INVESTIGATION ON PERFORMANCE CHARACTERISTICS OF DIESEL ENGINE USING JATROPHA BIODIESEL AND ITS BLENDS

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

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in

MECHANICAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the Project Report entitled **"INVESTIGATION ON PERFOMANCE CHARECTERTICS OF DIESEL ENGINE USING JATROPHA BIODIESEL AND ITS BLENDS"** being submitted by KANUMAREDDY HARI KRISHNA (317126520202), VADDI NAGENDRA (317126520227), TADAKA NEEHARIKA (317126520223), NEDURI ROHITH (317126520210), ANNEPU BHARADWAJ (317126520181) in partial fulfillments for the award of degree of **BACHELOR OF TECHNOLOGY** in **MECHANICAL ENGINEERING**. It is the work of bona-fide, carried out under the guidance and supervision of **MR. G. NARESH**, Assistant Professor, Department Of Mechanical Engineering, ANITS during the academic year of 2017-2021.

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ABSTRACT

In view of the fast depletion of fossil fuel, the search for alternative fuels has become inevitable, looking at huge demand of diesel for transportation sector, captive power generation and agricultural sector, is being viewed a substitute of diesel. The demand for petroleum has risen rapidly due to increasing industrialization and modernization of the world. This economic development has led to a huge demand for energy, where the major part of That energy is derived from fossil sources such as petroleum, coal and natural gas. However, the limited Reserve of fossil fuel has drawn the attention of many researchers to look for alternative fuels which can Be produced from renewable feedstock. Biodiesel has become more attractive because of its environmental benefits and it is obtained from Renewable resources. Significant work has been reported on the kinetics of Transesterification of edible vegetable oils but little work is reported on non-edible oils. Out of various non-edible oil resources, Jatropha curcas oil (JCO) is considered as future feedstocks for biodiesel Production in India and limited work is reported. There is a growing interest in using Jatropha curcas L. Oil as the feedstock for biodiesel production because it is non-edible and thus does not compromise the edible oils, which are mainly used for food consumption. Jatropha curcas Linnaeus, a multipurpose plant, contains high Amount of oil in its seeds which can be converted to biodiesel. J. Curcas is probably the most highly Promoted oilseed crop at present in the world. In this study Different proportions of fuel blends have been produced by the process of blending. The load test was conducted on Four Stroke Diesel engine using the blends of jatropha biodiesel mixed with diesel. 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 comparative graphs are drawn at different loads.

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CHAPTER - I

1.INTRODUCTION

1.1 Fossil Fuels:

The term fossil is used to describe the broad setoff 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:

1) Base catalysed trans-esterification of the oil.
2) Direct acid catalysed trans-esterification of the oil.
3) Conversion of the oil to its fatty acids and then to biodiesel.

There are 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, mustard, flax, sunflower, palm 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. Jatropha is a small pest and drought resistant shrub that is capable of being grown on marginal/degraded land and produces seeds that yield several times more oil per acre than soybeans.

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.
- An excessive production of soybeans in the world makes it an economic way to utilize this surplus for manufacturing the biodiesel fuel.
- 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 convertors.

- 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 biodiesel fuel advantages over other alternative fuels.
- The lubricating property of the biodiesel may lengthen the life time of engine

CHAPTER - II

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:

- **Chatpalliwarl et al.** [1] described the brief overview of the Bio-diesel 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.

- **Taymaz et al.** [2] described that the engine performance and exhaust emissions of a diesel direct injection engine using mixed palm olein/Soybean vegetable oil ethyl ester. Torque and brake power output of the engine which uses biodiesel, were slightly lower and specific fuel consumption was higher in comparison to Diesel. Decrease in CO and HC, CO2 emissions, indicates an advantage of exhaust emissions with those of diesel fuel, however, NO and NOx emissions were higher with the biodiesels.

- **G. Naresh et al.** [3] has conducted the load test on Four Stroke Diesel engine using the blends of rubber seed oil mixed with diesel. 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 load test on the four-stroke diesel engine has given good outputs for biodiesel from rubber seed oil because mechanical efficiency is maximum for biodiesel blend B20 and all other blends also has reasonably good efficiency due to less frictional losses.

- **Piyanuch Nakpong et al.** [4] 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.

- **S.L.Sinha and R.K.Yadav** [5] investigated, the biodiesel produced from the Jatropha seeds. It has been considered as a potential alternative for running the compression ignition engines. The different blends of biodiesel and conventional diesel have been tested on the engine. The experimental data obtained for various concentrations of biodiesel blends have been compared with base line data of conventional diesel. Significant improvement in engine performance has been observed due to the use of biodiesel and diesel. It has been observed that 20% of Jatropha oil can be substituted for diesel without any engine modification and preheating of blends. The level of hydrocarbon emission and noise level have been found to be reduced with the use of more biodiesel content.

