A STUDY ON PERFORMANCE CHARACTERSTICS OF DIESEL ENGINE USING PALM OIL BIODIESEL AND ITS BLENDS

A Project report submitted in partial fulfilment of the requirements for the Award of the Degree of

BACHELOR OF ENGINEERING

in

MECHANICAL ENGINEERING

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CERTIFICATE

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ACKNOWLEDGEMENT

We express immensely our deep sense of gratitude to **Mrs. P. Bala Divya, Mtech (PhD),** 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 also very thankful to **Prof. T.V. Hanumantha Rao,** Principal and **Prof. B. Naga Raju**, Head of the Department, Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We express our sincere thanks to **Dr. Vinod Babu Marri**, Senior Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences for his valuable support throughout the project.

We express our sincere thanks to the non-teaching staff of Mechanical Engineering Department 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.

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ABSTRACT

Increase in energy demand, stringent emission norms and depletion of oil resources led to the discovery of alternative fuels for internal combustion engines. Many alternative fuels like alcohols; bio-diesel, Liquid Petroleum Gas (LPG), Compressed Natural Gas (CNG), etc. have been already commercialized in the transport sector. In the present work, Palm oil is blended with diesel and used as an alternate fuel for CI engines. The Palm oil can be converted into bio diesel using a chemical process called trans-esterification.

Different proportions of fuel blends have been produced by the process of blending. The fuel properties of each blend are determined. The load test analysis of 4- Stroke Diesel engine using the blends of Palm oil with diesel is done. The performance parameters such as Power, Specific Fuel Consumption, Thermal Efficiencies, Mechanical Efficiency and Mean Effective Pressures are calculated based on the experimental observations of the engine and compared for different blends. The sustainability of using alternate fuels in Diesel engines, especially the potential use of Palm oil as biodiesel have been brought to the fore through this work.

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CHAPTER-1

1.INTRODUCTION

In this chapter, focus will be given toward biodiesel production from palm oil. Lately, oil palm plantation has been criticized to cause several serious environmental issues such as deforestation and habitat destruction of endangered species (specifically *orangutan*). Fortunately, with various researches and scientific findings, these accusations were found to be baseless Up to date, oil palm still remains as the most efficient edible oil-producing crop as shown in Table 1 (Malaysian Palm Oil Council (MPOC)). Oil palm plantation area only accounted for less than 5% of the world's agriculture land in year 2007, but yet it is able to supply 25% of the global oils and fats. Hence, if the intention is to optimize land usage to meet the food and fuel demand simultaneously, oil palm will be the outstanding option as large quantity of oil can be produced with minimum land requirement. In addition to that, new breeds of oil palm cloned by Applied Agricultural Resources Sdn. Bhd. are able to produce 10.6 tonne/ha/year of crude palm oil (CPO), almost double of the current yield.

Table-1:

Oil Crop	Average Oil Yield (Tonne/Year)	Planted Area (Million Hectare)	% of Total Area	Plantec
Soybean	0.4	94.15	42.52	
Sunflower	0.46	23.91	10.8	
Rapeseed	0.68	27.22	12.29	
Oil palm	3.62	10.55	4.76	

Apart from that, palm oil production has the highest energy efficiency factor (energy output to energy input) of 9.6 compared to rapeseed of 3.0 and soybean of 2.5. This is because less fertilizer and diesel (machinery and agrochemical usage) are required to produce 1 tonne of palm oil. Apart from the positive contributions toward the environment, sustainable oil palm plantation program can also leverage poverty by helping the poor farmers and rural dwellers to improve their living standards. The successful story of Malaysian palm oil industries in transforming the rural communities to have access to their basic needs for a healthy life reflects the significant outputs of the strategy. In fact, even the Food and Agriculture Organization(FAO) does agree that new demand for biofuels production from sustainable agricultural feedstock can indeed generate a new income opportunity for farmers, leading to increased food production and poverty eradication.

1.1 Fossil Fuels:

The term fossil is used to describe the broad set of fuels "formed in the Earth from plant or in the earth from plant or animal remains" that have been transformed into raw energy sources over the course of many years as a result of geological processes. In effect, fossil fuels are the repositories of millions of years of energy that has been accumulated and shaped into a concentrated form.

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, known as non-conventional or advance fuels, are any materials or substances that can be used as fuels, other than conventional fuels. Some well-known alternative fuels include biodiesel, bio alcohol (methanol, ethanol, and butanol), chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane, oil from waste tyres and plastic, and other biomass sources. These alternative fuels are economical when compared to diesel. So, these are most suitable for automobiles and they can meet the growing demand for fuels in the future.

1.3 Need for Shifting Towards Alternative Fuels:

Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved, increase in the number of automobiles alone dictates that there will be a great demand for fuel in the near future.

Alternative fuel technology, availability, and use must and will become more common in the coming decades. Another reason motivating the development of alternative fuels for the IC-engine is concerned over the emission problems of gasoline engines. Combined with air polluting systems, the large number of automobiles is a major contributor to the air quality problem of the world. 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 the larger oil fields.

1.4 Biodiesel:

Biodiesel is a clean burning alternative fuel produced from domestic, renewable resources. The fuel is a mixture of fatty acid alkyl esters made from vegetable oils, animal fats or recycled greases. Where available, biodiesel can be used in compression-ignition (diesel) engines in its pure form with little or no modifications.

Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulphur and aromatics. It is usually used as a petroleum diesel additive to reduce levels of particulates, carbon monoxide, hydrocarbons and toxics from diesel-powered vehicles. When used as an additive, the resulting diesel fuel may be called B5, B10 or B20, representing the percentage of the biodiesel that is blended with petroleum diesel.

Biodiesel is produced through a process in which organically derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form ethyl or methyl ester. The biomass-derived ethyl or methyl esters can be blended with conventional diesel fuel or used as a neat fuel (100% biodiesel). Biodiesel can be made from any vegetable oil, animal fats, waste vegetable oils, or microalgae oils. There are three basic routes to biodiesel production from oils and fats.

- Base catalyzed trans-esterification of the oil.
- Direct acid catalyzed trans-esterification of the oil.
- Conversion of the oil to its fatty acids and then to biodiesel.

There are a variety of oils that are used to produce biodiesel, the most common ones being soybean, rapeseed, and palm oil which make up the majority of worldwide biodiesel production. Other feedstock can come from waste vegetable oil, Jatropha, Canola oil, mustard, flax, sunflower, palm oil, neem oil or hemp. Animal fats including tallow, lard, yellow grease, chicken fat and fish oil by-products may contribute a small percentage to biodiesel production in the future, but it is limited in supply and inefficient to raise animals for their fat. Canola oil is a vegetable oil derived from a variety of rapeseed that is low in erucic acid, as opposed to colza oil. There are both edible and industrial forms produced from the seed of any of several cultivators of the plant family Brassicaceae.

Biodiesel can be blended in any proportion with mineral diesel to create a biodiesel blend or can be used in its pure form. Just like petroleum diesel, biodiesel operates in the compression ignition (diesel) engine, and essentially requires very little or no engine modifications because the biodiesel has properties similar to mineral diesel. It can be stored just like mineral diesel and hence does not require separate infrastructure. The use of biodiesel in conventional diesel engines results in substantial reduction in the emission of unburned hydrocarbons, carbon monoxide, and particulates. There are currently a large number of existing biodiesel production plants globally, and a large number under construction or planned to supply the growing global demand.

1.5 Advantages of Biodiesel:

- Biodiesel fuel is a renewable energy source unlike petroleum-based diesel.

- One of the main biodiesel fuel advantages is that it is less polluting than petroleum diesel.

- The lack of sulphur in 100% biodiesel extends the life of catalytic converters.

- Another of the advantages of biodiesel fuel is that it can also be blended with other energy resources and oil.

- Biodiesel fuel can also be used in existing oil heating systems and diesel engines without making any alterations.

- It can also be distributed through existing diesel fuel pumps, which is another advantage over other alternative fuels.

- The lubricating property of the biodiesel may lengthen the lifetime of engines.

CHAPTER-2

2.LITERATURE REVIEW

- **Kátia c. p. gabriel** [1] investigated that Biodiesel can be used as a substitute for fossil diesel. This work presents the study on the feasibility of using palm oil produced in Angola, with an acid index between 10 - 21mg KOH / g, for biodiesel production in batch reactors and in a reactive distillation column. The results show that using a molar ratio methanol / oil of 6:1, 0.8 % H_2SO_4 and KOH, 63 ± 2 °C and 1 hour of reaction led to the production of a biodiesel that comply with the international standards in terms of the density, viscosity, acid number and FAME content (98%).It was possible to obtain a 96% reduction of the initial fatty acids content of palm oil but the yield of the transesterification reaction was negligible. Therefore, it is necessary to adjust and optimize the operating conditions, such as the reagents and catalysts flow rates and the residence time.
- **Syarifah Yunus** [2] investigated that Engine performances (specific fuel consumption brake thermal efficiency) and emissions (exhaust gas temperature and Nox emission) were analyzed and have been discussed in this study. All tests were carried out at varied load conditions which were 0.13, 0.15, 0.17, 0.19 and 0.21 kW. The results revealed that B10JPB blended showed better engine performances compared to its other blends and comparable performances compared to PDF. Comparable Nox emitted of all Jatropha-Palm fuel blended biodiesel fuel sample has been demonstrated.
- **Eman N. Alia,**[3] presented that the optimum reaction time was 60 minutes, reaction temperature was 60 °C and the methoxide: oil ratio was 6:1, were the optimum yield of 88% was achieved. Testing and analysis was carried out to determine the physical properties of the product. The density of POME is 876.0 kg/m3, kinematic viscosity of 4.76 mm2/s, cetane number of 62.8, flash point of 170 °C, cloud point of 13 °C, pour point of 17 °C, and saponification value of 206.95 mg/L. The produced biodiesel has similar properties of ASTM D 6751, and EN 14214.
- **A.K. El Morsi b** [4] investigated that Palm oil/palm oil methyl esters are blends with diesel fuel, the blends were characterized as an alternative fuels for diesel engines. Density, kinematic viscosity, and flash point were

estimated according to ASTM as key fuel properties. Palm oil and palm oil biodiesel were blended with diesel. The properties of both blends were estimated. The results showed that the fuel properties of the blends were very close to that of diesel till 30% unless other characteristics are within the limits. The experimental data were correlated as a function of the volume fraction of oil/biodiesel in the blend. Different correlations were developed to predict the properties of the oil/bio-oil-diesel blends based on our experimental results. The developed correlations were validated by comparing the correlation prediction with experimental data in literature. A good agreement was found between modeled equations prediction and experimental data in literature. The developed equations can be used as a guide for determining the best blending mix- ture to be used for diesel engines.

- **Juan Gamarra-Torres** [5] reported that in order to improve the biodiesel from palm oil production process, the stages of acid esterification, basic trans-esterification, biodiesel washing and purification were simulated in the software Aspen ONETM 8.4. The full compositional profile of palm oil (Eleais Guineensis) was included, considering both homogeneous and heterogeneous triglycerides. With the help of software, thermodynamic properties such as enthalpy, entropy, and Gibbs free energy were determined for all streams. Then, chemical, physical and thermal exergies for the streams of the process were calculated – i.e., the exergy destroyed in the process. The overall exergy efficiency was 41 %. The analysis also allowed the identification of the high consumption of utilities and the exergy losses. These can be reduced using process integration, yielding an increase in the global efficiency of the palm oil biodiesel production process.

