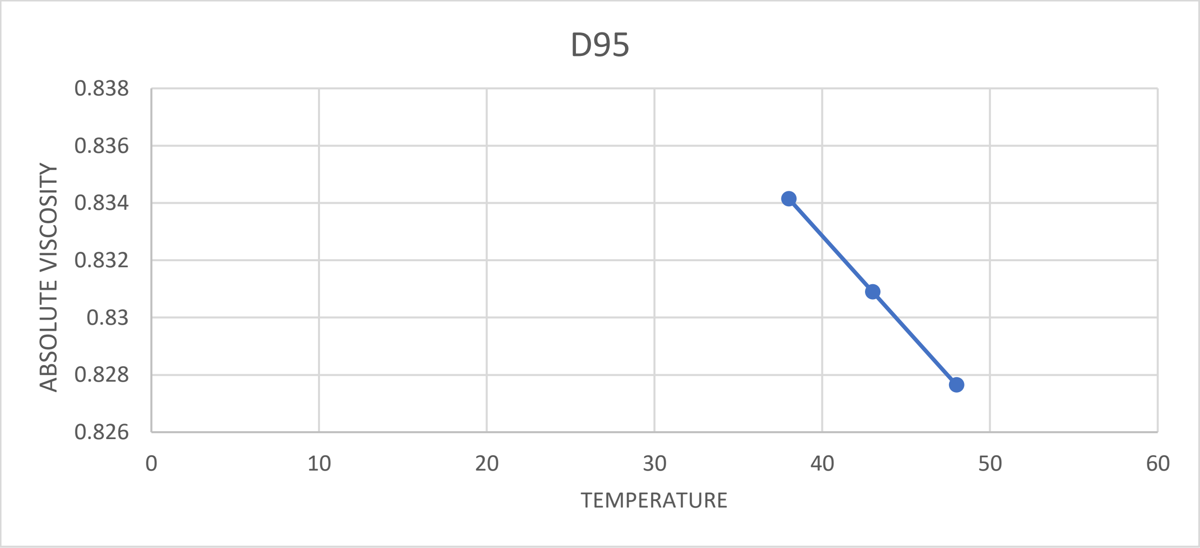
ln(v)=-3.162,

absolute viscosity(μ)=0.84-(v) ×(temp-29)

=0.84-(0.0065) × (38-29)

=0.83415 Centipoise





`

6.2.3. D90:

Table 6.7 D90 Load test:

W-S (kg)	T (Sec)	BP (kW)	FC (kJ/hr)	IP (kW)	SFC (kJ/kW hr)	BTE %	ITE %	ME %	IMEP	BMEP
0	81	0	0.38	2.2	0	0	50	0	3.18	0
1.7	68	0.558	0.451	2.758	0.808	11.7	52.4	20.23	4	0.81
3.4	57	1.116	0.539	3.316	0.483	17.7	52.7	33.65	4.78	1.61
5.1	52	1.674	0.59	3.874	0.352	24.3	56.3	43.21	5.6	2.42
6.9	46	2.265	0.667	4.465	0.294	29.2	57.4	50.72	6.46	3.28
8.7	36	2.855	0.853	5.055	0.299	28.7	50.8	56.47	7.31	4.13

Table 6.8 D90 Viscosity:

S. No	Temperature (°C)	Time for 50cc of oil in sec	A*Time	B/Time	Kinematic Viscosity (V) Centistokes	Ln(v)	Absolute Viscosity (μ) Centipoise
1	33	37	0.09768	0.5135	0.04633	-3.072	0.8374
2	40	35	0.0924	0.05428	0.03812	-3.267	0.83285
3	45	33	0.08712	0.05757	0.02955	-3.522	0.8296

Table 6.8 D90 Flash and Fire Point:

S. No	Flash point °c	Fire point °c
1	46	49

`

Load test:

Maximum load $=\frac{Rated\ B.P\times 60000}{2\pi NR\times 9.81}$

$= \frac{3.7\times 60000}{2\pi\times 1500\times 0.213\times 9.81}$

= 11.27 kg

Brake power (B.P) $= \frac{2\pi N(W-S)\times 9.81\times R}{60000}$

$= \frac{2\pi\times 1500\times 1.7\times 9.81\times 0.213}{60000}$

= 0.558kW

Fuel consumption (F.C) $= \frac{10}{t}\times\frac{specific\ gravity\times 3600}{1000}\ kJ$/hr

$= \frac{10}{68}\times\frac{0.853\times 3600}{1000}\ kJ/hr$

= 0.451 kJ/hr

Frictional power from graph (F.P) = 2.2 kW

Indicated power (I.P) = B.P + F.P =0.558+2.2

=2.758 kW

Specific fuel consumption (S.F.C) $= \frac{F.C}{B.P}\ kJ/kW.hr$

$= \frac{0.451}{0.558}$

= 0.808 $kJ/kW.hr$

Brake thermal efficiency $\eta_{Bth} = \frac{B.P\times 3600}{FC\times CV}$

$= \frac{0.558\times 3600}{0.451\times 37800}$

= 11.7 %

Indicated thermal efficiency $\eta_{Ith} = \frac{I.P\times 3600}{FC\times CV}$

$= \frac{2.758\times 3600}{0.451\times 37800}$

= 52.4 %

Mechanical efficiency $\eta_{mech} = \frac{B.p}{I.p}$

$= \frac{0.558}{2.758}$

= 20.23 %

`

Indicated mean effective pressure(IMEP)= $\frac{I.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

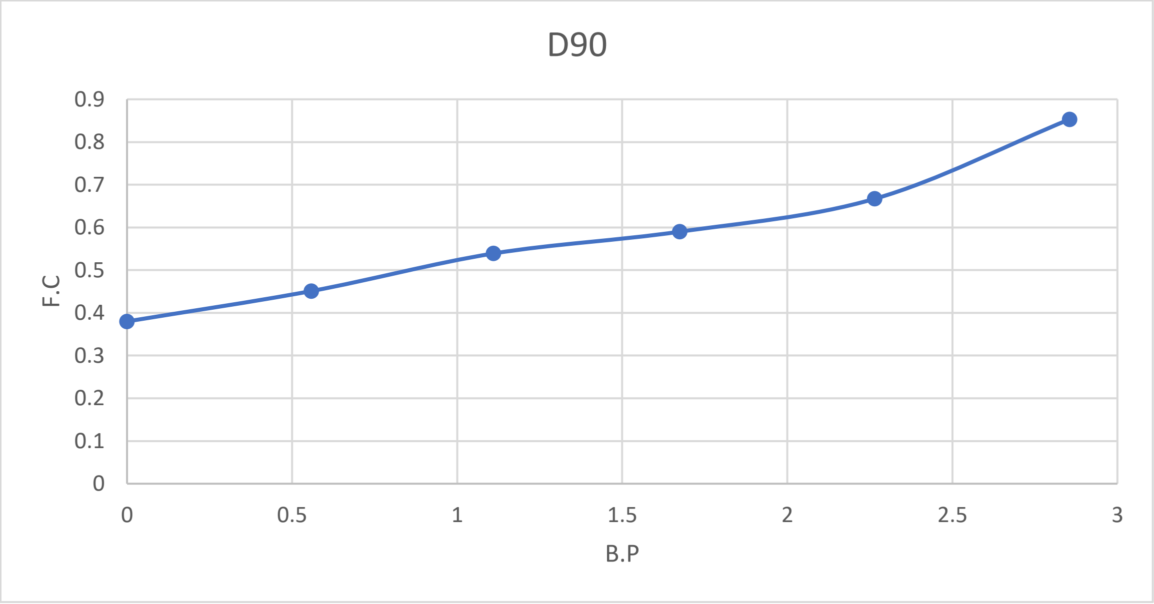
$$= \frac{2.758\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

= 4 bar

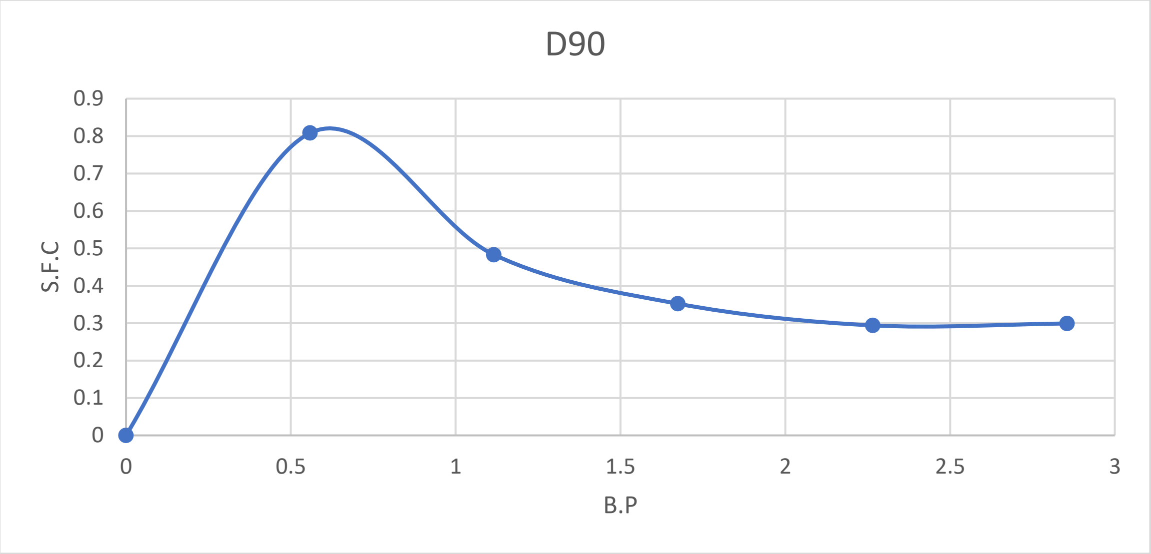
Break mean effective pressure (BMEP) = $\frac{B.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

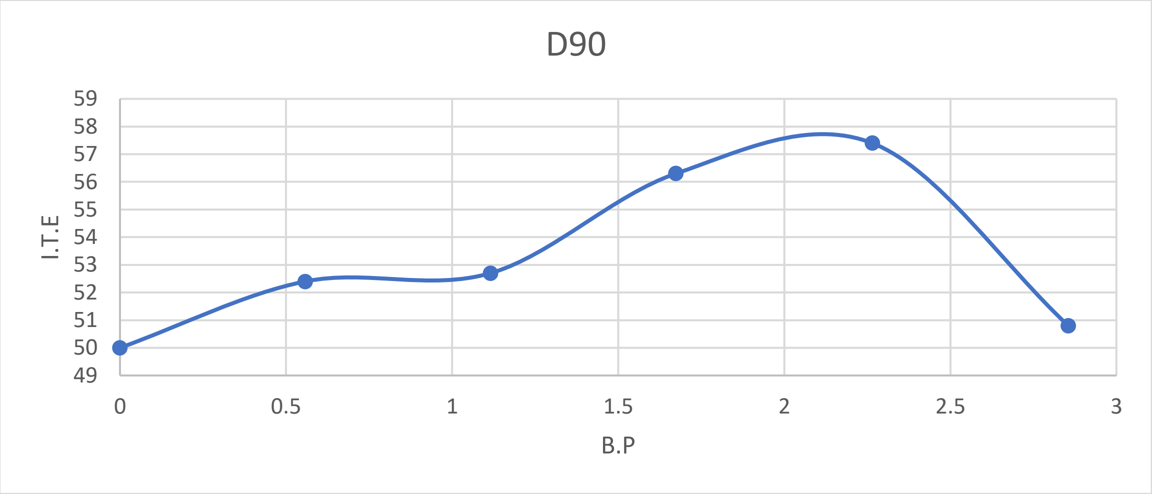
$$= \frac{0.558\times60000}{110\times10^{-3}\times\frac{\pi}{4}\times(80\times10^{-3})^2\times\frac{1500}{2}}$$