- **Avinash Kumar Agarwal** [6] 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 fuelled engine vis-a-vis mineral diesel fuelled engine was executed and the results are compared.

- **Sahoo et al**. [7] reported that the brake power is slightly increased and the BSFC is much higher compared to diesel at full load and different engine speeds. It is also reported that HC and smoke emissions are lower and CO and NOx emissions are higher for jatropha blends
- **Manickam et al.** [8] reported that the power is decreased except at optimised injection timing, and the BSFC is always higher at full load and different engine speeds. In the same literature, it is observed that all emissions except NOx are lower compared to diesel fuel.
- **Chauhan et al**. [9] reported that that biodiesel derived from non-edible oil like Jatropha could be a good substitute to diesel fuel in diesel engines in the near future as far as decentralized energy production is concerned. In view of comparable engine performance and reduction in most of the engine emissions, it can be concluded that biodiesel derived from Jatropha and its blends could be used in a conventional diesel engine without any modification.

- **Pramanik et al.** [10] analysed performance of the engine using blends of diesel and Jatropha oil in a single-cylinder CI engine. Significant improvement in engine performance was observed compared to vegetable oil alone. The specific fuel consumption and the exhaust gas temperature were reduced due to decrease in viscosity of the vegetable oil. Acceptable thermal efficiencies of the engine were obtained with blends containing up to 50% volume of Jatropha oil. From the properties and engine test results it has been established that 40e50% of Jatropha oil can be substituted for diesel without any engine modification

From the above literature survey, the authors have identified some of the gaps in the areas of Biodiesel. Hence the authors have embarked to study the influence of Alternative Fuels. In this work, the Performance of Compression Ignition Engine using jatropha seed oil as Biodiesel is carried out by following the experimental procedure.

CHAPTER - III

3.SYNTHESIS OF JATROPHA OIL & BIODIESEL

Biodiesel is produced through a process known as Trans-Esterification of triglycerides to methyl esters with methanol, a balanced and catalysed reaction. An excess of Methanol is required to obtain a higher degree of conversion. Jatropha and Rubber seed oils are among the some of the best for biodiesel uses.

The conventional catalyst in natural oil transesterification processes is selected among basis such as alkaline or alkaline earth hydroxides or alkoxides. However, transesterification could also be performed using acid catalysts such as hydrochloric, sulphuric 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.

3.1 Jatropha Seed Oil as a Biodiesel:

Oil from jatropha curcas are a few varieties of jatropha. Best among these are jatropha curcas. Jatropha oil is an important product from the plant for meeting the cooking and lighting needs of the rural population, boiler fuel for industrial purposes or as a viable substitute for Diesel. About one- third of the energy in the fruit of jatropha can be extracted as oil that has a similar energy value to Diesel fuel. Jatropha oil can be used directly in Diesel engines added to Diesel fuel as an extender or trans esterified to a biodiesel fuel. There are some technical problems with using jatropha oil directly in Diesel engines that have yet to be completely overcome. Moreover, the cost of producing jatropha oil as a Diesel substitute is currently higher than the cost of Diesel itself. So, by taking all the above considerations the jatropha seed oil has been selected for the project.

The plant that is generally cultivated for the purpose of extracting jatropha oil is Jatropha curcas. The seeds are the primary source from which the oil is extracted. Owing to the toxicity of jatropha seeds, they are not used by humans. The major goal of jatropha cultivation, therefore, is performed for the sake of extracting jatropha oil. Analysis of jatropha curcas seed shows the following chemical compositions.

Moisture: 6.20% Protein: 18.00% Fat: 38.00% Carbohydrates: 17.00% Fiber: 15.50% Ash: 5.30% The oil content is 25-30% in the seed. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. These are some of the chemical elements in the seed, which is poisonous and renders the oil not appropriate for human consumption. Oil has very high saponification value and is extensively used for making soap in some countries. Also, oil is used as an illuminate in lamps as it burns without emitting smoke. It is also used as fuel in place of, or along with kerosene stoves. Jatropha curcas oil cake is rich in Nitrogen, Phosphorus and Potassium and can be used as organic manure. By thermodynamic conversion process, pyrolysis, useful products can be obtained from the jatropha oil cake. The liquid, solid (char), and gaseous products can be obtained. The liquid can be used as fuel in furnaces and boilers. It can be upgraded to higher grade fuel by transesterification process

3.1 Methods of Extraction of Jatropha Seed Oil:

The extraction process can be classified based on combination of phases (solid, liquid, gas, supercritical fluid). For solid – liquid, this extraction is useful for the isolation and purification of naturally occurring sources while liquid – liquid is a more common method depending on solubility properties of components. Various solvents are used for extraction such as organic solvents and inorganic solvents where, organic solvents are less dense than water while inorganic solvents are denser than water. Commonly used organic solvents are diethyl ether, toluene, hexane, ethyl acetate, ethanol, and inorganic solvents are dichloromethane, chloroform and carbon tetrachloride. The most oil content of Jatropha is in the seed of the plant where it has about 40% of oil.