- **Tadesse Anbessie Degfe** [6] Biodiesel production from waste cooking oil (WCO) provides an alternative energy means of producing liquid fuels from biomass for various uses. Biodiesel production by recycling WCO and methanol in the presence of calcium oxide (CaO) nano-catalyst offers several benefits such as economic, environmental and waste management. A nano-catalyst of CaO was synthesized by thermal-decomposition method and calcinated at 500°C followed by characterization using x-ray diffraction (XRD) and scanning electron microscope

(SEM) techniques. The XRD results revealed nano-scale crystal sizes at high purity, with a mean particle size of ~29nm. The SEM images exhibited morphology of irregular shapes and porous structure of the synthesized nano catalysts. The highest conversion of WCO to biodiesel was estimated to be 96%, at optimized experimental conditions i.e., 50°C, 1:8 WCO oil to methanol ratio, 1% by weight of catalyst loading rate and 90minutes reaction time, which is among few highest conversions reported so far. Biodiesel properties were tested according to the American (ASTM D6571) fuel standards. All reactions are carried-out under atmospheric pressure and 1500rpm of agitation.

- **Sam Ki Yoon 2** [7] Due to the rapid development of the global economy, fossil oil is widely used, leading to its depletion and gradual deterioration of the global environment, including global warming, the greenhouse effect, fog, and haze. Therefore, many researchers have been interested in studying alternative fuels in an attempt to develop an eco-friendly fuel to replace traditional fuel and solve the above environmental problems. Biodiesel is a renewable and eco-friendly fuel that is the most promising alternative fuel for diesel engines, and a significant amount of research and development has focused on biodiesel. Canola oil biodiesel (COB) is one type of biodiesel, and it has an advantage in oil production per unit area compared with other biodiesels. This paper summarizes and reviews studies related to the use of COB in different diesel engines under a variety of operating conditions. We focus on evaluating the combustion and emission characteristics of COB based on a large number of papers (including our previous studies). In addition, this paper serves as a valuable reference for in-depth studies of COB use in diesel engines, as it covers the topic from the production of COB to its use in diesel engines.
- **Joshua Folaranmi** [8] This research work is about the production of biodiesel from jatropha oil. Other oils can also be used for the production, but jatropha was chosen because it is not edible therefore, it will not pose a problem to humans in terms of food competition. Before the transesterification process was carried out, some basic tests such as free fatty acid content, iodine value, and moisture content were carried out. This was done so as to ascertain quality yield of the biodiesel after the reaction. The production of the biodiesel was done with standard materials and under standard conditions which made the production a hitch-free one. The jatropha oil

was heated to 60°C, and a solution of sodium methoxide (at 60°C) was added to the oil and stirred for 45 minutes using a magnetic stirrer. The mixture was then left to settle for 24 hours. Glycerin, which is the byproduct, was filtered off. The biodiesel was then thoroughly washed to ensure that it was free from excess methanol and soap. The characterization was done at NNPC Kaduna refinery and petrochemicals. The result shows that the product meets the set standard for biodiesel.

- **Md. Zahangir Alam**[9] Biodiesel is a non-toxic, renewable and environmental friendly fuel. This study involved the production of biodiesel from sludge palm oil (SPO), a low-cost waste oil via enzymatic catalysis. The enzyme catalyst was a *Candida cylindracea* lipase, locally-produced using palm oil mill effluent as the low cost based medium. The results in solvent system for biodiesel production showed that ethanol gave higher yield of biodiesel as compared to methanol. One-factor-at-a time (OFAT) method was applied to investigate several factors for enzymatic biodiesel production. The optimum levels of ethanol-to-SPO molar ratio, enzyme loading, reaction temperature, mixing speed and reaction time were 4:1, 10 U, 40°C, 250 rpm and 24 h, respectively with maximum yield of biodiesel of 62.3% (w/w SPO). The SPO had a promising potential for enzymatic biodiesel production using locally-produced lipase.

- **Ching-Yuan Chang**[10]The effects of ultrasonic irradiation time (t_{US}) on the transesterification yield (Y_F) of biodiesel from Tung (*Vernicia fordii*) and blended oils with CH_3OH and KOH, and on some properties of biodiesel such as acid value (AV), iodine value (IV), kinematic viscosity (KV), density and cold filter plugging point (CFPP) were investigated. The blended oil is consisted of 20, 50 and 30% of Tung, canola and palm oils, respectively. The molar ratio of methanol to oil is 6:1 and the catalyst concentration is 1 wt.%. Temperature and ultrasonic frequency were kept at 20–30 °C and 25 kHz, respectively. The t_{US} was set in the range of 1–30 min. The results showed that Y_F reaches high value of 87–91% for Tung oil as $t_{US} \geq 5$ min, while of about 92–94% for blended oil as $t_{US} \geq 1$ min. At $t_{US} = 10$ min, the properties of biodiesel produced from Tung oil are with AV of 0.11 mg KOH/g, IV of 159.36 mg I_2/100 g, KV of 9.17 mm^2/s, density of 905 kg/m^3 and CFPP of −16 °C, while those from blended oil are with AV of 0.11 mg KOH/g, IV of 120.35 mg I_2/100 g, KV of 5.54 mm^2/s, density of

887 kg/m^3 and CFPP of −5 °C. Comparing these values with the ASTM-D6751 standards with AV < 0.5 mg KOH/g, KV = 1.9–6 mm^2/s and density = 860–900 kg/m^3 pointed out that the Tung oil should be blended with other oils in order to produce biodiesel satisfying the biodiesel standards. Moreover, the results indicated that a certain enough time, say 5 min, is needed to provide sufficient cavity heating and mixing via ultrasonic wave ensuring good properties of biodiesel produced. The KV of biodiesel using blended oil decreases from 6.26 mm^2/s at t_{US} = 1 min to 5.54 mm^2/s at t_{US} = 5 min, thus meeting the ASTM-D6751 value of 1.9–6.0 mm^2/s. The information obtained in this study is useful for the proper use of Tung oil in conjunction with other edible oils for the production of biodiesel with satisfactory qualities and the rational design and operation of ultrasonically catalytic transesterification process.

CHAPTER 3

3. SYNTHESIS OF PALM OIL & BIODIESEL

Biodiesel is produced through a process known as Trans-Esterification of triglycerides to methyl esters with methanol, a balanced and catalyzed reaction. An excess of Methanol is required to obtain a high degree of conversion. Palm and neem oils are among the main vegetable oil candidates for biodiesel uses.

The conventional catalysts in natural oil transesterification processes are selected among basis such as alkaline or alkaline earth hydroxides or alkoxides. However, transesterification could also be performed using acid catalysts, such as hydrochloric, sulfuric and sulfonic acid, or using metallic base catalysts such as titanium alcoholates or oxides of tin, magnesium or zinc. All these catalysts act as homogeneous catalysts and need to be removed from the products after methanolysis step.

Edible vegetable oils such as canola, soyabean, and corn have been used for biodiesel production and are proven diesel substitutes. Reducing the cost of the feedstock is necessary for biodiesel's long- term commercial viability. One way to reduce the cost of this fuel is to use less expensive feedstocks including waste cooking oils and vegetable oils that are non-edible and/or require low harvesting costs. Palm Oil, which are much less expensive than edible vegetable oil, is a promising alternative to edible vegetable oil. This environmentally threatening problem could be turned into both economic and environmental benefit by proper utilization and management of Palm oil as a fuel substitute. Palm oil, as an alternative feedstock for biodiesel, was studied with different aspects such as optimization using supercritical methanol (SCM) transesterification, process design and technological assessment, fuel property analysis and cost estimation approaches. Since biodiesel is made up of esters derived from oils and fats from renewable biological sources, it has been reported to emit far less regulated pollutants than petroleum diesel fuel.

3.1 Palm Oil as A Biodiesel:

Palm biodiesel is an alternative fuel derived from palm oil and can be used in compression ignition engines, ie. diesel engines without any modifications. It refers to methyl esters derived from palm oil through a process known as 'transesterification'.

Generally, it is not economically viable to use palm biodiesel in Malaysia as our petroleum diesel is relatively cheap. This is mainly due to the subsidy for petroleum diesel for transport given by our Malaysia Government.

It is very feasible for overseas markets where the petroleum diesel is very expensive and price for biodiesel is high. This makes palm biodiesel very competitive as palm oil is cheaper than other vegetable oils.

Palm biodiesel is renewable, biodegradable, non-toxic and safe to handle (flash point is higher than petroleum diesel) and essentially free of sulphur. It also provides a safety net to stabilize the price of palm oil by removing surplus stock.

Generally, the demand for this commodity is increasing rapidly because of the increasing demand of edible oil in consumer countries, especially China, EU, Pakistan, India and the US. The use of palm biodiesel also contributes to this increased demand and thus to some extent helps to enhance palm oil prices.

There are many environmental benefits of using palm biodiesel as compared to petroleum-based diesel. Various studies indicate that sulphur dioxide, hydrocarbons, carbon monoxide and carbon dioxide emissions, and particulate matters are reduced with the use of biodiesel. Biodiesel has a higher cetane number that improves engine performance and results in cleaner emissions compared to petroleum diesel.

The quality of the palm biodiesel produced using MPOB biodiesel production technology meets the stringent specifications of international biodiesel specifications of ASTM D6751 and EN 14214.

3.2 Experimental work on palm oil as biodiesel:

Transesterification is a process that converts triglycerides, like palm oil, into fatty acid methyl esters, commonly known as biodiesel. This conversion reaction requires the triglyceride feedstock, an alcohol, and an alkali-catalyst to produce the biodiesel. Biodiesel is a versatile biofuel that is renewable, biodegradable, and environmentally beneficial in the sense that combustion adds only biogenic carbon to the atmosphere. The main limitation of commercialization of biodiesel is cost. However, developing closed-loop systems that have an available triglyceride supply, such as palm oil, as well as demand for diesel based fuels, can achieve substantial emissions reductions and energy avoidance, while simultaneously solving a waste disposal issue. Thus, an analysis of the development of a closed-loop palm oil to biodiesel fuel production process is warranted.

A waste-to-energy system like this offers great potential to institutions. Thus, this analysis includes the development of a palm oil to biodiesel fuel program utilizing the available palm oil of a university,the production of the fuel, the internal use of the fuel, and subsequent analysis of the fuel characteristics, emissions, and the life cycle environmental and energy impacts of the production process and ultimate use.

3.3 Methodology of Trans-Esterification Process of Palm Oil:

Palm oil was collected from a local arena in Vizag. Potassium hydroxide flakes, methanol (AR Grade), and diethyl ether were procured from the Chemistry Department. The mixture was stirred at the speed of 300 rpm. All experiments of transesterification reaction were performed in a 1000 mL round-bottom flask. A magnetic pallet arrangement was used for heating the mixture in the flask and fitted with a temperature reader as shown in fig 1.

3.4 Transesterification Reaction:

The transesterification process was widely used in bio-diesel production from different biomass materials. The process consists of two steps namely, acid esterification and alkali transesterification.

Step 1: Acid esterification: Acid esterification reduces the FFA value of un-refined oil using an acid catalyst.

Step 2: Alkali trans- esterification: After removing the impurities of the pro- duct from the Step 1, it is trans-esterified to monoesters of fatty acids using an alkali catalyst.