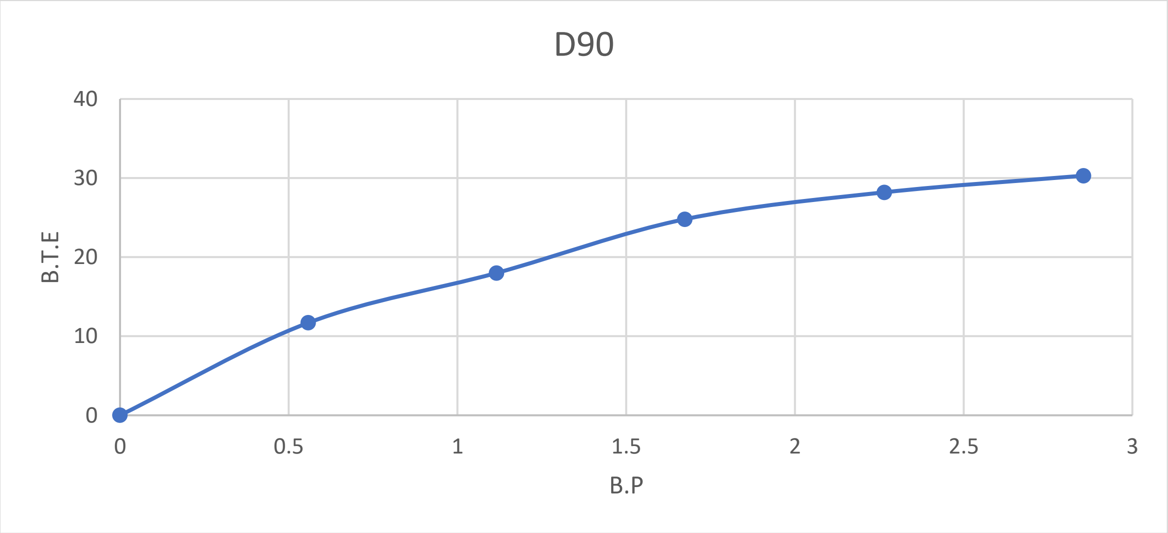
= 0.81 bar



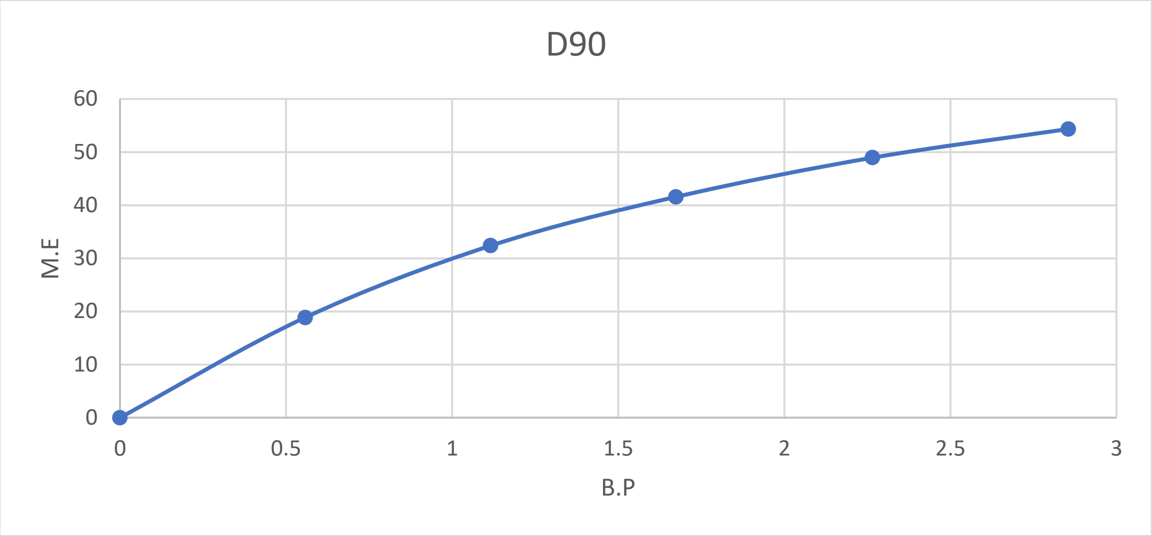
`

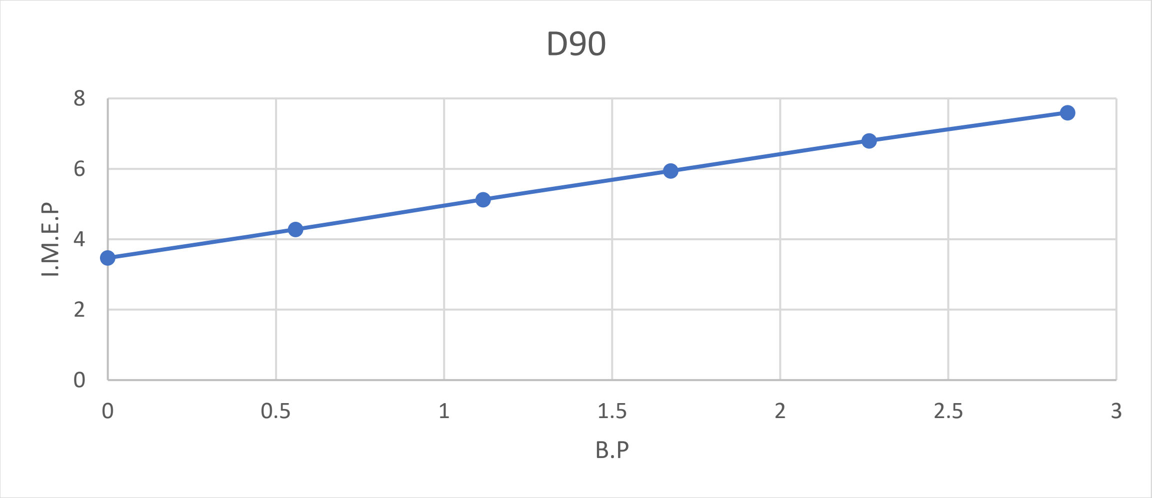

D90
S.F.C
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
B.P

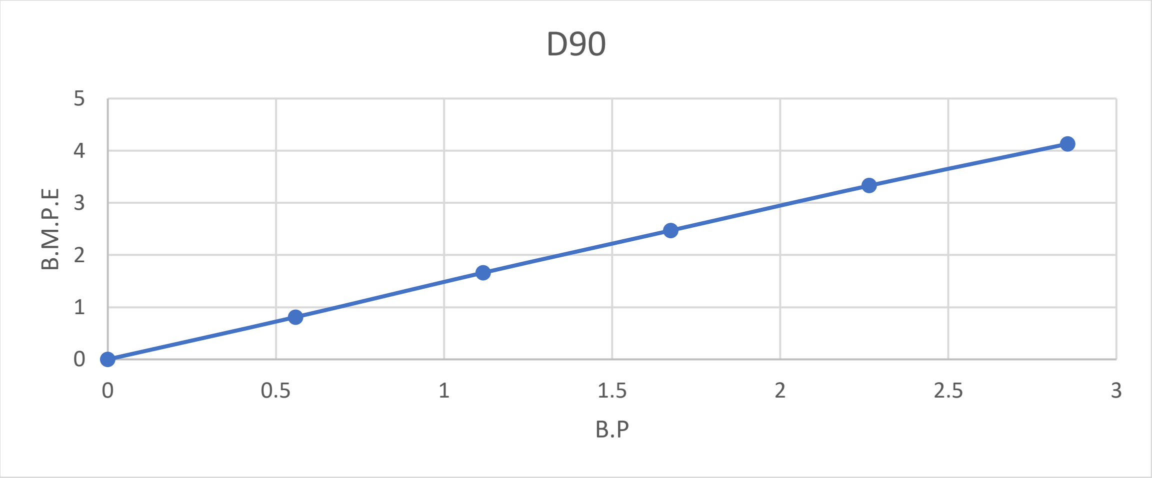

D90
I.T.E
59
58
57
56
55
54
53
52
51
50
49
0
0.5
1
1.5
2
2.5
3
B.P


D90
B.T.E
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P

`


D90
M.E
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D90
I.M.E.P
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
B.P


D90
B.M.P.E
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
B.P

`

<u>Viscosity:</u>

Temp=33 °C, Time (t_r)=37 sec

A=0.00264, B=1.9

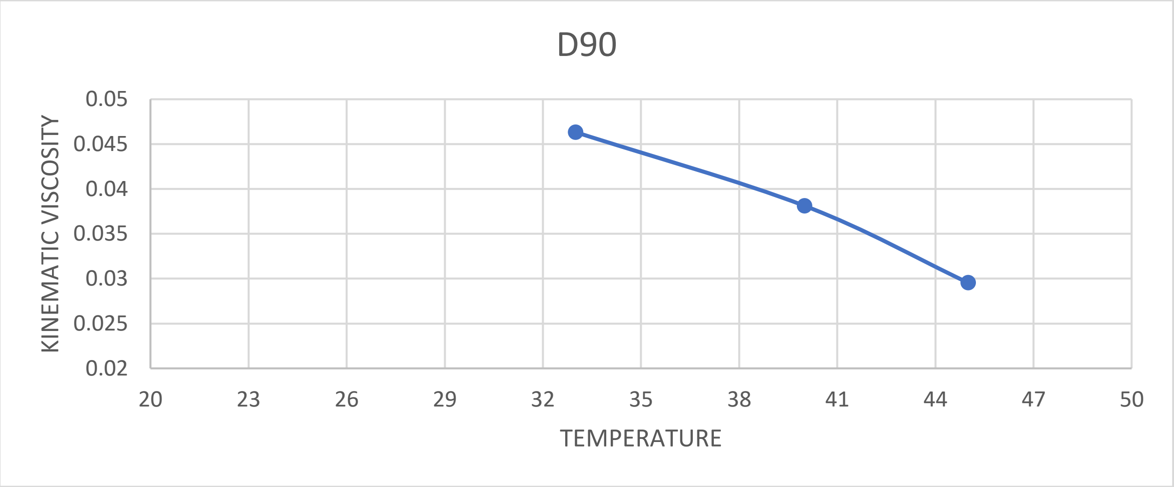
Kinematic(v)=At_r- B/t_r=0.09768-0.04633=0.04633 Centistokes