Traditional Method: these methods by which the oil is extracted from the seeds by hand using simple implements are till practiced in rural and le developed areas.

Mechanical Extraction: Mechanical pressing is the oldest and simplest method for oil extraction. Continuous screw-presses replaced the conventional hydraulic press equipment. Mechanical extraction of the oil is accomplished by exerting sufficient force on confined seed. Under this condition pressure is high enough to rupture the cells and force oil from the seed to escape. Extraction is accomplished by compressing the material in a container that has small perforations, either round or slotted, that allow the liquid component to leave.

Oil Expellers: these are used for the purpose of jatropha oil extraction. The most commonly used ones are the Shayari oil expeller and the komet expeller. The raw materials are squeezed under high pressure in a single step. The machine uses friction and continuous pressure from the screw drive to move and compress the seed material. The oil seeps through small openings that do not allow seed fiber solids to pass.

Hot Oil Extraction: Extraction of oil is done at high pressure. Hot oil extraction leads to the oil flow more quickly due to higher viscosity. The press cake that remains after extraction has less content, which is about 3 to 7%. During the oil extraction method, many stuffing of seeds converts them into gum like substances and some non-organic element. These are unwanted products, and they have to be refined.

Ultrasonic Assisted Extraction: oil extraction is based on ultrasound waves. Ultrasound is used for the extraction of intra-cellular compounds through disintegration of cell structures which is also known as lysis of the cell. The process of extraction oil through this method is known as cavitation. Cavitation's occur when vapor bubbles of a liquid form in an area where pressure of the liquid is lower than its vapor pressure.

3.3 Experimental Work on Jatropha Seed Oil:

For production of bio-diesel from jatropha seed oil different researchers has found different methods for increasing biodiesel yield such as pyrolysis, micro-emulsification, ultra sound energy method, and transesterification. Out of these, transesterification process is the most common procedure used widely throughout the world. In transesterification process there are different types like conventional transesterification (homogeneous catalyst), heterogeneous catalyst, supercritical method (SCM), in-situ process, ultrasound assisted process, and enzymatic process. Each process has its own advantages.

3.4Methodology of Trans-Esterification Process of Jatropha SEED Oil:

1. Conventional transesterification (homogeneous catalyst):

An effective way to produce biodiesel from raw materials of non-edible oil is through two stages. The first step is esterification to reduce the FFA content of the oil. The second step is converting the triglyceride portion of the oils to mono-alkyl ester and glycerol by transesterification. FFA is able to react with the base catalyst to produce soap. It certainly leads to a loss of catalyst, while the soap produced deactivates the catalyst. Therefore, the FFA content has to be removed or converted to alkyl esters via acid esterification. Conventionally, sulfuric acid catalyst is used in acid esterification and alkali metal hydroxides and alkoxides used as catalyst for transesterification reaction.

2. Heterogeneous catalyst:

Homogeneous base-catalysts are reactive on free fatty acids to form unwanted soap as by-products that need expensive separation cost. Thus, the biodiesel production using solid catalysts is preferred. Moreover, the main advantages of heterogeneous reaction come from compatibility with the environment and reduction of manufacturing cost by elimination of the expensive process steps such as separation and purification of biodiesel. Clinker loaded with solid methoxide is used as a catalyst which is reusable and can be carried at low temperatures in single stage only.

3. Supercritical method (SCM):

When the non-catalysed supercritical methanol treatment is applied, the yield of biodiesel has no less significant. By this process, the transesterification of feedstock oil with methanol is done under temperature and pressure, which exceeding the critical properties of methanol. The consequence of transesterification reactions that use supercritical conditions is an expensive investment in process equipment.

4. In-situ process:

In this the oil–bearing material contacts with acidified or alkalized alcohol directly. A catalyst is needed to activate the reaction. Acid or alkali catalyst also helps to hit the cell wall of the seed and improve the ability of the solvent to access the oil. The problem arising from this in-situ method is relatively similar to that of a homogeneous catalyst process; difficult to recycle and impact of serious corrosion and environmental problems.