The mechanism of synthesis of biodiesel via two-step transesterification process is represented as

Fig: 3.1 Trans -Esterification process

Step- 1:

$$RCOOH + CH_3OH \xrightarrow{H2SO4} RCOOH_3 + H_2O$$

Step- 2:

$$\begin{array}{l} CH_2OOCR \\ | \\ CHOOCR \\ | \\ CH_2OOCR \end{array} + 3CH_3OH \xrightarrow{KOH} 3CH_3COOR + \begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

3.5 Draining of Glycerol:

After the transesterification reaction, we must wait for the glycerol to settle to the bottom of the container when kept in a separating funnel. This happens because Glycerol is heavier then biodiesel. The settling will begin immediately, but the mixture should be left a minimum of eight hours to make sure all of the Glycerol has settled out. The Glycerol volume should be approximately 20% of the original oil volume. The objective is to remove only the Glycerol and stop when the biodiesel is reached. Glycerol looks very dark compared to the yellow biodiesel as shown in Fig 2. The viscosity difference is large enough between the two liquids that the difference in flow from the drain can be seen.

Fig: 3.2 Separation of Glycerol and Esters

The Methyl esters thus obtained from the trans-esterification of Palm oil is to be water washed with the warm distilled water in 1:1 proportions of oil and warm distilled water.

After completion of water washing, the obtained oil should be heated upto 110°C and wait around 20 minutes to evaporate the remaining water in the oil.

Finally, we get the pure biodiesel.

Fig:3.3 Water Washing

Fig:3.4 Biodiesel

CHAPTER-4

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4 EXPERIMENTAL SET UP

4.1 Basic Theory

Engine: Engine is device or machine used to convert one form of energy to mechanical energy.

Heat Engine: It converts chemical energy of the fuel into heat energy which is used to do work. They are classified into two categories:

1. Internal Combustion engine (ICE): ICE is a heat engine where the combustion of a fuel occurs with an oxidizer (usually air) in a combustion chamber.

2. External Combustion engine (ECE): ECE is heat engine where a working fluid contains internally, is heated by combustion in an external source, through the engine wall or a heat exchanger.

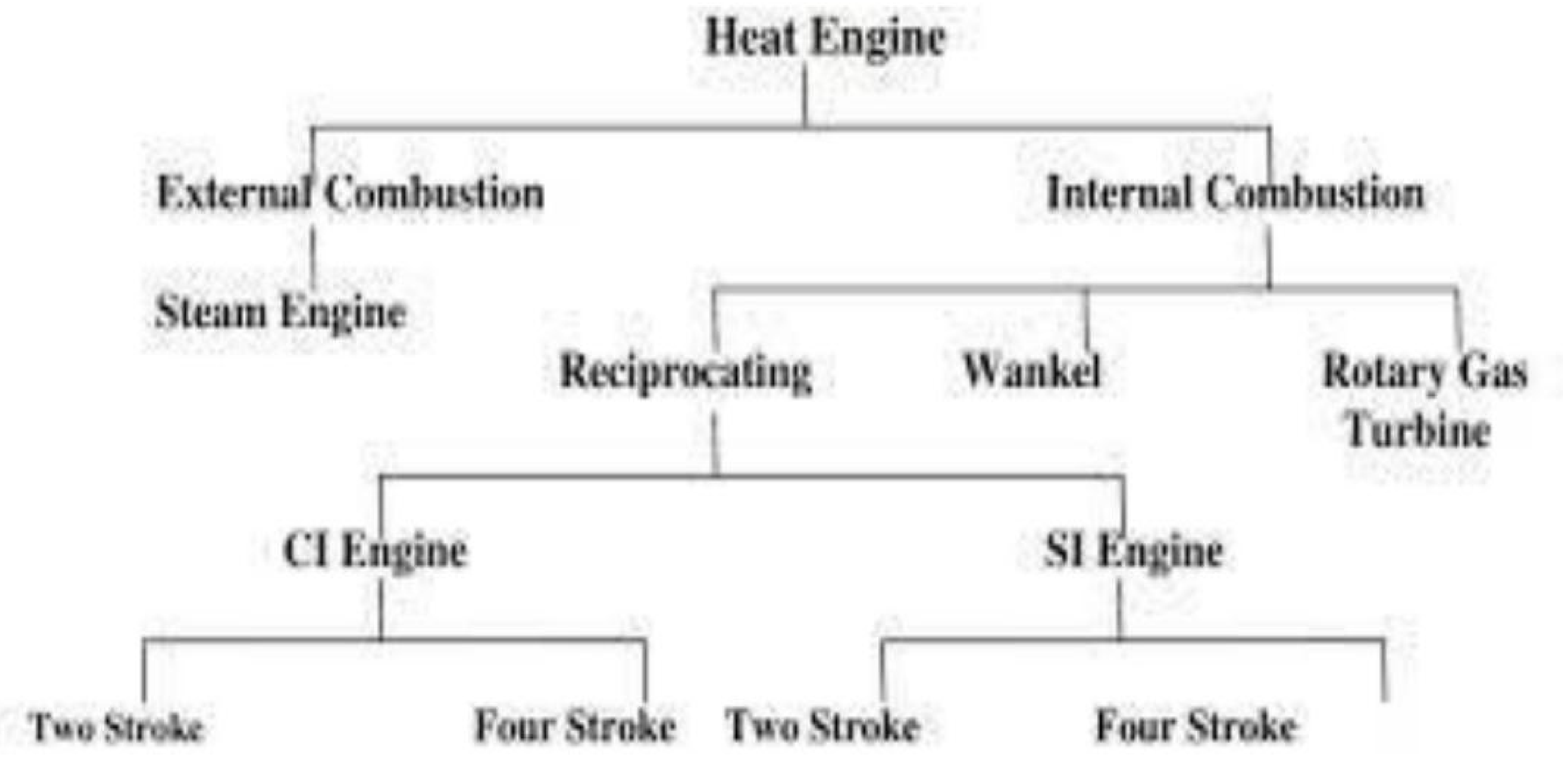

Fig:4.1 Classification of Heat Engine

4.2 IC Engines Classifications:

There are several possible ways of to classify IC engines.

Reciprocating

- By number of strokes
  1. Two stroke engines

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2. Four stroke engines
3. Six stroke engines

- By type of ignition
  1. Compression-Ignition Engine
  2. Spark-Ignition Engine

Rotary

- Gas Turbines
  1. Turbojet
  2. Turbofan
  3. Turboprop
- Ramjet
- Rocket Engine

Reasons for selection of Four Stroke Diesel Engine over Petrol Engine:

1. Diesel cars are more efficient: Due to how a diesel engine works, it makes this fuel more efficient than petrol. Because of burning fuel at high compression ratio instead of using spark plugs, this gives diesel engines an edge over the petrol-powered engine in terms of efficiency. They are also unthrottled which gives them even better efficiency.
2. Diesel engines have a longer service interval**:** There are multiple reasons for this. Diesel engines work at lower RPMs compared to a petrol engine which causes less wear and tear. The parts of the diesel engine are thicker due to the pressure they have to withstand. This makes them more study thus less likely to fail. Diesel being a light oil also lubricates the combustion chamber every time it's being used. This also makes it last longer as less friction equals less wear which in turn means less service required.

3. Diesel engines are torquey: These engines are built for more torque while being more efficient than a petrol engine. The reason is the compression ratio. As diesel engines are self-igniting, they need to generate enough pressure in the combustion chamber which would make the diesel ignite. This increase in compression ratio means more torque is produced when combustion occurs. The diesel engine also has faster combustion which means more torque as well.

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4. Diesel is more reliable in the long run: From fewer visits to the service station to stronger engine parts that don't fail as often, diesel engines are more reliable than petrol in the long run. They are costlier to repair than petrol but they fail less often as compared to petrol thus making the odds in favour of diesel.

5. Fuel Cost is Significantly Lower: Overall cost for kilowatt for diesel fuel runs between 30 to 50% lower than gasoline powered engines. Moreover, diesel require work to refine than gasoline.

6. Diesel is Much Safer Higher flash and fire point makes diesel much safer than gasoline and vaporization loss are less compared to petrol engines

4.3 Diesel Engine

Diesel engine (also known as compression ignition engine) named after **Rudolf Diesel**, is an internal combustion engine in which fuel ignition is caused by elevated temperature of air due to adiabatic compression in the cylinder. In this fuel injectors are used inject the fuel into the cylinder in the form of small droplets which atomizes the fuel with compressed air.

A diesel engine, also known as a compression-ignition engine, is an internal combustion engine that uses the heat of compression to initiate ignition of 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 a German inventor Rudolf Diesel in 1893 [11].

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. 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%.

The diesel internal combustion engine differs from the gasoline powered Otto cycle by using highly compressed hot air to ignite the fuel rather than using a spark plug (compression ignition rather than spark ignition)

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4.4 Diesel Cycle:

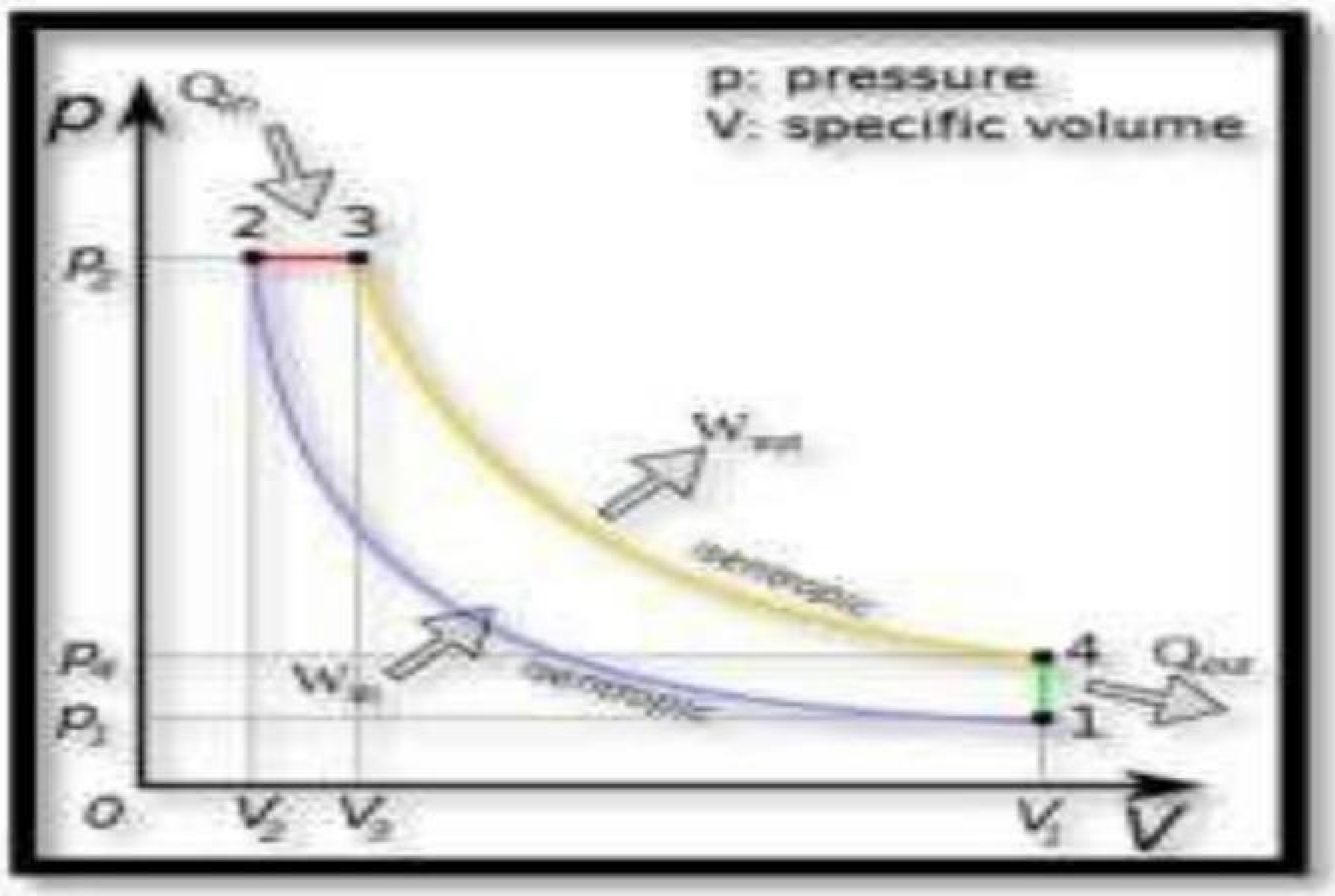

Fig 4.2: Diesel cycle

The p–V diagram shown in Fig 4.1 is a simplified and idealized representation of the events involved in a Diesel engine cycle, arranged to illustrate the similarity with a Carnot cycle. Starting at 1, the piston is at bottom dead center and both valves are closed at the start of the compression stroke; the cylinder contains air at atmospheric pressure. Between 1 and 2 the air is compressed adiabatically that is without heat transfer to or from the environment by the rising piston. During this compression, the volume is reduced, the pressure and temperature both raise. At or slightly before 2 fuel is injected and burns in the compressed hot air.

Chemical energy is released and this constitutes an injection of thermal energy (heat)

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into the compressed gas. Combustion and heating occur between 2 and 3.

In this interval the pressure remains constant since the piston descends, and the volume increases; the temperature rises as a consequence of the energy of combustion. At 3 fuel injection and combustion are complete, and the cylinder contains gas at a higher temperature than at 2. Between 3 and 4 this hot gas expands, again approximately adiabatically. Work is done on the system to which the engine is connected. During this expansion phase the volume of the gas rises, and its temperature and pressure both fall. At 4 the exhaust valve opens, and the pressure falls abruptly to atmospheric temperature.

4.5 Engine Description:

The prepared fuel blends are tested in a Kirloskar make four stroke, single cylinder, constant speed, water-cooled diesel engine- test rig in the laboratory. Provision is made to measure the exhaust heat with the help of a exhaust gas calorimeter and thermocouples fixed at salient points. This engine is provided with a crank handle for starting. The engine is mounted with an absorption dynamometer of brake drum type. The engine set up is also provided with burette, graduations duly marked and a 3way valve is used to measure the fuel flow rate.

Through the load test analysis, the performance characteristics and 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 is shown in Fig 4.3.

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Fig 4.3: Four Stroke, Single Cylinder, Vertical Diesel Engine

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Table 4.1: Specifications of Diesel Engine

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

CHAPTER -5

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5.EXPERIMENTAL PROCEDURE

5.1Biodiesel preparation:

Initially some oil has been taken. Pour the oil in the beaker and place it on the heating machine and with the help of magnetic stirrer, heating and stirring is done simultaneously. Now some KaoH billets are added to methanol solution and stirred until the billets get melted completely. Then, this solution is added to the oil. The process of heating and stirring is done around 52-55 degrees centigrade until the separation is visible. Now the solution is allowed for sedimentation until clear separation of two layers. One layer contains biodiesel and other glycerol. Glycerol is allowed to solidify and the biodiesel is separated. With the help of distilled water any further impurities are removed from the biodiesel.

5.2 Blending:

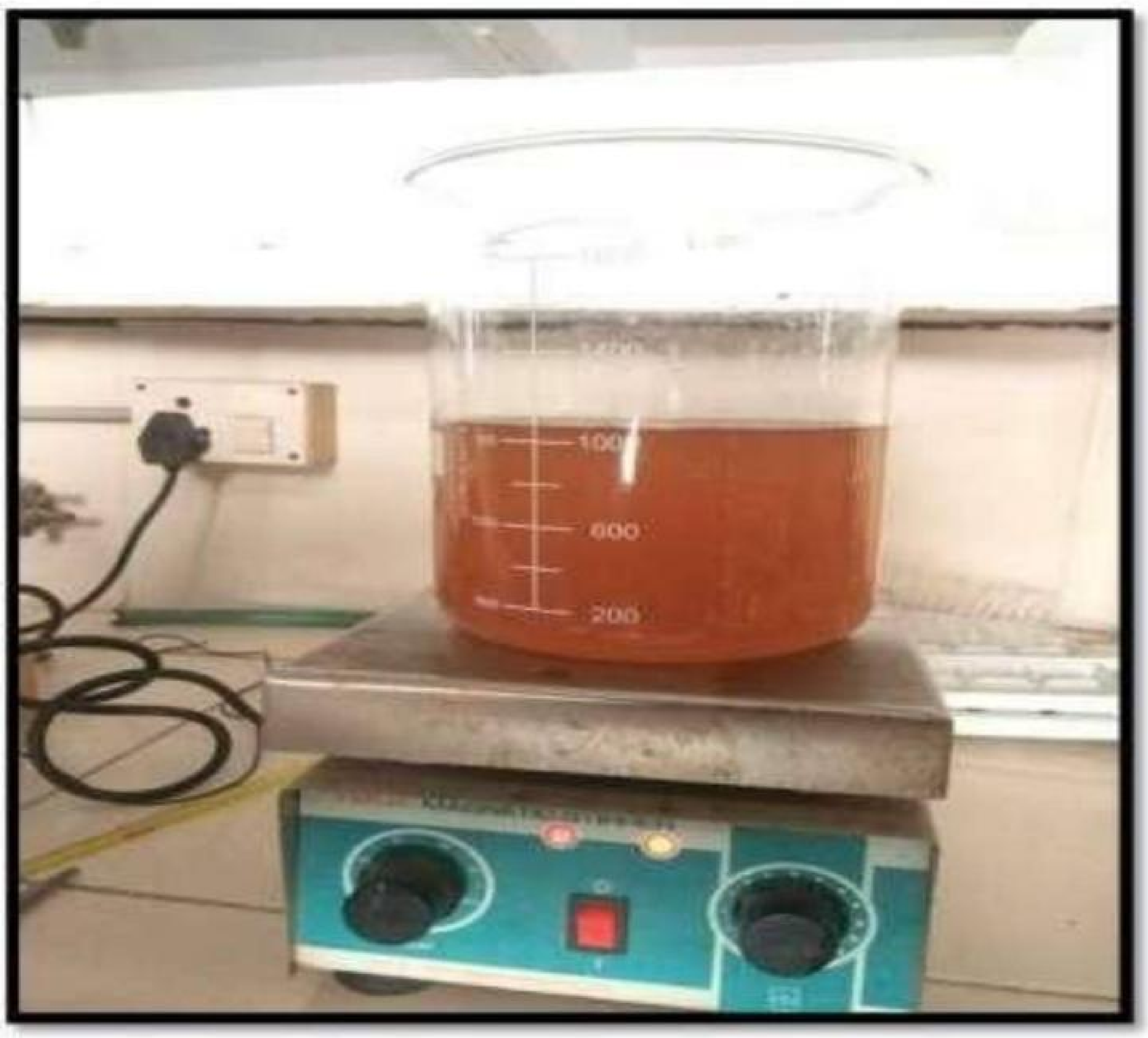

Fig 5.1: Blending of Oils using Magnetic Stirrer

It is the main process involved for preparation of biodiesels by using as a magnetic stirrer as shown in Fig 5.1. It is nothing but mixing of oil in certain proportions to obtain the required properties.

Blends	Diesel(ml)	Palm Oil Biodiesel(ml)
B5	950	50
B10	900	100
B15	850	150
B20	800	200

Table 5.1: Oil proportion in fuel blends

This process involves:

a. Taking proportions of Biodiesel.

b. Mixing Biodiesel with Petroleum Diesel in the mixer.

5.3Blending of oils:

Generally, in this B5, B10, B15 etc., where "B" represents the fuel as Biodiesel and the digit represents the percentage of blend.

10% biodiesel, 90% diesel is given as B10

20% biodiesel, 80% diesel is given as B20

In this work, the following fuel blends with their respective proportions of its constituents were used of 1000 mL each as shown in table 5.1.

5.4 Properties of Oil Blends:

	DIESEL	B5	B10	B15	B20
Flash point (°C)	49	50	50	52	54
Fire point (°C)	52	55	58	58	61
Specific Gravity	0.853	0.832	0.836	0.837	0.839
Calorific value (kJ/kg)	44500	42275	40080	37825	35600

Table 5.2: Properties of Oil Blends

5.5Testing Procedure:

Check the fuel and lubricating oil systems before starting the engine Connect water supply to the engine and brake drum and remove all load on the brake drum. Keep 3way cock in horizontal position so that fuel flows from the tank to the engine filling the burette. Start the engine by hand cranking and allow the engine to pick up rated speed. Allow the engine to run for some time in idle condition. Put the 3way cock in vertical position and measure the fuel consumption rate by noting the time taken for 10 cc of fuel flow. Experiment repeated at different loads. Engine is stopped after detaching load from the engine.

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CHAPTER 6

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6 RESULTS AND DISCUSSION

In this chapter, the observations are evaluated from the basic formulae to obtain the required results and graphs. The observations and results are tabulated which are also mentioned in this chapter. The results were analyzed and the conclusions have been derived.

6.1 Basic Data for Calculations:

1. Rated brake power of engine B.P = 5 H.P = 3.7KW
2. Speed of engine N = 1500rpm
3. Effective radius of the brake drum R = 0.213 m
4. Stroke length L =110×10^{-3} m
5. Diameter of cylinder bore D = 80×10^{-3} m
6. Time taken for 10cc fuel consumption is 't' sec

6.2 Basic Formulae for Calculations:

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

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

$$= 11.27 \text{ Kg}$$

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

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

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

Where F.P is the Frictional Power obtained from the graph drawn between Brake Power and Fuel Consumption. The linear portion of the graph is extended to cut the negative of the x-axis

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on which B.P. is taken. The length of intercept point from zero gives Frictional Power. This method of determining F.P. is known as Willian's Line Method.