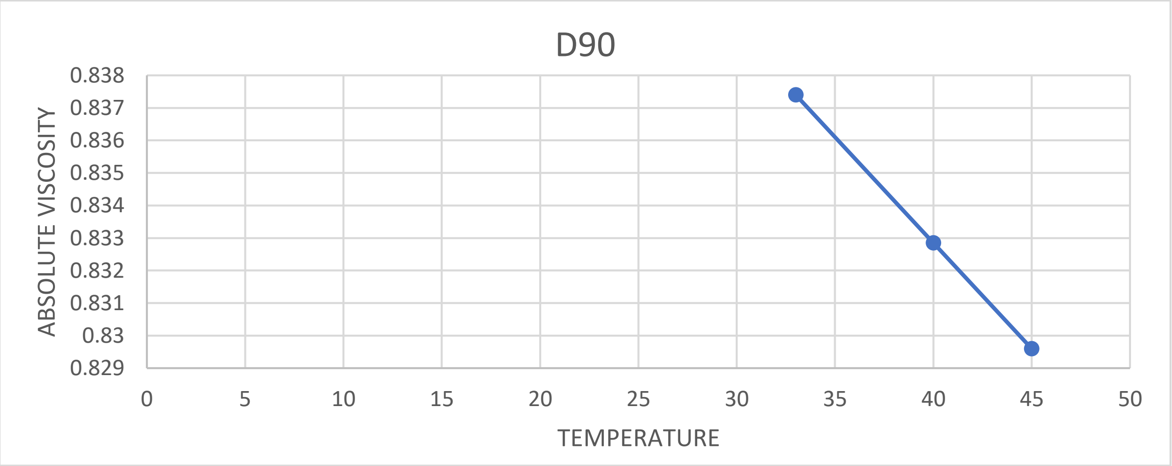
ln(v)=-3.072,

absolute viscosity(μ)=0.84-(0.0065)×(temp-29)

=0.84-(0.0065)×(33-29)

=0.83415 Centipoise





6.2.4. D85:

Table 6.9 D85 Load test:

W-S (kg)	T (Sec)	BP (kW)	FC (kJ/hr)	IP (kW)	SFC (kJ/kW hr)	BTE %	ITE %	ME %	IMEP	BMEP
0	83	0	0.37	2.4	0	0	55.6	0	3.47	0
1.7	68	0.558	0.451	2.958	0.808	12.4	56.2	18.86	4.28	0.81
3.5	56	1.149	0.548	3.549	0.477	18	55.5	32.37	5.13	1.66
5.2	52	1.707	0.59	4.107	0.346	24.8	59.6	41.56	5.94	2.47
7	44	2.3	0.7	4.7	0.304	28.2	57.5	48.93	6.8	3.33
8.7	38	2.855	0.808	5.255	0.283	30.3	55.7	54.33	7.6	4.13

Table 6.10 D85 Viscosity:

S. No	Temperature (°C)	Time for 50cc of oil in sec	A*Time	B/Time	Kinematic Viscosity (V) Centistokes	Ln(v)	Absolute Viscosity (μ) Centipoise
1	35	42	0.11088	0.04523	0.06565	-2.723	0.8361
2	40	40	0.1056	0.0475	0.0581	-2.846	0.83285
3	45	37	0.09768	0.05135	0.04633	-3.072	0.8296

Table 6.11 D85 Flash and Fire point:

S. No	Flash point °c	Fire point °c
1	44	48

`

Load test:

Maximum load = $\frac{Rated\ B.P \times 60000}{2\pi NR \times 9.81}$

$= \frac{3.7 \times 60000}{2\pi \times 1500 \times 0.213 \times 9.81}$

= 11.27 kg

Brake power (B.P) = $\frac{2\pi N(W-S) \times 9.81 \times R}{60000}$

$= \frac{2\pi \times 1500 \times 1.7 \times 9.81 \times 0.213}{60000}$

= 0.558 kW

Fuel consumption (F.C) = $\frac{10}{t} \times \frac{specific\ gravity \times 3600}{1000}\ kJ$/hr

$= \frac{10}{68} \times \frac{0.853 \times 3600}{1000}\ kJ/hr$

= 0.451 kJ/hr

Frictional power from graph (F.P) = 2.4 kW

Indicated power (I.P) = B.P + F.P =0.558+2.4

=2.958 kW

Specific fuel consumption (S.F.C) = $\frac{F.C}{B.P}\ kJ/kW.hr$

$= \frac{0.451}{0.558}$

= $0.808 kJ/kW.hr$

Brake thermal efficiency $\eta_{Bth} = \frac{B.P \times 3600}{FC \times CV}$

$= \frac{0.558 \times 3600}{0.451 \times 35700}$

= 12.4 %

Indicated thermal efficiency $\eta_{Ith} = \frac{I.P \times 3600}{FC \times CV}$

$= \frac{2.958 \times 3600}{0.451 \times 35700}$ = 56.2 %

`

Mechanical efficiency $\eta_{\text{mech}} = \frac{B.p}{I.p}$

$$= \frac{0.558}{2.958}$$

$$= 18.86\ \%$$

Indicated mean effective pressure (IMEP)$= \frac{I.P\times 60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

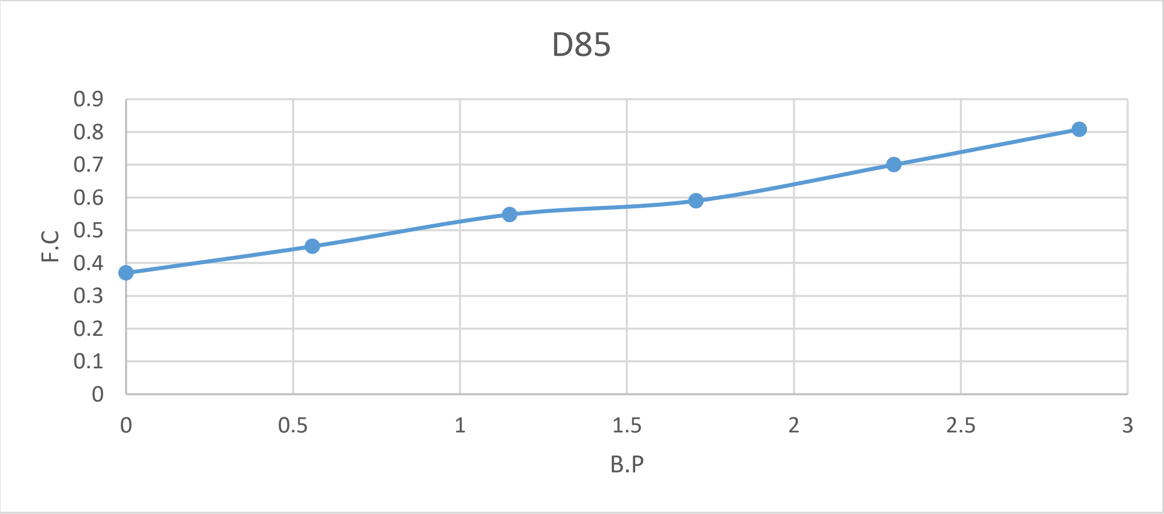
$$= \frac{2.958\times 60000}{110\times 10^{-3}\times\frac{\pi}{4}\times(80\times 10^{-3})^2\times\frac{1500}{2}}$$

= 4.28bar

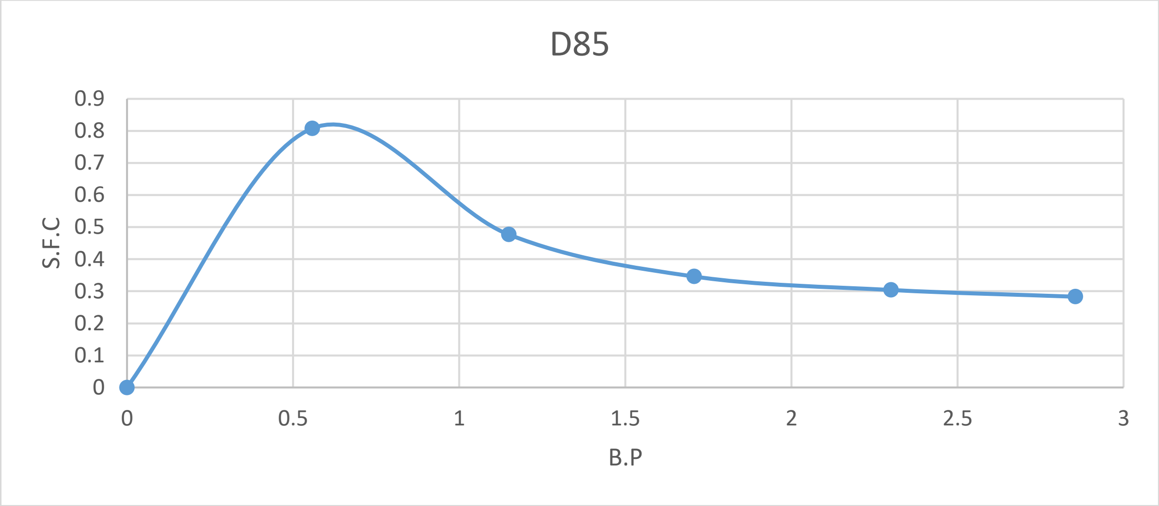
Break mean effective pressure (BMEP) $= \frac{B.P\times 60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}\ N/m^2$

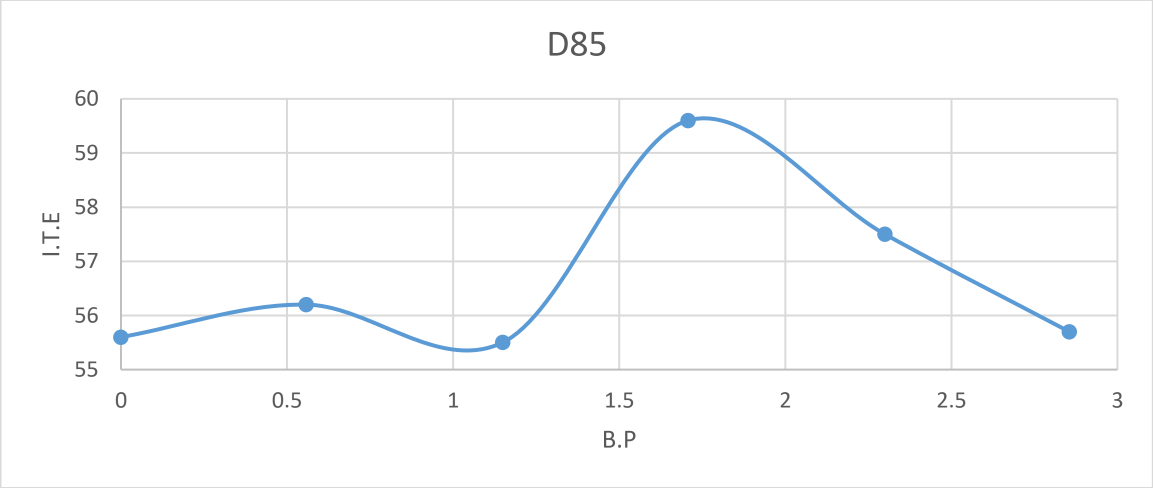
$$= \frac{0.558\times 60000}{110\times 10^{-3}\times\frac{\pi}{4}\times(80\times 10^{-3})^2\times\frac{1500}{2}}$$