5. **Ultrasound assisted process:**

The interactions between alcohols and vegetable oils are weak because of their difficult mixed properties and different reactant densities lead to low reaction rates and increased reaction time. One of the most effective and interesting procedures to overcome this problem is by using ultrasonication (ultrasound) that produces sound waves. The chemical effect comes from radicals such as H+ and OH- produced during a transient implosive collapse of bubbles (in a liquid irradiated with ultrasound), accelerate chemical reaction in the bulk medium. Meanwhile, the physical effect comes from emulsification, in which the microturbulence generated due to radial motion of bubbles leads to intimate mixing (homogenize the mixture) of the immiscible reactants. This both effects speed up the reaction rates of the process.

Out of this all-processes heterogeneous catalyst has advantages like reuse of catalyst, elimination of carrion problems etc.

3.4 Trans-esterification 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 product from the step 1, it is trans-esterified to monoesters of fatty acids using an alkali catalyst.

Fig 3.1: Trans-Esterification Process

3.5 Draining of Glycerol Jatropha seed oil as a bio-diesel:

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 than 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 biodiesel as shown in Fig 3.2. 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 trans-esterification of jatropha seed oil is referred as Biodiesel in this work. The Biodiesel is mixed with Petroleum Diesel by the process of Blending with varying proportions to obtain various fuel blends.

CHAPTER - IV

4.EXPERIMENTAL SETUP:

4.1 Basic Theory:

Engine: Engine is a device or a 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, contained internally, is heated by combustion in an external source, through the engine wall or a heat exchanger.

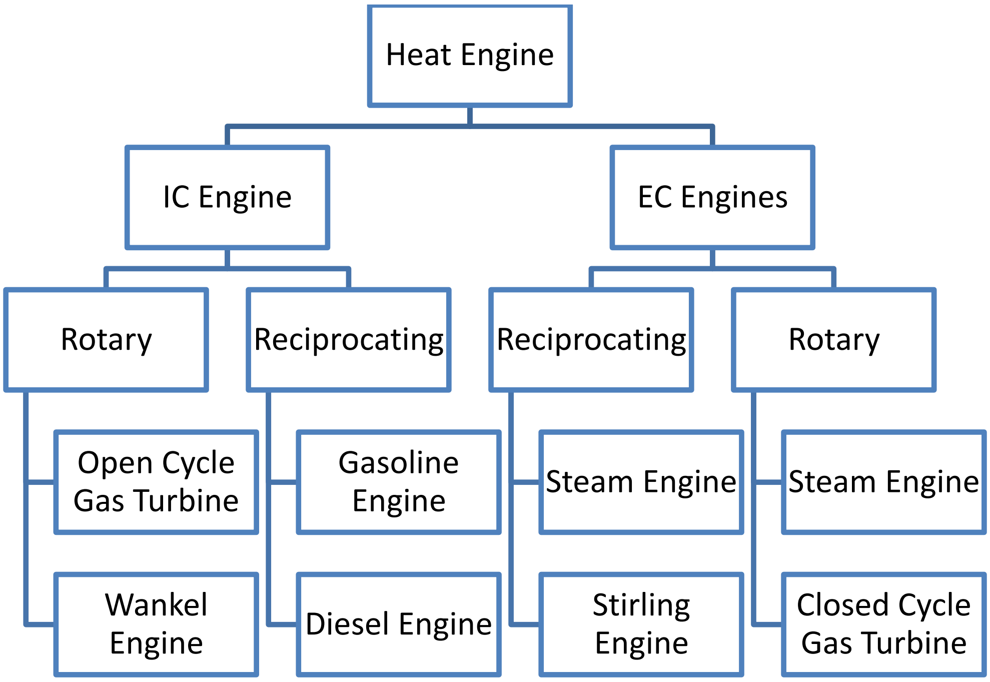


Fig 4.1: Classification of Heat Engine

4.2 IC Engines Classification:

There are several possible ways of to classify IC engines

Reciprocating:

- By number of strokes

   1. Two stroke engines
   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 Diesel Engine Over Petrol Engine:

1. Diesel Engines are More Efficient: As of now diesel engines convert 45-50% of the energy whereas gasoline engines convert only 30% of energy.
2. More Reliable: Because it doesn't require high voltage ignition system so they don't emit RF (radio frequency) issues with vehicle electronic system. As long as good maintenance is done, vehicles life would be around 5,00,000 miles with advancements in turbo technology some drawbacks are minimized.
3. 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.
4. Diesel is Much Safer: Higher flash and fire point makes diesel much safer than gasoline and vaporization loses are less compared to petrol engines.

4.3Diesel 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 to inject the fuel into the cylinder in the form of small droplets which atomizes the fuel with compressed air.

Fig 4.2: Four Stroke, Single Cylinder, Vertical Diesel Engine

4.4 Diesel Cycle:

Unlike Otto cycle, here the heat addition process takes place at constant pressure because the fuel is injected after the compressed air reaches the temperature higher than the self-ignition temperature of the fuel. So, this is also known as

Constant Pressure Cycle but is better to avoid this term as it creates confusion with Joule's cycle.