CALCULATIONS:

1. $Specific\ fuel\ Consumption\ (SFC) = \frac{F.C}{B.P}$ kg/kw. hr
2. $Brake\ Thermal\ efficiency\ \eta\ Bth = \frac{B.P\times3600}{FC\times CV}$
3. $Indicated\ Thermal\ efficiency\ \eta\ Ith = \frac{I.P\times3600}{FC\times CV}$
4. $Mechanical\ efficiency\ \eta\ mech = \frac{B.P}{I.P}$
5. $Indicated\ mean\ effective\ pressure\ \ (I.M.E.P) = \frac{I.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}$ N/m^2
6. $Brake\ mean\ effective\ pressure\ \ (B.M.E.P) = \frac{B.P\times60000}{L\times\frac{\pi}{4}\times D^2\times\frac{N}{2}}$ N/m^2

6.3 Model Calculations:

Considering pure diesel at 3.4 kgf load:

Specific gravity is 0.853 gm/cc

Calorific value is 44500 KJ/Kg

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

$$= \frac{2\pi \times 1500 \times 3.4 \times 9.81 \times 0.213}{60000}$$

= 1.1159 KW

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

$$= \frac{10 \times 0.853 \times 3600}{55 \times 1000} \text{ kg/hr}$$

= 0.5583 kg/hr

Frictional power from graph (F.P) = 3.05 kW

Indicated power (I.P) = B.P + F.P = 1.1159+3.05

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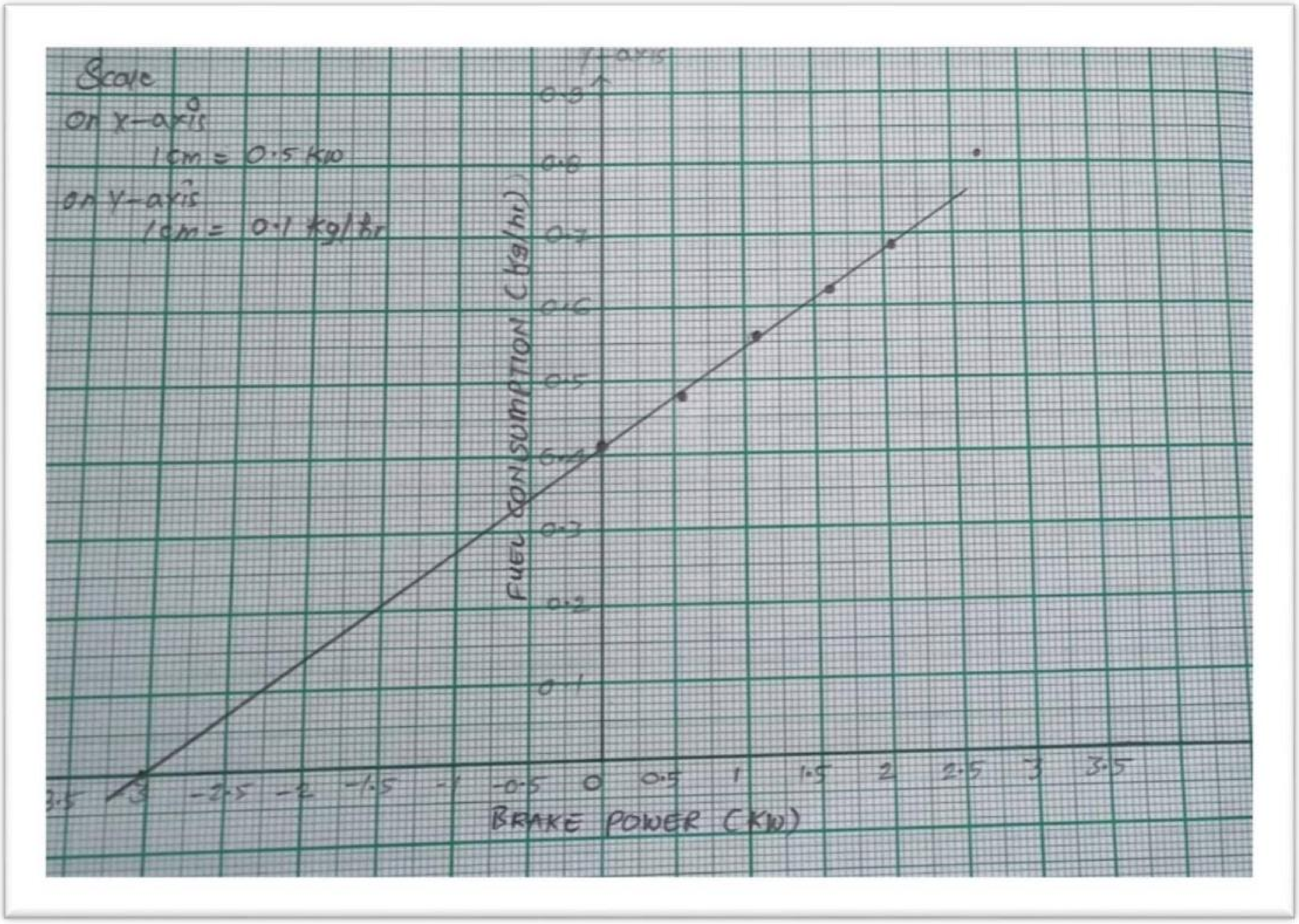
= 4.165 kW

Where F.P is the Frictional Power obtained from the graph drawn between Brake Power and Fuel Consumption as shown in Fig 6.1. The linear portion of the graph is extended to cut the negative of the x-axis on which B.P. is taken as shown in Fig 6.1. The length of intercept point from zero gives Frictional Power. This method of determining F.P. is known as Willian's Line Method.



$$Specific\ fuel\ Consumption\ (SFC) = \frac{\text{F.C}}{\text{B.P}}\ \text{kg/kw. hr}$$

$$= \frac{0.5583}{1.1159}$$

$$= 0.5003\ \text{kg/kw.hr}$$

$$Brake\ Thermal\ efficiency\ \eta\ Bth = \frac{\text{B.P} \times 3600}{FC \times CV}$$

$$= \frac{1.1159 \times 3600}{0.5583 \times 44500}$$

$$=16.6$$

$$Indicated\ Thermal\ efficiency\ \eta\ Ith = \frac{\text{I.P} \times 3600}{FC \times CV}$$

$$= \frac{4.1659 \times 3600}{0.5583 \times 44500}$$

$$= 60.35\ \%$$

$$Mechanical\ efficiency\ \eta\ mech = \frac{\text{B.P}}{I.P}$$

$$= \frac{1.1159}{4.1659}$$

$$= 26.78\%$$

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

$$= \frac{4.1659 \times 60000}{110 \times 10^{-3} \times \frac{\pi}{4} \times (80 \times 10^{-3})^2 \times \frac{1500}{2}}$$

$$= 6.0274\ \text{bar}$$

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

$$= \frac{1.1159 \times 60000}{110 \times 10^{-3} \times \frac{\pi}{4} \times (80 \times 10^{-3})^2 \times \frac{1500}{2}}$$

$$= 1.6145\ \text{bar}$$

6.3.1 Model Calculations for B15 Blend:

Considering B15 blend at 5kgf load:

Specific gravity is 0.837 gm/cc

Calorific value is 37825 KJ/Kg

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

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

`

= 1.2143 KW

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

$$= \frac{10 \times 0.837 \times 3600}{61 \times 1000} \text{ kg/hr}$$

= 0.5033 kg/hr

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

Indicated power (I.P) = B.P + F.P = 1.2143+2.4

= 3.6143 kW

$$\textit{Specific fuel Consumption (SFC)} = \frac{\text{F.C}}{\text{B.P}} \text{ kg/kw. hr}$$

$$= \frac{0.5033}{1.2143}$$

=0.4144 kg/kw.hr

$$\textit{Brake Thermal efficiency } \eta\, Bth = \frac{\text{B. P} \times 3600}{FC \times CV}$$

$$= \frac{1.2143 \times 3600}{0.5033 \times 37825}$$

=22.94%

$$\textit{Indicated Thermal efficiency } \eta\, Ith = \frac{\text{I. P} \times 3600}{FC \times CV}$$

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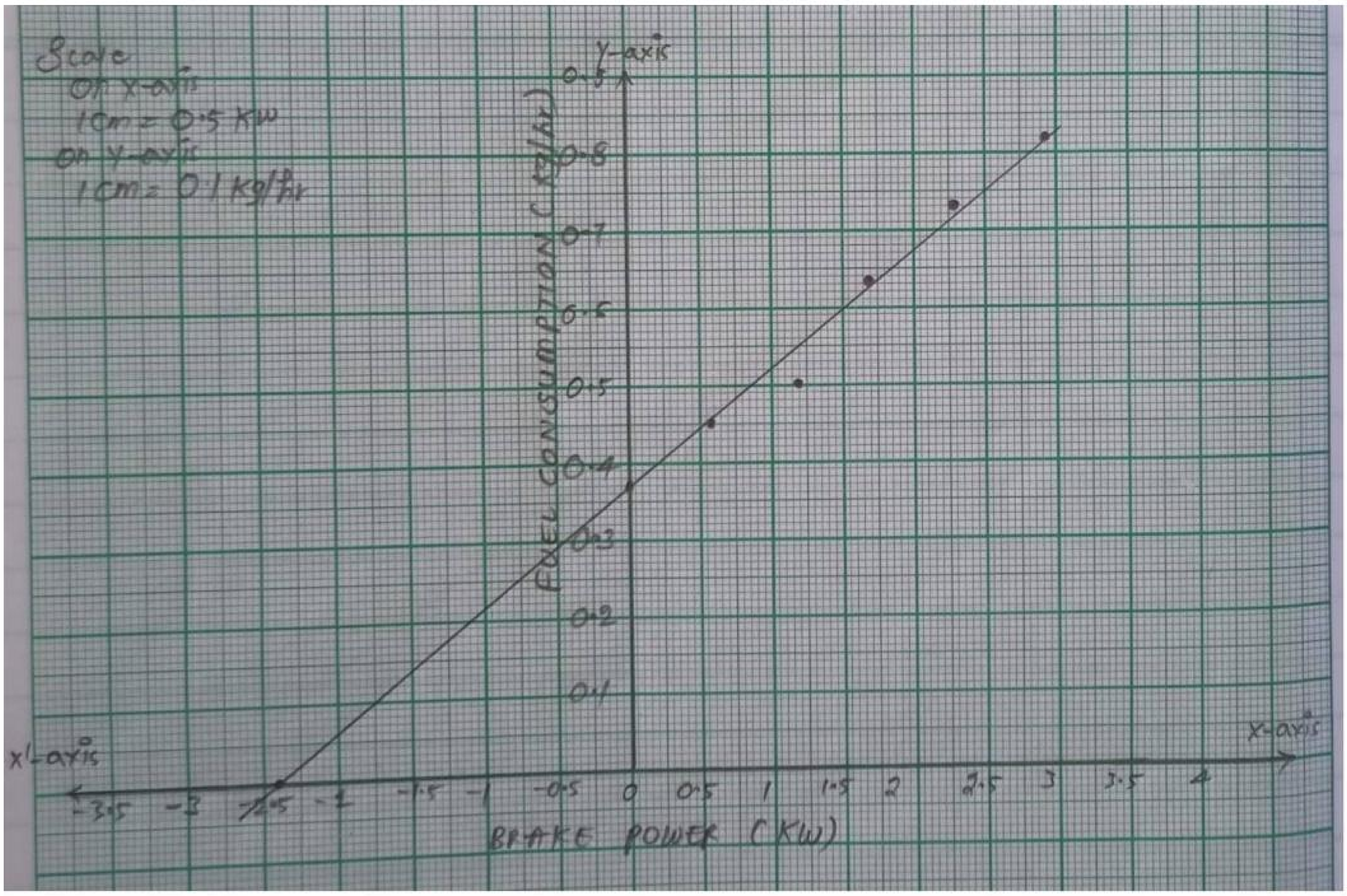
$$= \frac{3.6143 \times 3600}{0.5033 \times 37825}$$

$$= 68.29\ \%$$



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

$$= \frac{1.2143}{3.6143}$$

$$= 33.39\%$$

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

$$= \frac{3.6143 \times 60000}{110 \times 10^{-3} \times \frac{\pi}{4} \times (80 \times 10^{-3})^2 \times \frac{1500}{2}}$$

$$= 5.228\ bar$$

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

$$= \frac{1.2143\times 60000}{110\times 10^{-3}\times\frac{\pi}{4}\times(80\times 10^{-3})^2\times\frac{1500}{2}}$$

$$= 1.756\ \text{bar}$$

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Table 6.1: Observations for pure Diesel