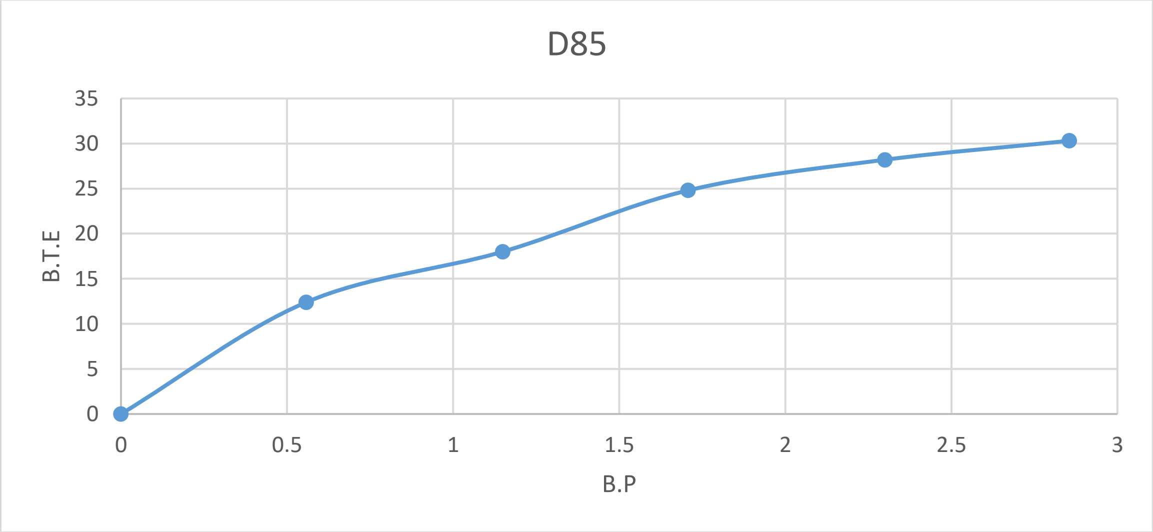
= 0.81 bar



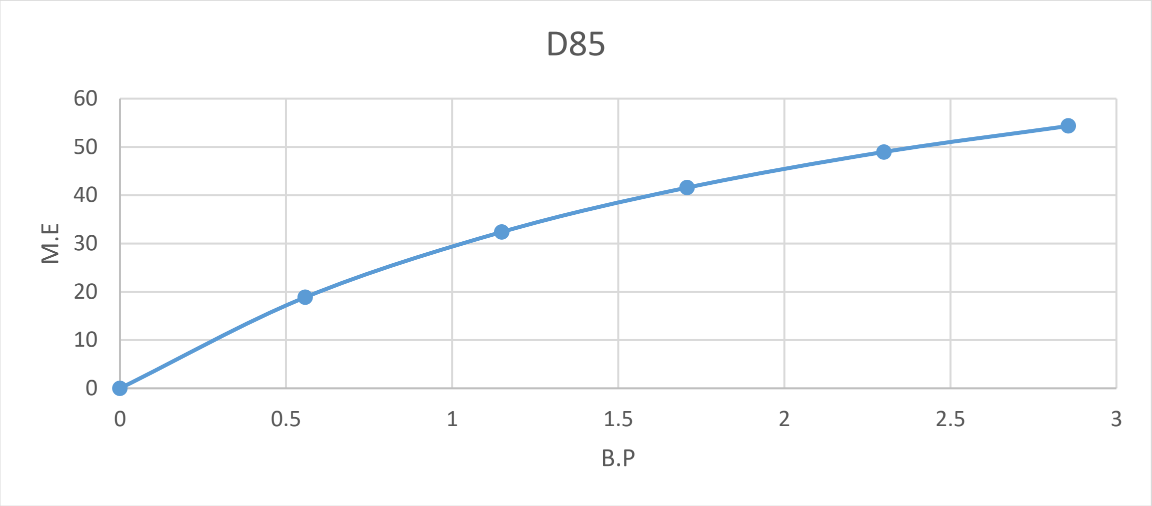
`

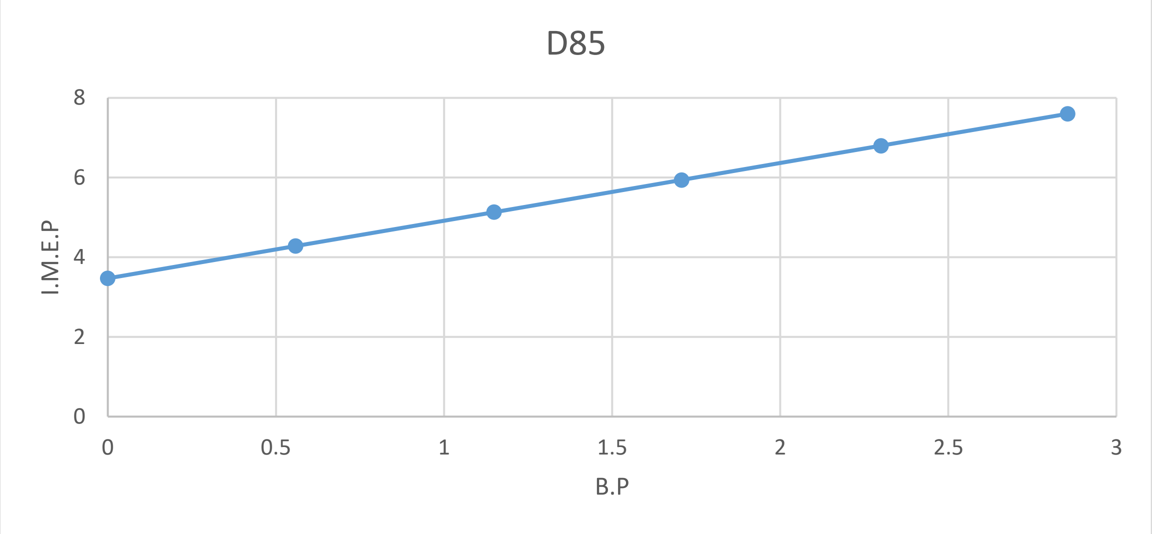

D85
S.F.C
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
B.P

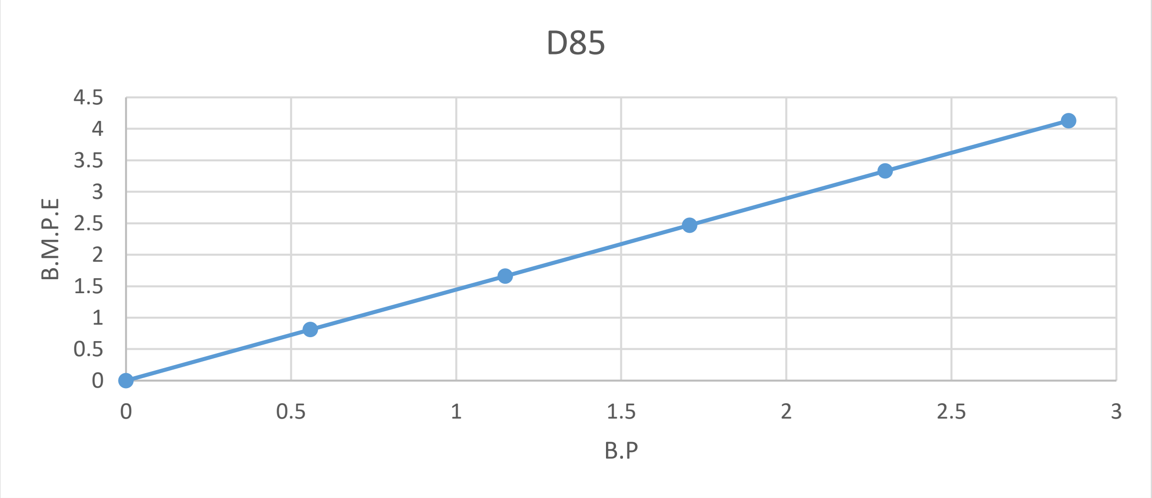

D85
I.T.E
60
59
58
57
56
55
0
0.5
1
1.5
2
2.5
3
B.P


D85
B.T.E
35
30
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
B.P

`


D85
M.E
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D85
I.M.E.P
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
B.P


D85
B.M.P.E
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
B.P

`

Viscosity:

Temp=35 °C,   Time(t_r)=42sec

A=0.00264, B=1.9

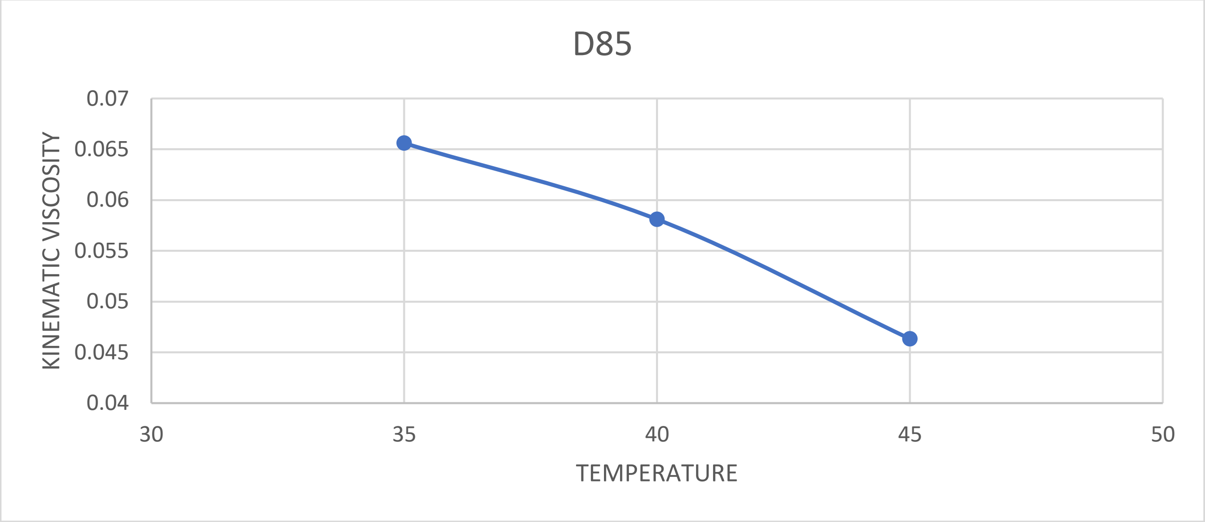
Kinematic(v)=At_r- B/t_r=0.11088-0.04523=0.06565 Centistokes