The following process takes place during the cycle

- Suction: Here, air enters through inlet valve opening due to creation of low pressure inside the cylinder till the crank angle reaches 180 degrees in four stroke engine and 90 degrees in two stroke engines.
- Isentropic compression: In this process, air in the cylinder gets compressed through the movement of piston from bottom dead center (BDC) to top dead center (TDC). Since this process takes place in the short period of interval it can be assumed as adiabatic compression process. The compression ratios are higher in order for the air in the cylinder to achieve self-ignition temperature of the fuel.
- Constant pressure heat addition: At the end of the compression process, when the piston is nearer to TDC the fuel injection starts injecting fuel into cylinder in the form of small droplets due to high temperature and pressure present in the cylinder the fuel vaporizes instantaneously and combustion starts taking place. The fuel is added till the initial part of the power stroke so the air-fuel mixture is allowed to expand during the heat addition.
- Isentropic expansion: After the heat addition is done the power stroke takes place till the BDC and work is transferred to the crank shaft through connecting rod. Since the heat addition done at constant pressure the amount of torque generated can be controlled with the change in fuel addition.
- Constant volume heat rejection: When the piston reaches BDC this process starts with the opening of exhaust valve. Here all the burnt and un-burnt gases escape due to the pressure difference inside the cylinder and exhaust manifold.
- Exhaust: The remaining exhaust gases are pushed out with the movement of piston from BDC and the exhaust valve closes simultaneously when the piston reaches TDC. Thus finishes one ideal diesel cycle process.

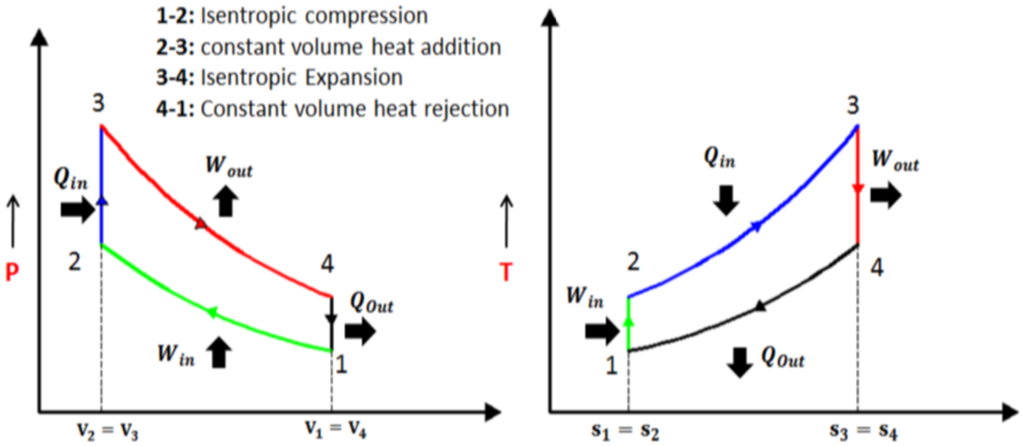


Fig4.3: P-V and T-S Diagram of Otto Cycle

4.5 Types of Diesel Engine:

1. **Two stroke diesel engines:** In this the cycle is completed in one revolution of the crankshaft. The major difference is method of filling the fresh charge and removing the burnt gases from the cylinder. During the expansion stroke, the charge from the inlet uncovers the exhaust port, due to the decrease of pressure to atmospheric value exhaust products leave the cylinder. Further movement uncovers the transfer ports, permitting slightly compressed charge into the cylinder. To eliminate mixing of charges provisions are made on the cylinder which pushes the fresh charge to top portion and allows the burnt gases to leave from cylinder. Now, during the compression stroke charge in cylinder is compressed and fresh charge is introduced using spring loaded valve into the crankcase. This is the basic working process of the two-stroke engine.

2. **Four stroke diesel engines:** The working of this cycle is similar as explained in the above diesel cycle

Advantages of Four Stroke Engine Over Two Stroke Engine:

1. Less noise: 4 stroke engines make less noise and mixture remains only in the combustion chamber.
2. More torque: In general, 4 stroke engines always make extra torque than 2 stroke engines at low RPM. Although 2 stroked ones give higher torque at higher RPM but it has a lot to do with fuel efficiency.
3. More fuel efficiency: 4 stroke engines have greater fuel efficiency than 2 stroke ones because fuel is consumed once every 4 strokes.
4. Less pollution: As power is generated once every 4 strokes and as no oil or lubricant is added to the fuel so 4 stroke engine produces less pollution.
5. More durability: We all know that more the engine runs, quicker it wears out. 2 stroke engines are designed for high RPM. If a 4-stroke engine with 100 rpm will run for 100 minutes than the other 2 stroke engine which has a higher rpm of 500 and will run for only 20 minutes.
6. No extra addition of oil: Only the moving parts need lubrication intermediately. No extra oil or lubricant is added to fuel.