S.NO	Load on brake drum (w-S)	Time for 10cc fuel consumption T (sec)	F.C (kg/hr)	Brake Power B.P (KW)	Indicated Power I.P (KW)	Frictional Power F.P (KW)	Specific fuel consumption (kg/kw-hr)	Brake thermal efficiency (%)	Indicated thermal efficiency (%)	Mechanical efficiency (%)	I.M.E.P (bar)	B.M.E.P (bar)
1	0	74	0.4149	0	3.0500	3.0500	-	0	59.46	0	4.412	0
2	1.7	64	0.4798	0.5579	3.6079	3.0500	0.8600	9.40	60.82	15.46	5.220	0.807
3	3.4	55	0.5583	1.1159	4.1659	3.0500	0.5003	16.16	60.35	26.78	6.027	1.614
4	5.1	49	0.6266	1.6739	4.7239	3.0500	0.3742	21.60	60.98	35.43	6.834	2.421
5	6.7	45	0.6824	2.1990	5.2490	3.0500	0.3103	26.06	62.70	41.89	7.594	3.186
6	8.3	38	0.8081	2.7242	5.7742	3.0500	0.2966	27.26	57.74	47.17	8.354	3.941

Table 6.2: Observations for B5 Blend

S.NO	Load on brake drum (w-S)	Time for 10cc fuel consumption T (sec)	F.C (kg/hr)	Brake Power B.P (KW)	Indicated Power I.P (KW)	Frictional Power F.P (KW)	Specific fuel consumption (kg/kw-hr)	Brake thermal efficiency (%)	Indicated thermal efficiency (%)	Mechanical efficiency (%)	I.M.E.P (bar)	B.M.E.P (bar)
1	0	84	0.3567	0	2.3750	2.3750	-	0	56.69	0	3.4355	0
2	1.8	68	0.4408	0.5908	2.9658	2.3750	0.7457	11.41	57.31	19.92	4.2901	0.8546
3	3.5	58	0.5166	1.1487	3.5237	2.3750	0.4497	18.93	58.08	32.59	5.0971	1.6616
4	5.1	51	0.5875	1.6739	4.0489	2.3750	0.3509	24.26	58.68	41.34	5.8569	2.4213
5	6.7	44	0.6810	2.1990	4.5740	2.3750	0.3096	27.49	57.19	48.07	6.6165	3.1809
6	8.4	39	0.7683	2.7570	5.1320	2.3750	0.2786	30.55	56.87	53.72	7.4236	3.9881

Table 6.3: Observations for B10 Blend

S.NO	Load on brake drum (w-S)	Time for 10cc fuel consumption T (sec)	F.C (kg/hr)	Brake Power B.P (KW)	Indicated Power I.P (KW)	Frictional Power F.P (KW)	Specific fuel consumption (kg/kw-hr)	Brake thermal efficiency (%)	Indicated thermal efficiency (%)	Mechanical efficiency (%)	I.M.E.P (bar)	B.M.E.P (bar)
1	0	74	0.4149	0	3.0500	3.0500	-	0	59.46	0	4.412	0
2	1.8	64	0.4798	0.5579	3.6079	3.0500	0.8600	9.40	60.82	15.46	5.220	0.807
3	3.5	55	0.5583	1.1159	4.1659	3.0500	0.5003	16.16	60.35	26.78	6.027	1.614
4	5.1	49	0.6266	1.6739	4.7239	3.0500	0.3742	21.60	60.98	35.43	6.834	2.421
5	6.7	45	0.6824	2.1990	5.2490	3.0500	0.3103	26.06	62.70	41.89	7.594	3.186
6	8.4	38	0.8081	2.7242	5.7742	3.0500	0.2966	27.26	57.74	47.17	8.354	3.941

Table 6.4: Observations for B15 Blend

S.NO	Load on brake drum (w-S)	Time for 10cc fuel consumption T (sec)	F.C (kg/hr)	Brake Power B.P (KW)	Indicated Power I.P (KW)	Frictional Power F.P (KW)	Specific fuel consumption (kg/kw-hr)	Brake thermal efficiency (%)	Indicated thermal efficiency (%)	Mechanical efficiency (%)	I.M.E.P (bar)	B.M.E.P (bar)
1	0	82	0.3744	0	2.4000	2.4000	-	0	60.96	0	3.471	0
2	1.9	68	0.4515	0.6235	3.0235	2.4000	0.7241	13.13	63.68	20.62	4.373	0.909
	3.7	61	0.5033	1.2143	3.6143	2.4000	0.4144	22.94	68.29	33.59	5.228	1.756
4	5.3	48	0.6397	1.7394	4.1394	2.4000	0.3677	25.85	61.53	42.02	5.987	2.516
5	7.2	42	0.7310	2.3630	4.7630	2.4000	0.3093	30.74	61.96	49.61	6.889	3.418
6	9.0	37	0.8298	2.9538	5.3538	2.4000	0.2809	33.85	61.35	55.17	7.744	4.272

Table 6.5: Observations for B20 Blend

S.NO	Load on brake drum (w-S)	Time for 10cc fuel consumption T (sec)	F.C (kg/hr)	Brake Power B.P (KW)	Indicated Power I.P (KW)	Frictional Power F.P (KW)	Specific fuel consumption (kg/kw-hr)	Brake thermal efficiency (%)	Indicated thermal efficiency (%)	Mechanical efficiency (%)	I.M.E.P (bar)	B.M.E.P (bar)
1	0	83	0.3699	0	2.1500	2.1500	-	0	58.76	0	3.110	0
2	1.8	67	0.4582	0.5907	2.7407	2.1500	0.7756	13.03	60.47	21.55	3.964	0.854
3	3.5	55	0.55582	1.1487	3.2987	2.1500	0.4859	20.80	59.74	34.82	4.771	1.661
4	5.3	49	0.6266	1.7394	3.8894	2.1500	0.3602	28.06	62.75	44.72	5.626	2.516
5	7.1	41	0.7489	2.3302	4.4802	2.1500	0.3213	31.45	60.48	52.01	6.464	3.370
6	8.9	36	0.8529	2.9210	5.0710	2.1500	0.2919	34.62	60.10	57.60	7.316	4.225

The Frictional Power in case of each blend is determined through the Willians's Line Method as described earlier. The Willian Line for each blend is obtained from the graphs shown in Figs 6.2, 6.3, 6.4, 6.5 and 6.6 for Diesel, B5, B15, B20 and B25 respectively.

The Frictional Power obtained from the above graphs for each fuel blend is as follows:

For Diesel F P= 2 KW

For B5 F.P = 1.85KW

For B10 F.P. = 0.85 KW

For B15 F.P. = 2.1 KW

For B20 F.P. = 1.8 KW

6.4 Performance Characteristics:

The values of brake power, mechanical efficiency, specific fuel consumptions, indicated thermal efficiency, brake thermal efficiency are set to be the parameters of performance of the 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

6.4.1 Comparison of Mechanical Efficiency:

Mechanical efficiency indicates how good an engine is converting the indicated power to useful power. The values of Mechanical Efficiency at different Brake Powers are plotted as shown in Fig 6.1. B20 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.

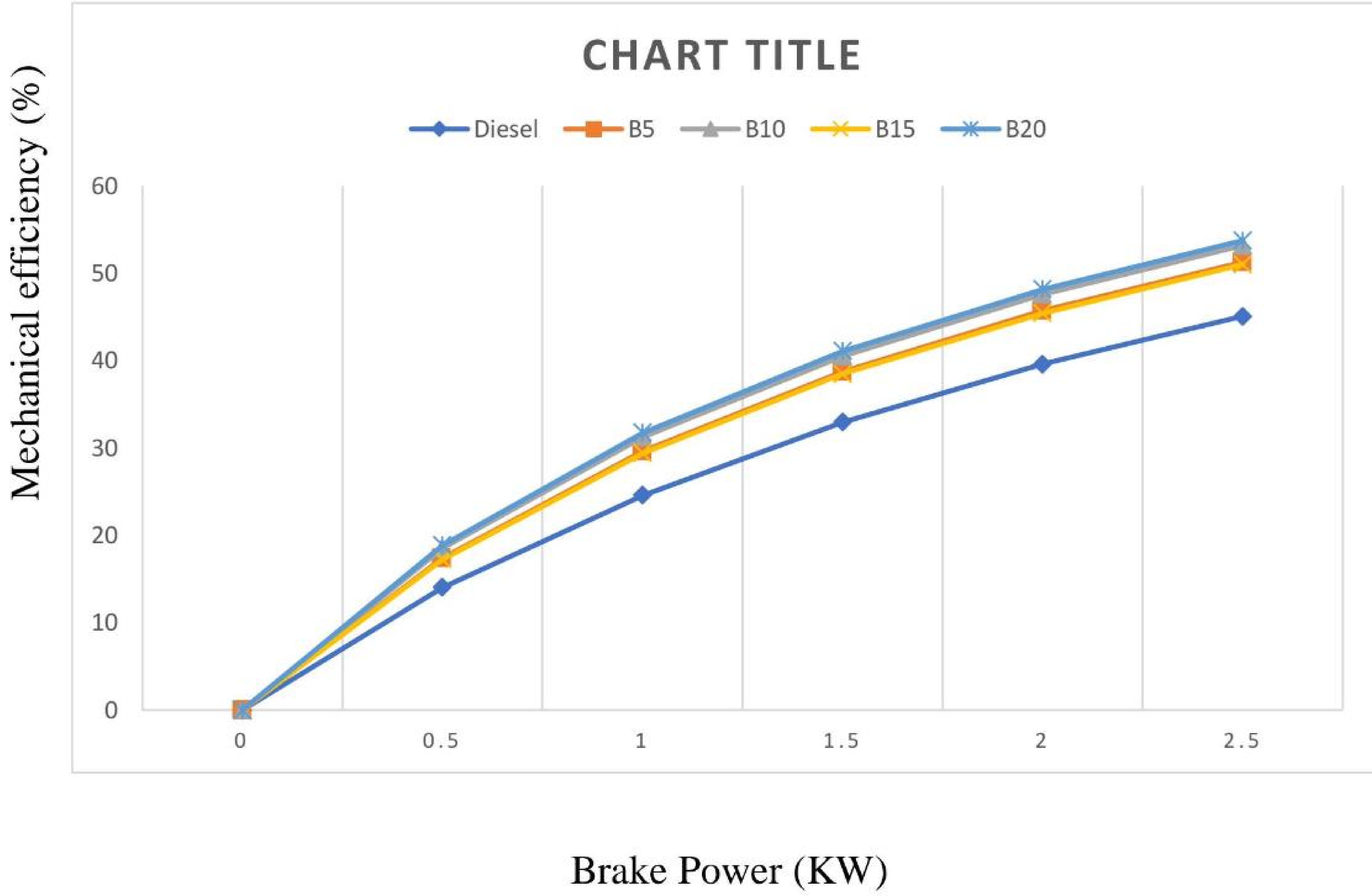

Fig 6.1: Brake power Vs Mechanical efficiency

6.4.2 Comparison of 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 as shown in Fig 6.2. B20 blend offers the maximum Brake Thermal Efficiency of all the mixtures and Diesel offers the least Brake Thermal Efficiency.