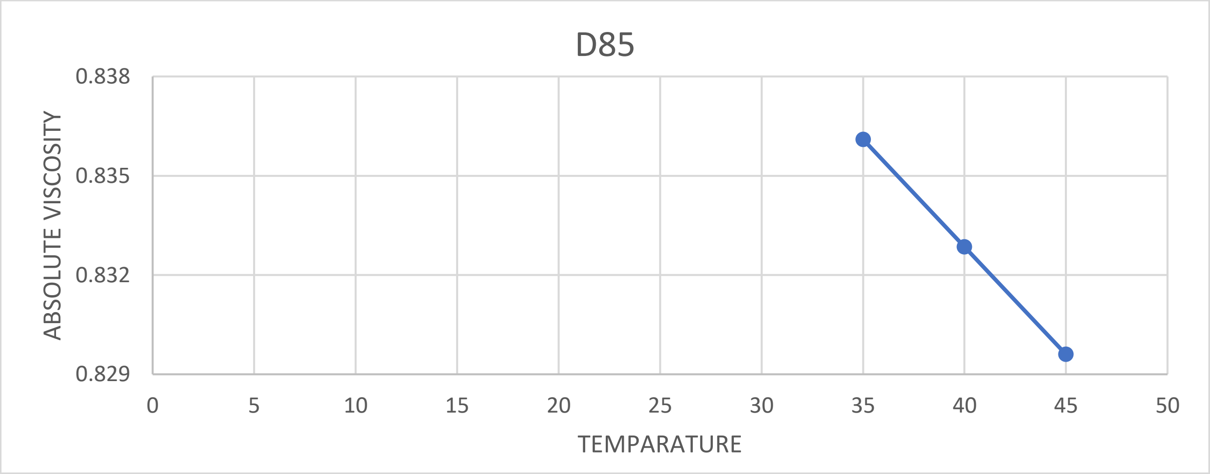
ln(v)=-2.723,

absolute viscosity(µ)=0.84-(0.0065) × (temp-29)

=0.84-(0.0065) ×(35-29)

=0.8361 Centipoise





`

6.2.5. D80:

Table 6.13 D80 Load Test:

W-S (kg)	T (Sec)	BP (kW)	FC (kJ/hr)	IP (kW)	SFC (kJ/kW hr)	BTE %	ITE %	ME %	IMEP	BMEP
0	83	0	0.37	2.5	0	0	58	0	3.62	0
1.7	67	0.558	0.458	3.058	0.816	13.25	57.2	18.25	4.42	0.81
3.5	56	1.149	0.548	3.649	0.477	18	57.0	31.48	5.28	1.66
5.2	50	1.707	0.614	4.207	0.36	23.8	58.7	40.57	6.08	2.47
7	45	2.3	0.682	408	0.3	28.6	60.3	48	6.94	3.3
8.8	38	2.855	0.808	5.355	0.283	30.3	56.8	53.31	7.75	4.13

Table 6.14 D80 Viscosity:

S. No	Temperature (°C)	Time for 50cc of oil in sec	A*Time	B/Time	Kinematic Viscosity (V) Centistokes	Ln(v)	Absolute Viscosity (μ) Centipoise
1	33	42	0.11088	0.04523	0.06565	-2.723	0.8374
2	43	44	0.11616	0.04318	0.07298	-2.618	0.8309
3	48	46	0.12144	0.04130	0.08014	-2.524	0.82765

Table 6.15 D80 Flash and Fire point:

S. No	Flash point °c	Fire point °c
1	43	47

`

Load test:

Maximum load =$\frac{Rated\ B.P \times 60000}{2\pi NR \times 9.81}$

$= \frac{3.7 \times 60000}{2\pi \times 1500 \times 0.213 \times 9.81}$

= 11.27 kg

Brake power (B.P) = $\frac{2\pi N(W-S) \times 9.81 \times R}{60000}$

$= \frac{2\pi \times 1500 \times 1.7 \times 9.81 \times 0.213}{60000}$

= 0.558 kW

Fuel consumption (F.C) = $\frac{10}{t} \times \frac{specific\ gravity \times 3600}{1000}\ kJ$/hr

$= \frac{10}{67} \times \frac{0.853 \times 3600}{1000}\ kJ/hr$

= 0.458 kJ/hr

Frictional power from graph (F.P) = 2.5 kW

Indicated power (I.P) = B.P + F.P =0.558+2.5

=3.058 kW

Specific fuel consumption (S.F.C) = $\frac{F.C}{B.P}\ kJ/kW.hr$

$= \frac{0.458}{0.558}$

= 0.816$kJ/kW.hr$

Brake thermal efficiency η_{Bth}=$\frac{B.P \times 3600}{FC \times CV}$

$= \frac{0.558 \times 3600}{0.458 \times 33600}$

= 13.25%

Indicated thermal efficiency η_{Ith} =$\frac{I.P \times 3600}{FC \times CV}$

$= \frac{2.958 \times 3600}{0.451 \times 33600}$ = 56.2 %

`

Mechanical efficiency η mech = $\frac{B.p}{I.p}$

$$= \frac{0.558}{2.958}$$

$$= 18.86\ \%$$

Indicated mean effective pressure (IMEP)= $\frac{I.P\times 60000}{L\times\frac{\pi}{4}\times D^{2}\times\frac{N}{2}}\ N/m^{2}$

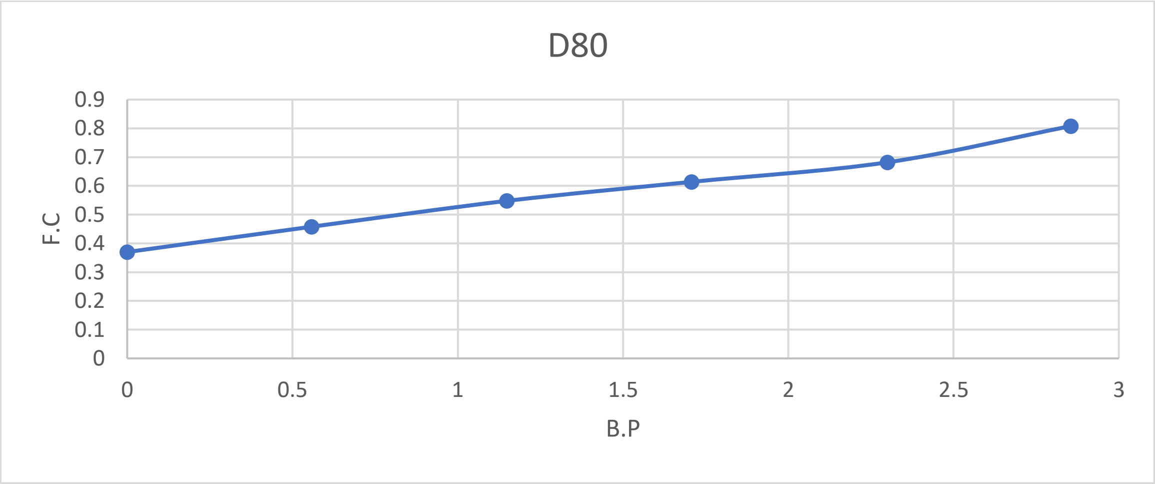
$$= \frac{3.058\times 60000}{110\times 10^{-3}\times\frac{\pi}{4}\times(80\times 10^{-3})^{2}\times\frac{1500}{2}}$$

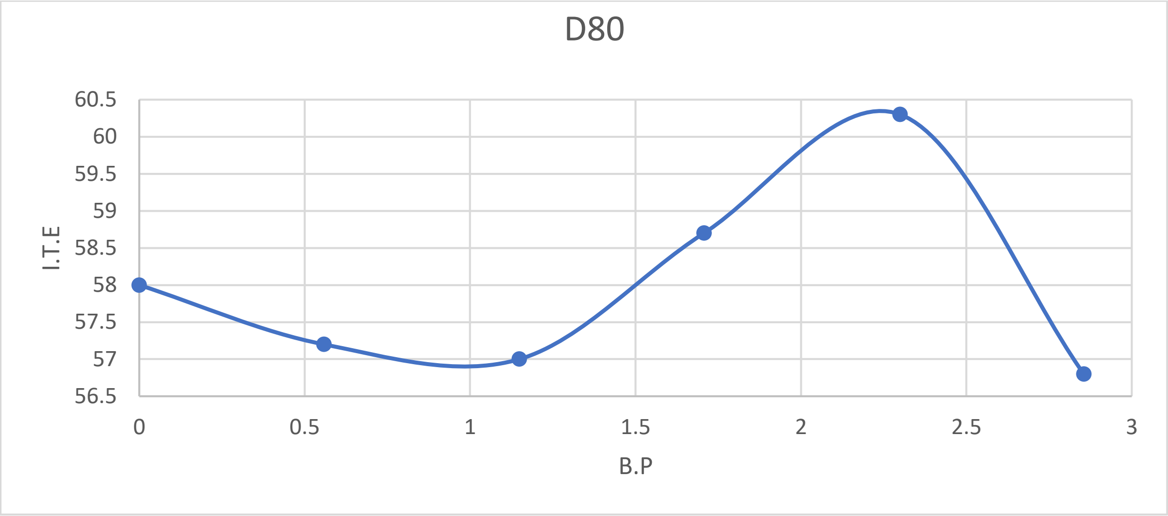
= 4.28bar

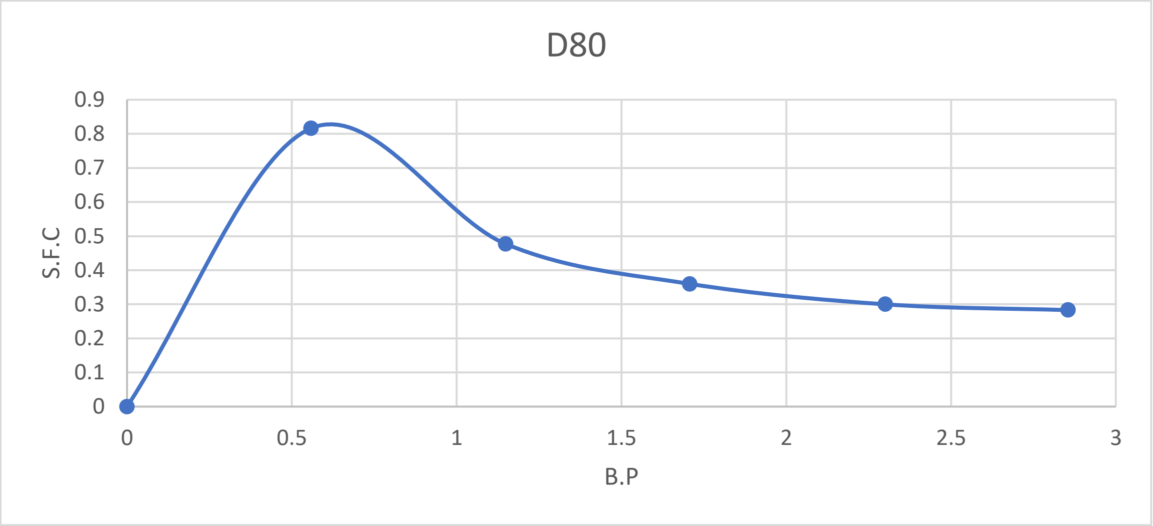
Break mean effective pressure (BMEP) = $\frac{B.P\times 60000}{L\times\frac{\pi}{4}\times D^{2}\times\frac{N}{2}}\ N/m^{2}$