Limitations of Four Stroke Engine:

1. Complicated design: A 4 stroke engine has complex valve mechanisms operated & controlled by gears & chain. Also, there are many parts to worry about which makes it harder to troubleshoot.
2. Less powerful: As power gets delivered once every 2 rotations of crankshaft (4 strokes), hence 4 stroke is less powerful.
3. Expensive: A four stroke engine has much more parts than 2 stroke engines. So, they often require repairs which lead to greater expense.

Combustion Processes in Diesel Cycle:

- Unlike in SI engines, combustion process mainly happens with high compression ratios and heterogeneous mixture combustion takes places due to fuel injection.

Stages of Combustion in CI Engines:

- **Ignition Delay Period:** At the instant of injection of fuel droplets the mixture doesn't ignite immediately so some time is taken up by the cycle to build up pressure inside the chamber which has huge effect on combustion rate, knocking, engine start ability and presence of smoke in exhaust. This period is known as ignition delay period.

  It mainly divided into two parts

1. Physical delay: It is the time between the injection and attainment of chemical reaction conditions. During this the fuel gets atomized, vaporized, mixed with air and reaches self-ignition temperature. It mainly depends on type of fuel used.
2. Chemical delay: In this the reactions starts slowly and accelerate until ignition takes place. Generally, it takes lager time but it depends on temperature of surroundings and at high temperatures it takes shorter time than physical delay.

- **Period of Rapid Combustion:** After the delay period, most of the fuel admitted would have evaporated and forms a combustible mixture with air. The period of rapid combustion starts from end of delay period to the point of attainment of maximum pressure in the cylinder. The rate of heat release is also maximum and it depends on duration of delay period.
- **Period of Controlled Combustion**
- **Period of After-Burning**

4.6 Engine Description:

After the diesel preparation and blending has been done proper type of diesel engine is to be selected which is a crucial step in determining the main conclusions in the project. By conducting survey on the available engines in our locality, based on merits Kirloskar make, four stroke, single speed, water cooled vertical diesel engine test-rig in ANITS college laboratory. The engine is provided with burette, graduations duly marked and three-way valve for fuel flow measurement. Along with-it provisions are made for applying load with the help of spring balance on the brake drum. So, from the above experimental set we can conduct load test on the four-stroke diesel engine and performance characteristics for different blends of bio-diesel can be determined.

Table 4.1: Specifications of Diesel Engine

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
Air Box Orifice Diameter	20 mm
Cooling	Water Cooled
Starting	Hand Cranking
Dynamometer	Rope Brake

4.7 Viscometer:

Viscosity is the measure of resistance offered by the fluid in the form of layers due to gradual deformation by shear stress or tensile stress. In general, it corresponds to the informal concept of “thickness”. For example, oil takes more time to fill than water.

A viscometer (also called viscosimeter) is a device used to measure the viscosity of a fluid which is an important property for determining the characteristics of the bio-diesel. For liquids viscosities which vary with flow conditions, an instrument called rheometer is used. Viscometers only measure under one flow condition. There are different types of viscometers such as Ostwald viscometers or glass capillary viscometers, Falling-sphere viscometers, vibrational viscometers based on different principle of operations.

At 20.00 degrees Celsius the viscosity of water is 1.002mPa and its kinematic viscosity (ratio of viscosity to density) is 1.0038 mm2/s. These values are used for calibrating certain types of viscometers. Redwood viscometer determines the viscosity in terms of seconds. Here, initially time for collection of 50 cc fluid through a small orifice which is uniformly heated in terms of seconds is noted from this value by calculations viscosity can be determined.

Redwood viscometers are of two types:

1. Redwood viscometer No.1 (for fluids having viscosity corresponds to redwood seconds less than 2000)
2. Redwood viscometer No.2 (for fluids having viscosity corresponds to redwood seconds greater than 2000)