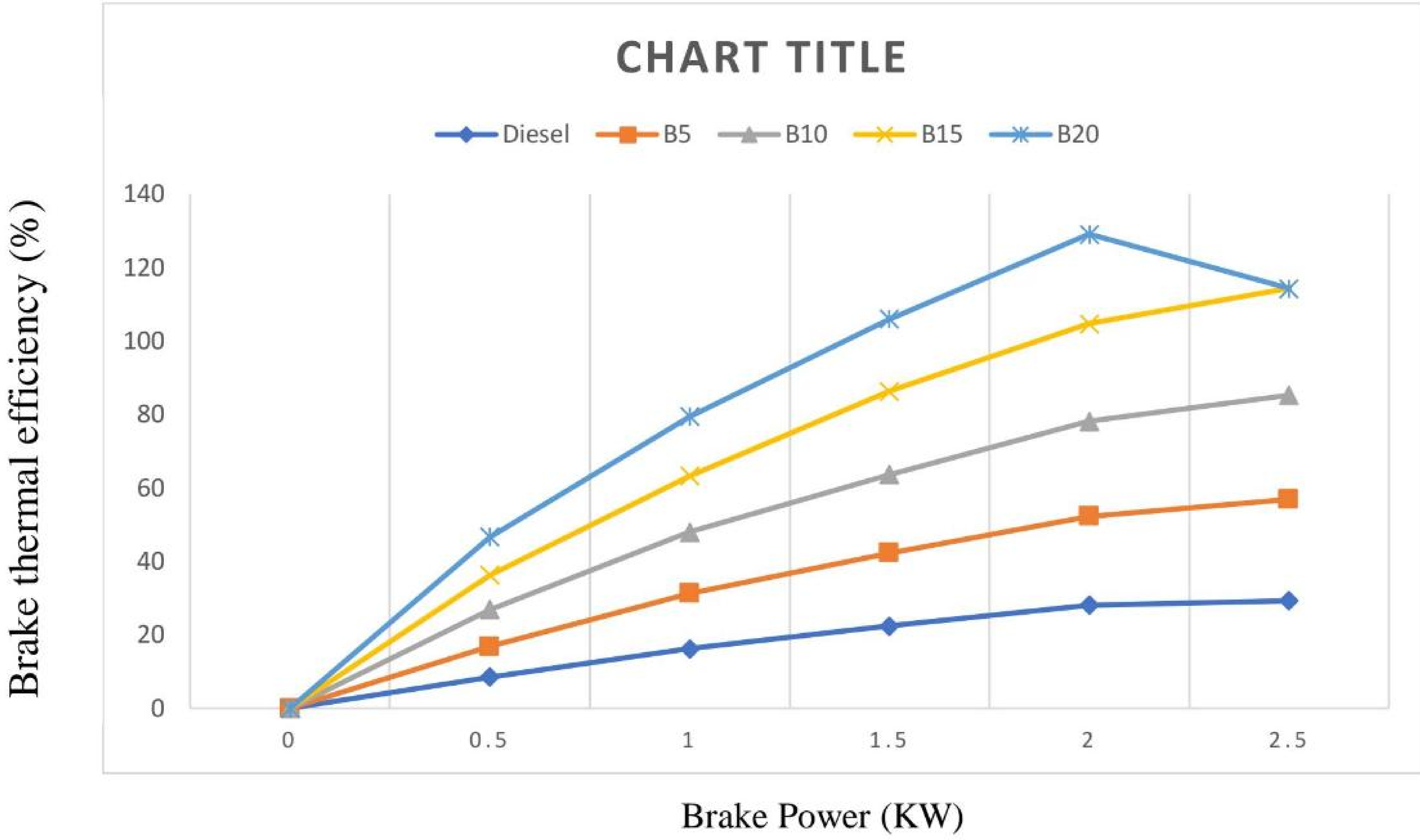

Fig 6.2 Brake power Vs Brake Thermal efficiency

6.4.3 Comparison of Indicated Thermal Efficiency:

The values of Indicated Thermal Efficiency at different brake powers are plotted as shown in Fig 6.3. Diesel blend offers the maximum Indicated Thermal Efficiency of all the mixtures and it seems to be the best mixture, while pure B20 offers the minimum Indicated Thermal Efficiency.

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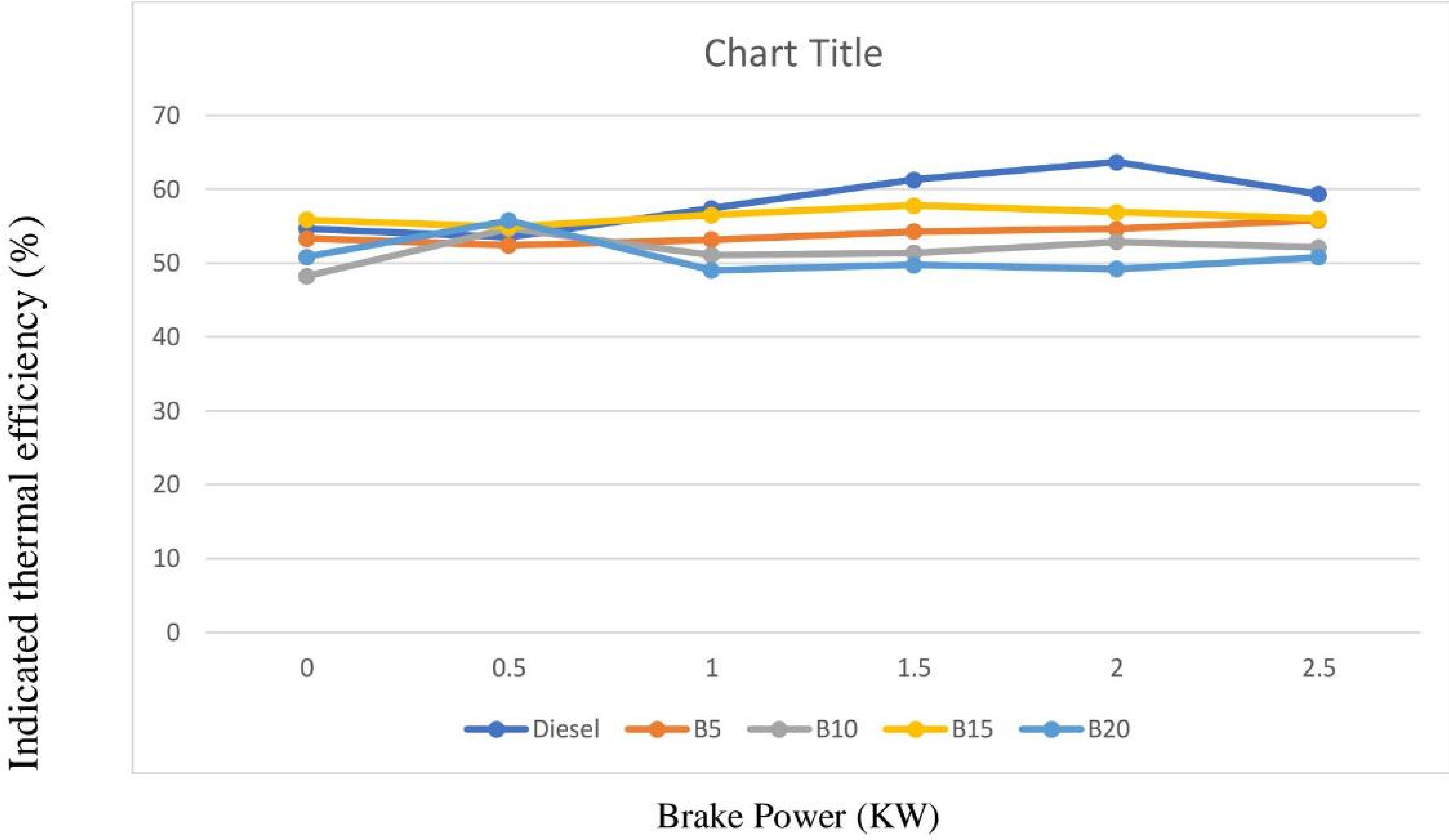

Fig 6.3: Brake power Vs Indicated Thermal efficiency

6.4.4 Comparison of 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 as shown in Fig 6.4. B15 blend offers the least Specific Fuel Consumption of all the mixtures while Diesel has the maximum Specific Fuel Consumption.