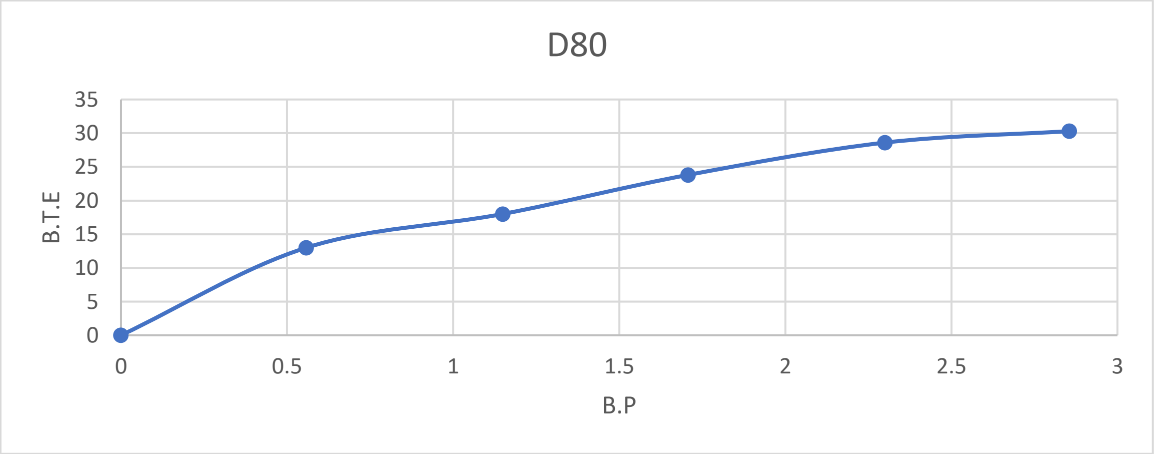
$$= \frac{0.558\times 60000}{110\times 10^{-3}\times\frac{\pi}{4}\times(80\times 10^{-3})^{2}\times\frac{1500}{2}}$$

= 0.81 bar

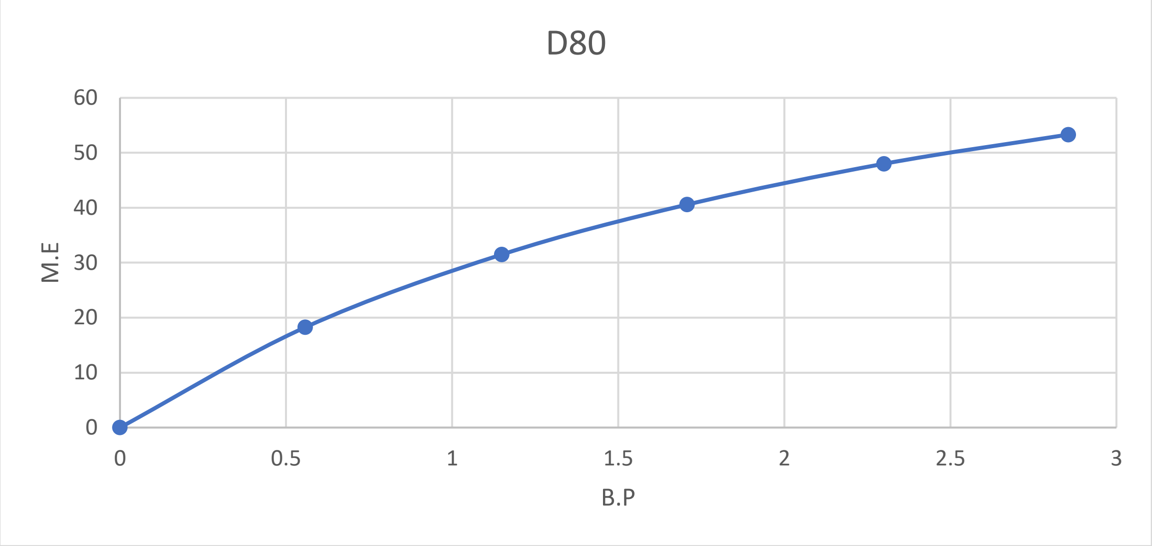


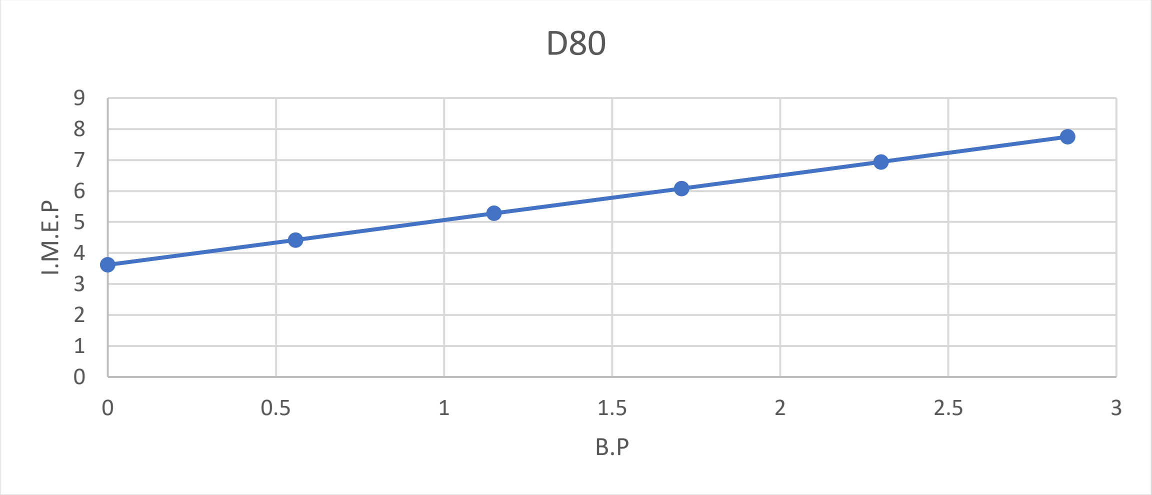

D80
60.5
60
59.5
59
58.5
58
57.5
57
56.5
I.T.E
0
0.5
1
1.5
2
2.5
3
B.P

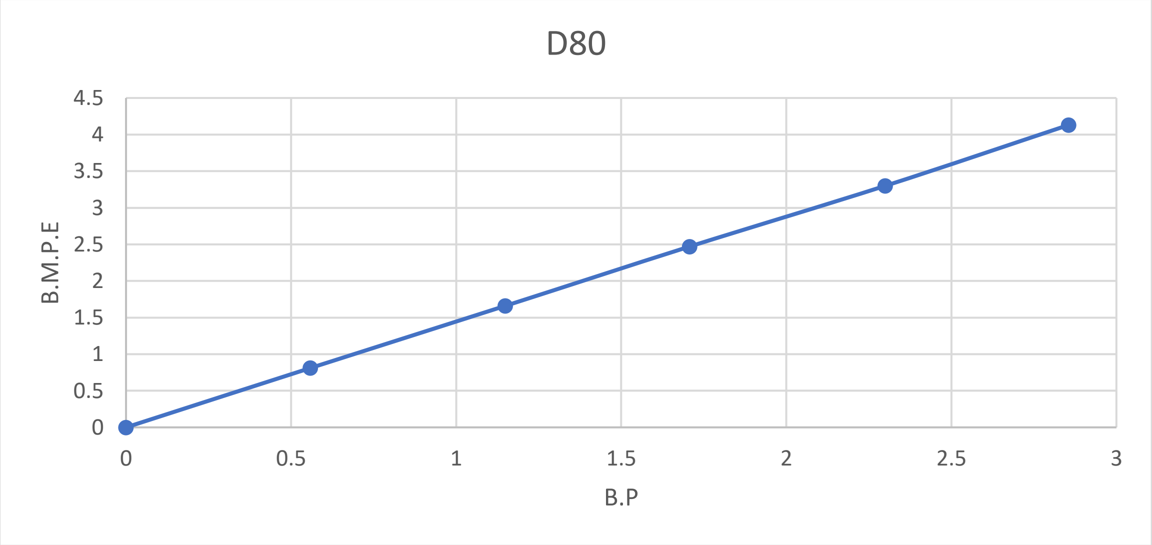

D80
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
S.F.C
0
0.5
1
1.5
2
2.5
3
B.P


D80
35
30
25
20
15
10
5
0
B.T.E
0
0.5
1
1.5
2
2.5
3
B.P

`


D80
M.E
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
B.P


D80
I.M.E.P
9
8
7
6
5
4
3
2
1
0
0
0.5
1
1.5
2
2.5
3
B.P


D80
B.M.P.E
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
B.P

`

Viscosity:

Temp=33℃ , Time(t_r)=42sec

A=0.00264, B=1.9

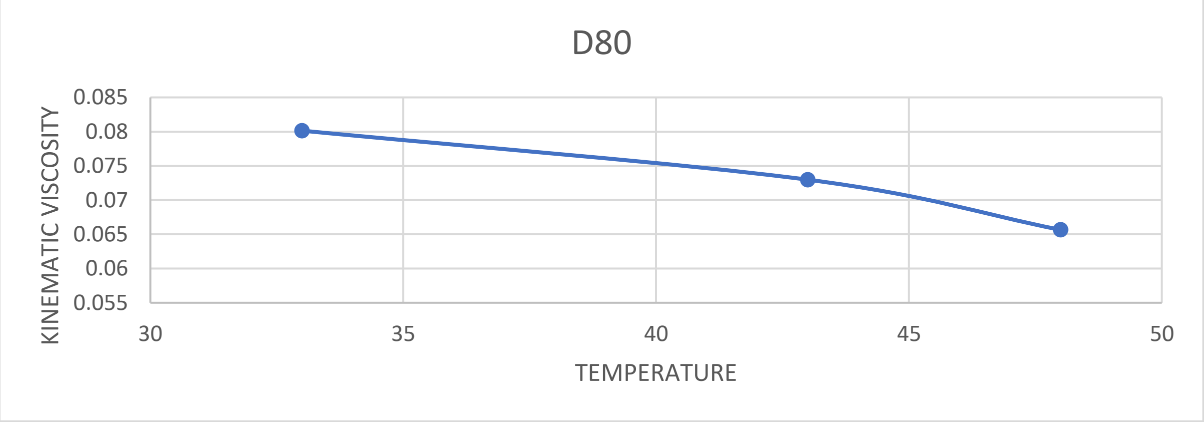
Kinematic(v)=At_r- B/t_r=0.11088-0.04523=0.06565 Centistokes.