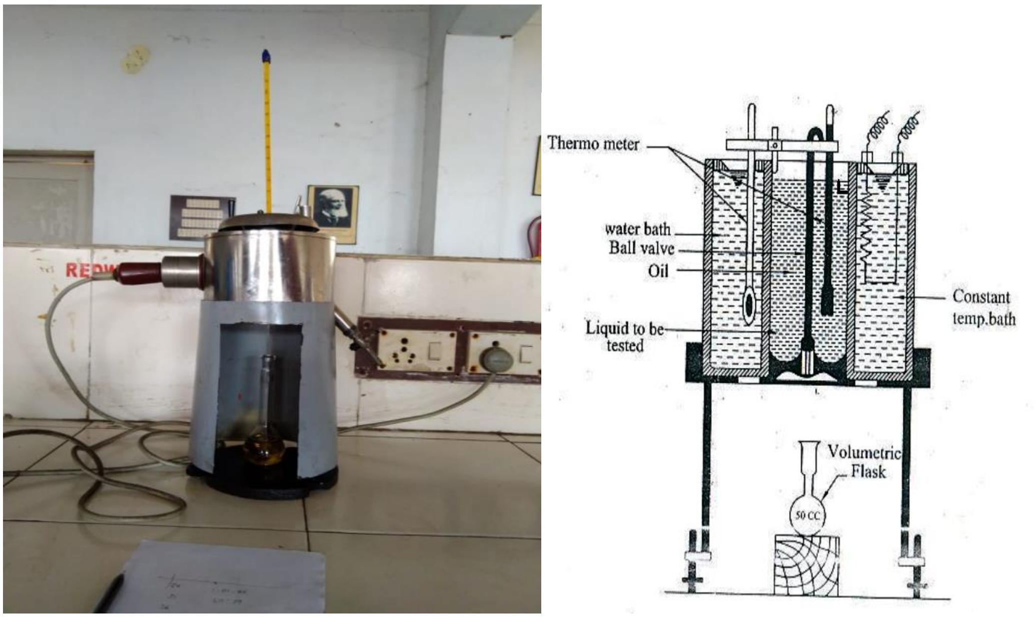


Fig 4.4: Viscometer Apparatus

CHAPTER - V

5.EXPERIMENTAL PROCEDURE:

5.1 Biodiesel preparation:

1. First the oil is manufactured from the jatropha seeds.
2. Removal of impurities and particulate matter from the oil through filter.
3. Removal of water particles by heating the oil up to 100 degrees centigrade.
4. Now allow the oil to cool then methanol and sulfuric acid is added in required quantities.
5. Place the mixture on the heating machine and with the help magnetic stirrer heating and stirring is done simultaneously around 2 hours.
6. In the second stage KaoH billets are added to methanol solution and stirred until the billets gets melted completely. Then this solution is added to the main mixture.
7. Again, the process of heating and stirring is done around 52-55 degrees centigrade until the separation is visible.
8. Now the solution is allowed for sedimentation until clear separation of two layers.
9. One layer contains biodiesel and other glycerol. Glycerol is allowed to solidify and the biodiesel is separated.
10. With the help of distilled water any further impurities are removed from the biodiesel.

- **Precautions:**
  1. Make sure that the apparatus is free from impurities and water particles.
  2. The oil should not contain any other proportions of chemicals.

5.2 Blending:

It is the main process involved for preparation of biodiesels by using a magnetic stirrer mixing is done with different oils to obtain the required properties.

This process involves:

a. Taking proportions of biodiesel.
b. Mixing biodiesel with petroleum diesel in the mixer.

Fig 5.1: Blending of Oils using Magnetic Stirrer

5.3Blending of oils:

In general terminology to indicate the composition of biodiesel is as B5, B10, B15 etc., where "B" represents the percentage of blend.

For example: 10% biodiesel, 90% diesel is represented as B10.

Table 5.1: Oil Proportion in Fuel Blends

Blends	Diesel (ml)	Jatropha Oil(ml)
B 5	712.5	37.5
B 10	675	75
B 15	637.5	112.5
B 20	600	150
B 25	562.5	187.5

Table 5.2: Properties of Oil Blends

	B5	B10	B15	B20	B25
Specific Gravity (gm/cc)	0.8324	0.8360	0.8378	0.8394	0.8422
Calorific Value (kJ/kg)	44406.3	44204.2	44080.6	43608.1	43441.9

5.5 Testing procedure:

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

CHAPTER - VI

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 analysed and the conclusions have been derived.

6.1 Basic Data for Calculations:

1. Rated brake power of the engine B.P = 5 H.P =3.77KW
2. Speed of the 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:

$$\text{Maximum load} = \frac{Rated\ B.P\times60000}{2\pi NR\times9.81}$$

$$= \frac{3.7\times60000}{2\pi\times1500\times0.213\times9.81}$$

$$=11.27\ \text{kg}$$

$$\text{Brake Power (B.P)} = \frac{2\pi N(W-S)\times9.81\times R}{60000}$$

$$\text{Fuel Consumption (F.C)} = \frac{10}{t}\times\frac{specific\ gravity\times3600}{1000}\text{kg/hr}$$

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

CALCULATIONS:

1. Specific fuel consumption (SFC) = $\frac{F.C}{B.P}$kg/KW.hr

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

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

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

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

6.Brake mean effective pressure (BMEP) = $\frac{B.P \times 60000}{L \times \frac{\pi}{4} D^2 \times \frac{N}{2}}$ 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 42000 KJ/kg