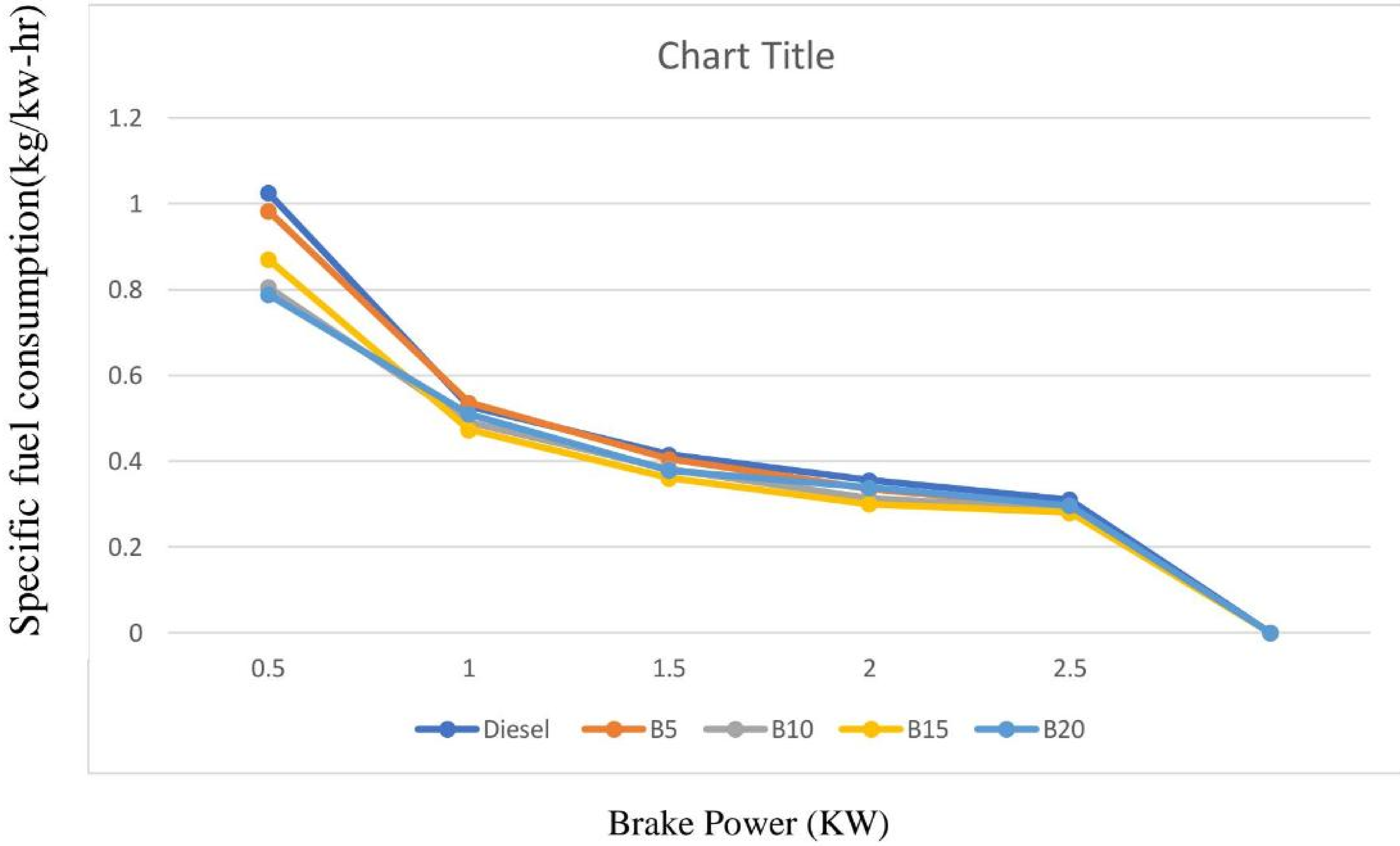

Fig 6.4: Brake power Vs Specific fuel Consumption

6.4.5 Comparison of Indicated Mean Effective Pressure:

Indicated Mean Effective Pressure is defined as the average pressure produced in the combustion chambers during the operating cycle. IMEP is equal to the brake mean effective pressure. The variations of Indicated Mean Effective Pressure with respect to Brake Power for different fuel blends and Diesel are shown in Fig 6.5. B20 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 B5 offers the maximum Indicated Mean Effective Pressure.

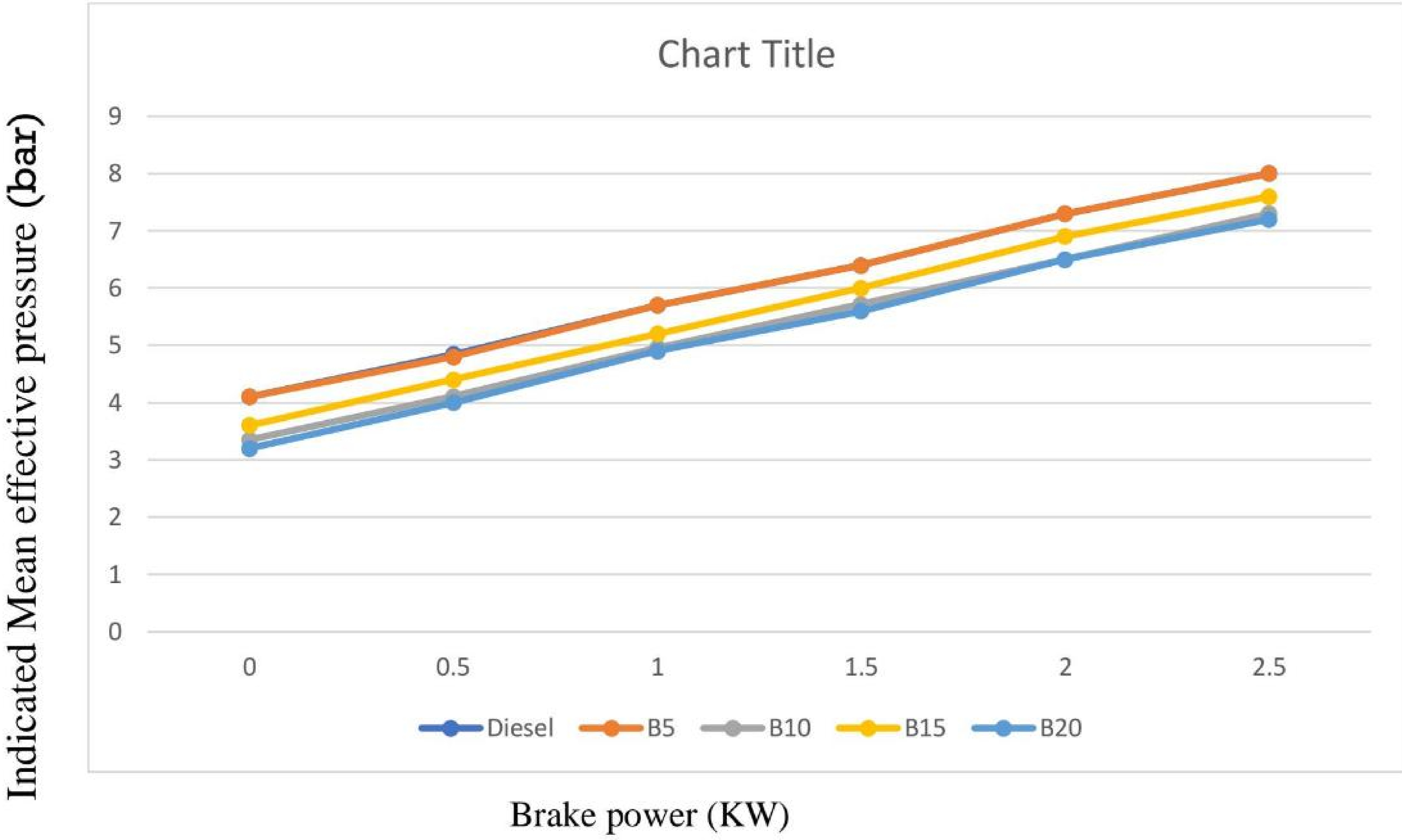

Fig 6.5: Brake power Vs Indicated Mean Effective Pressure

6.4.6 Comparison of 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 an indication of engine efficiency regardless of capacity or engine speed. The more efficient it is the higher the average pressure or BMEP. Pressure increases by compression alone can do wonders to a stock engine, it is, by factory choice, usually a low number.

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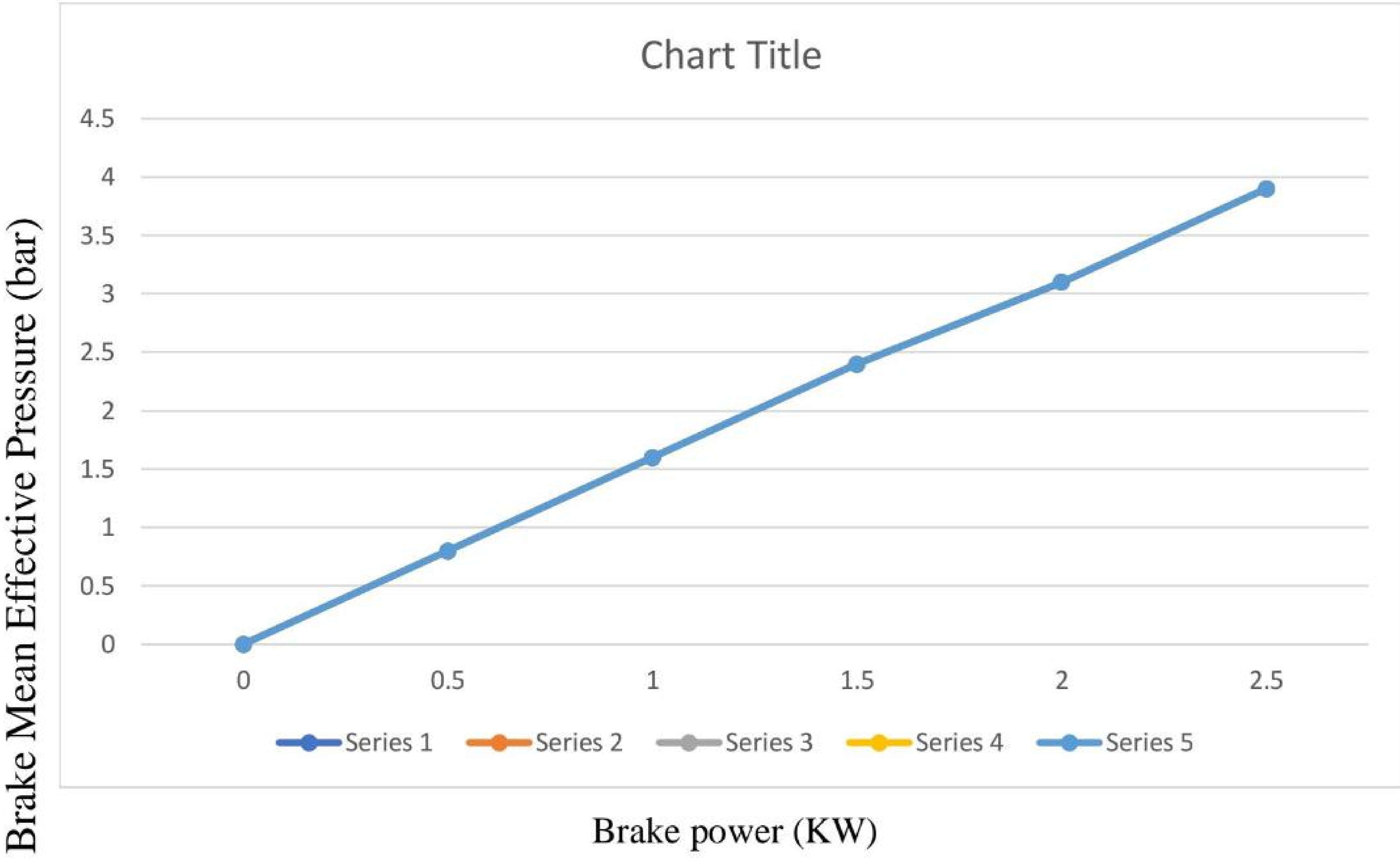

Fig 6.6: Brake power Vs Brake Mean Effective Pressure

CHAPTER-7

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7.CONCLUSIONS

An experimental study is conducted to evaluate and compare the use of Palm oil as a full or partial supplement to conventional diesel fuel in IC engine.

A series of tests were conducted using each of the fuels in various proportions with the engine working under the constant speed of 1500 rpm, and at different loads ranging from no load to full load. For each test performed, the performance gauging parameters such as fuel consumption, thermal efficiency, mechanical efficiency, mean effective pressures etc. were computed.

Based on the experimental results, the following conclusions have been drawn:

- Comparing the mechanical efficiencies at different loads for all blends, it can be inferred that B15 offers the highest mechanical efficiency.
- Comparing the specific fuel consumption for each particular blend, it was observed that B10 has least specific fuel consumption for shaft output greater than 1kW. For output less than 1kW, B10 seems to be the best blend.
- The different blends were also evaluated for the thermal efficiencies and it was observed that B10 is best mixture for brake output greater than 1kW and for power less than 1kW, B20 is the best.
- B20 composition is the best among all blends in terms of the intensity of smoke.

- This conclusion is drawn based on the values of HSU obtained from the smoke analysis. It can therefore be concluded that the usage of oxygen in the air and the effectiveness of combustion is best for this blend.
- Pure Diesel is the best among all blends in terms of low Hydro carbons, Carbon monoxide and Oxygen emissions. It is having more Carbon Di-oxide Emissions. From this Point of view Diesel is best for environment
- It can therefore be concluded that B10 blend containing 90% diesel, 10% palm oil biodiesel is the best blend.

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