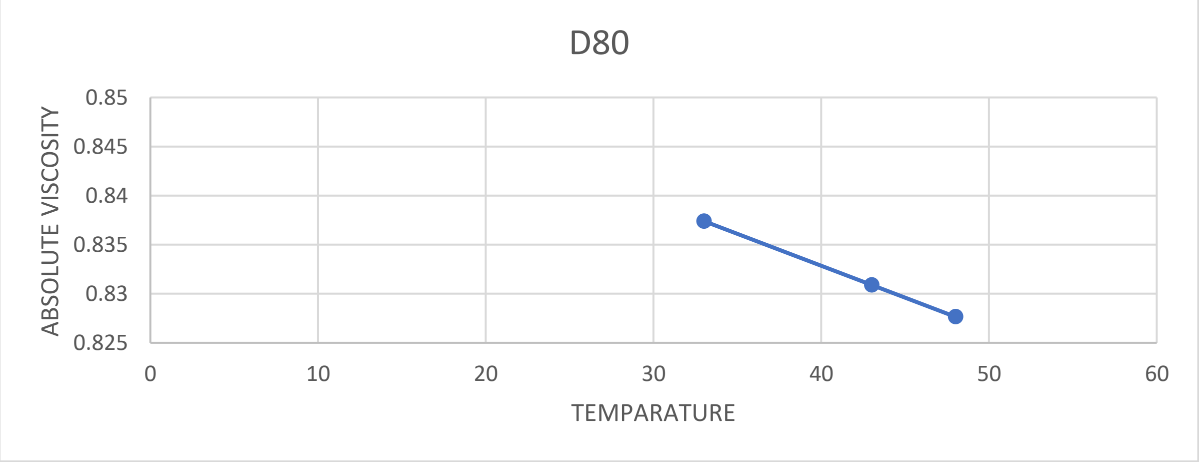
ln(v)=-2.723,

absolute viscosity(µ)=0.84-(0.0065) ×(temp-29)

=0.84-(0.0065) × (33-29)

=0.8374 Centipoise.





`

CHAPTER 7

PERFORMANCE CHARACTERISTICS

`

7.PERFORMANCE CHARACTERISTICS

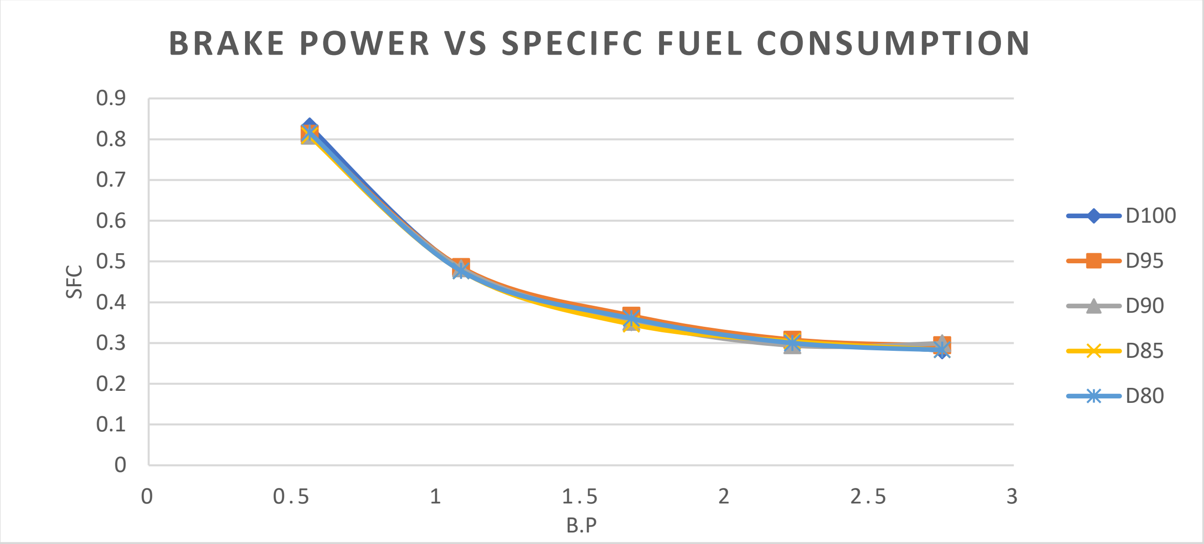


Fig 7.1 Variation of Brake Power Vs Specific Fuel Consumption

Specific fuel consumption is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft power. It is typically used for comparing the efficiency of IC engines with a shaft output. It is a rate of Fuel consumption with respect to power produced. The variations of Specific Fuel consumption with respect to Brake Power for different fuel blends are plotted. D80 blend offers the least Specific Fuel Consumption of all the mixtures while D95 has the maximum Specific Fuel Consumption.

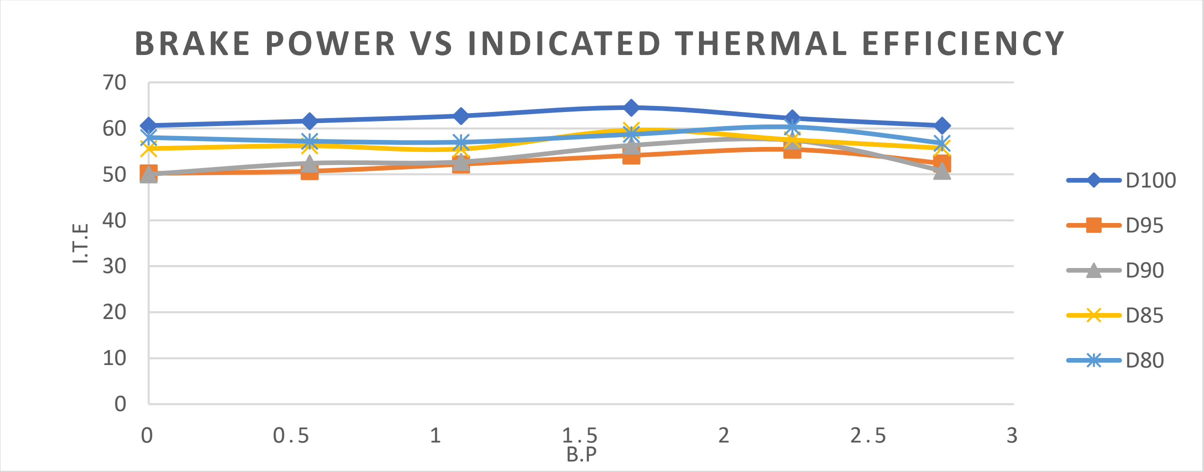


Fig 7.2 Variation of Brake Power Vs Indicated Thermal Efficiency

`

The values of Indicated Thermal Efficiency at different brake powers are plotted. D80 blend offers the maximum Indicated Thermal Efficiency of all the mixtures and it seems to be the best mixture, while D90 offers the minimum Indicated Thermal Efficiency.

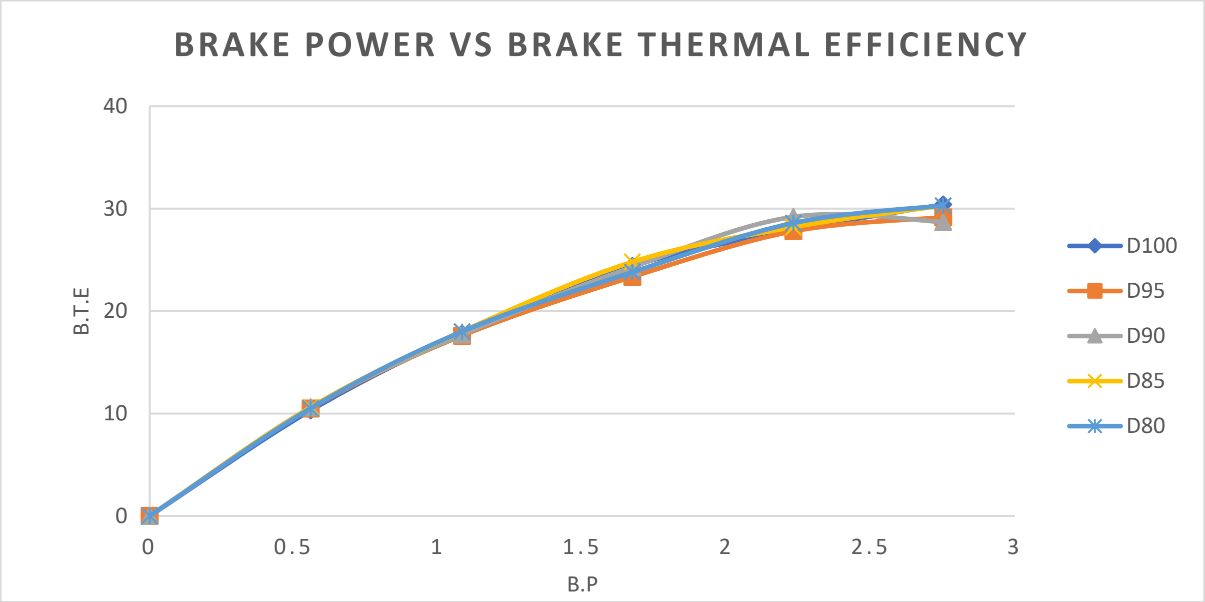


Fig 7.3 Variation of Brake Power Vs Brake Thermal Efficiency

Brake Thermal Efficiency is defined as Brake Power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how well an engine converts the heat from a fuel to mechanical energy. The values of Brake Thermal Efficiency at different brake powers are plotted. D90 offers least Brake Thermal Efficiency.

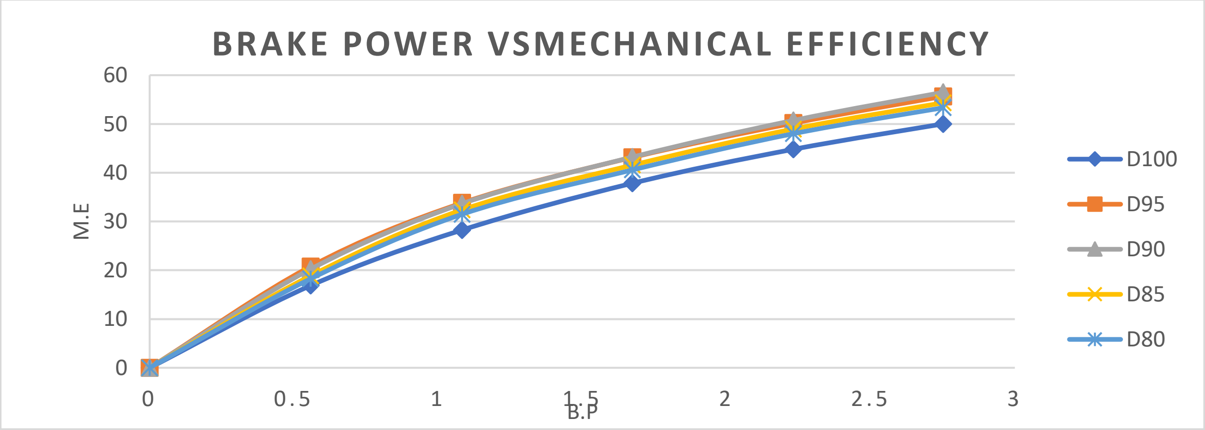


Fig 7.4 Variation of Brake Power Vs Mechanical Efficiency

`

Mechanical efficiency indicates how good an engine is inverting the indicated power to useful power. The values of Mechanical Efficiency at different Brake Powers are plotted as shown in D90 blend offers the best Mechanical Efficiency of all the mixtures and therefore seems to be the best mixture with regards to the minimum Frictional Power. Diesel gives the least Mechanical Efficiency.

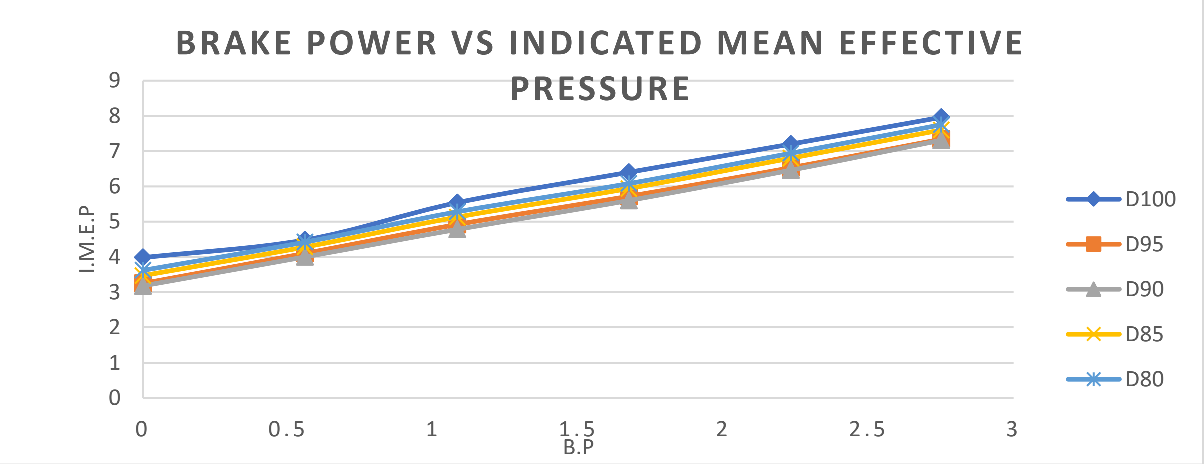


Fig 7.5 Variation of Brake Power Vs Indicated Mean Effective Pressure

Indicated Mean Effective Pressure is defined as the average pressure produced in the combustion chambers during the operation cycle. IMEP is equal to the brake mean effective pressure plus friction mean effective pressure. The variations of Indicated Mean Effective Pressure with respect to Brake Power for different fuel blends and Diesel are shown. D90 blend offers the minimum Indicated Mean Effective Pressure of all the mixtures and it seems to be the best mixture with regards to minimum Frictional Power while D80 offers the maximum Indicated Mean Effective Pressure.

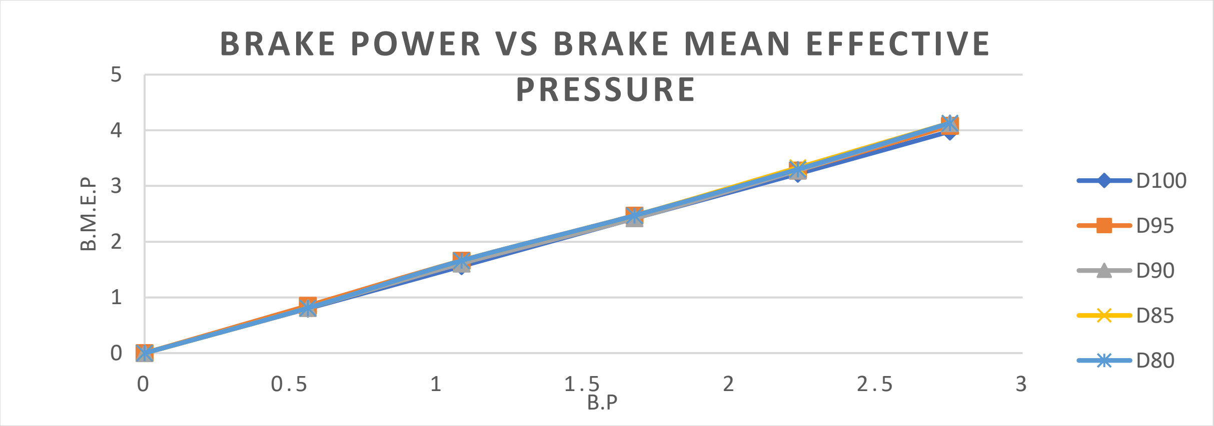


Fig 7.6 Variation of Brake Power Vs Brake Mean Effective Pressure

`

Brake mean effective pressure is a calculation of the engine cylinder pressure that would give the measured brake horsepower. Brake mean effective pressure is a indication of engine efficiency regardless of capacity or engine speed. The more efficient it is, the higher the average pressure or BMEP. D95 offers minimum Brake mean effective pressure whereas D80 offers maximum Brake effective pressure.

`

CHAPTER 8

RESULT AND DISCUSSIONS

`

8. RESULT AND DISCUSSIONS

A comparative analysis of diesel with different blends of diesel and trans-esterified mustard oil with reference to the performance of the engine and cost of the fuel was taken up for experimental study and analysis. It has been observed that a right blend of two oils only gives best performance but is not economically viable. The following observations were made from graphs plotted:

1. It is found that frictional power which is generally function of speed of engine is also found to be variable which changes with composition. From experimentation, it is inferred that D90 blend has minimum losses in terms of mechanical power and power consumed by auxiliaries, which put together generally known as Frictional Power. Therefore D90 blend offers the best mechanical efficiency.

2. The specific fuel consumption varies directly with respect to fuel consumption. It is observed that at no loads, specific fuel consumption is less for D80 blend and also at higher loads D85 is found to be the best.

3.Indicated thermal efficiency of diesel engine varies inversely with fuel consumption rate. The lesser the fuel consumption, higher is the indicated thermal efficiency and vice versa. It is observed that at higher loads D80 offers higher indicated thermal efficiency.

4. Flash point is high for D95 and it’s low for D80 and Fire point is high for D95 and it’s low for D80.

5.The viscosity is low for D95 and it is high for D80.

`

CHAPTER 9

CONCLUSION

`

9. CONCLUSION

The experimental study is conducted to evaluate and compare the blends of Mustard oil biodiesel to conventional diesel fuel in single cylinder naturally aspirated four stroke diesel engine.

The series of tests are conducted using each of fuels with the engine working at a constant speed of 1500 rpm and at different loads starting from no load. In each test fuel consumption, specific fuel consumption, thermal efficiency, mechanical efficiency and mean effective pressure are computed from measured flow rate and calorific value.

From the performance characteristics it is observed that when mechanical efficiency values are considered it is better to use D90 blend. But conventional diesel fuel still remains a economically viable option as price being lesser than the other blends. When specific fuel consumption is considered, it is found that D80 has low specific fuel consumption than other blends. When indicated thermal efficiency is considered D80 is more preferable than other blends.

`

10.REFERENCES

[1]Yedilfana Setarge Mekonnen Anbessie Degfie Tadios, TesfayeTadiosTesfaye, Optimized Biodiesel Production from Waste Cooking Oil (WCO) using Calcium Oxide (CaO) Nano-catalyst, Sci Rep, 2019.

[2]Murat Kadir Yesilyurt, Mevlüt Arslan & Tanzer Eryilmaz, Application of response surface methodology for the optimization of biodiesel production from yellow mustard (Sinapis alba L.) seed oil, 2018.

[3]Chatpalliwarl et al., Modelling of Biodiesel Plant Design: Data estimation and generation based on suppositions and interpolation, IJMIE ,Vol. 2 , Iss. 2 (2012).

[4]Deepak Agarwal and Avinash Kumar Agarwal, "Performance and emission characteristics of Jatropha oil (preheated and blends) in a direct injection compression ignition engine", Elsevier, Applied Thermal Engineering 27, 2007, pp.2314-2323.

[5]Abuhabaya, A., J. Fieldhouse, and D. Brown,The optimization of biodiesel production by using response surface methodology and its effect on compression ignition engine. Fuel Processing Technology 113:57–62,2013.

[6]Ahmad, M., M. Zafar, S. Sultana, A. Azam, and M. A. Khan. 2 The optimization of biodiesel production from a novel source of wild non-edible oil yielding plant. Silybum Marianum. International Journal of Green Energy 11:589–94, 2014.

[7]Rashid, U., F. Anwar, M. Ashraf, M. Saleem, and S. Yusup. Application of response surface methodology for optimizing transesterification of Moringa oleifera oil: Biodiesel production. Energy Conversion and Management 52 (8):3034–42, 2011.

[8]Meher, L. C., D. V. Sagar, and S. N. Naik. Technical aspects of biodiesel production by transesterification-A review. Renewable and Sustainable Energy Reviews 10:248–68, 2006.

`

[9]Moser, B. R., R. Q. Evangelista, and G. Jham. Fuel properties of Brassica juncea oil methyl esters blended with ultra-low sulphur diesel fuel. Renewable Energy 78:82–88, 2015.

[10]Lin, B. F., J. H. Huang, and D. Y. Huang. Experimental study of the effects of vegetable oil methyl ester on DI diesel engine performance characteristics and pollutant emissions. Fuel 88:1779–85, 2009.

[11]A. Srivasata and R. Prasad, “Triglyceride based diesel Fuels,” Renewable and sustainable Energy Reviews, Vol. 4, No. 2, pp. 111-133, 2000.

[12]M. Stumborg, A. Wong and E. Hogan, “Hydro processed Vegetable Oils for Diesel Fuel Improvement,” Biore-source Technology, Vol. 56, pp. 13-18, 1996.

[13]Ong, H. C., H. H. Masjuki, T. M. I. Mahlia, A. S. Silitonga, W. T. Chong, and K. Y. Leong. Optimization of biodiesel production and engine performance from high free fatty acid Calophyllum inophyllum oil in CI diesel engine. Energy Conversion and Management 81:30–40, 2014.

[14]Helwani, Z., M. R. Othman, N. Aziz, W. J. N. Fernando, and J. Kim. Technologies for production of biodiesel focusing on green catalytic techniques: A review. Fuel Processing Technology 90:1502– 14, 2009.