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

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

$$=1.1159 \text{ KW}$$

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

$$=\frac{10}{52}\times\frac{0.833\times 3600}{1000}\text{kg/hr}$$

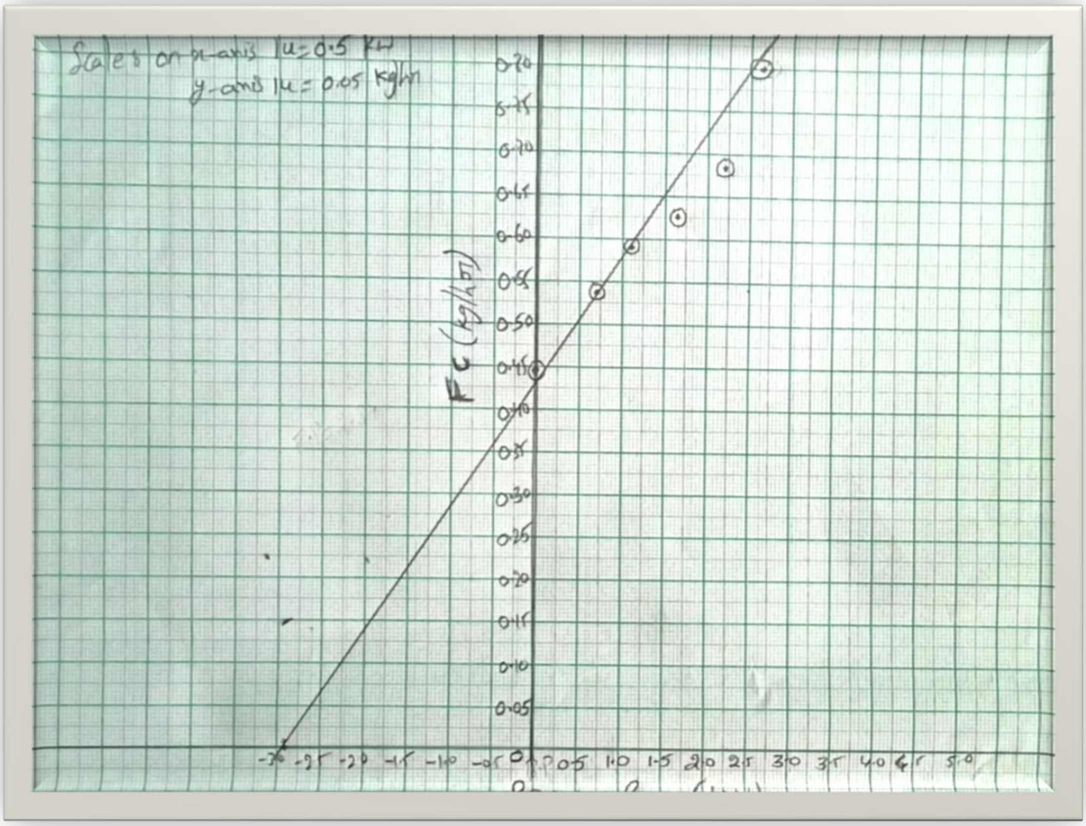
$$=0.5905 \text{ kg/hr}$$

Frictional Power from graph (F.P) =2.841 KW

Indicated power (I.P) = B.P +F. P =1.1159+2.841

=3.9569 KW

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 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 Willan’s line method.



Specific fuel consumption (SFC)= $\frac{F.C}{B.P}$kg/KW.hr

$=\frac{0.5905}{1.1159}$

=0.5289 kg/KW hr

Brake thermal efficiency η_{Bth} $=\frac{B.P\times3600}{FC\times CV}$

$=\frac{1.1159\times3600}{0.5905\times42000}$

=0.16204

=16.204%

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

$$=\frac{3.956\times3600}{0.5905\times42000}$$

=0.57426

=57.426%

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

$$=\frac{1.115}{3.956}$$

=0.28217

=28.217%

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

$$=\frac{3.956\times60000}{110\times10^{-3}\times\frac{\pi}{4}(80\times10^{-3})^2\times\frac{1500}{2}}$$

=572254.15 N/m^2

=5.722 bar

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

$$=\frac{1.1159\times60000}{110\times10^{-3}\times\frac{\pi}{4}(80\times10^{-3})^2\times\frac{1500}{2}}$$

=161462.73 N/m^2

=1.6146 bar

6.3.1 Model Calculations for B10 Blend:

Considering B10 blend at 5 kgf load:

Specific gravity is 0.836 gm/cc

Calorific value is 44200 KJ/kg

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

$=\frac{2\pi\times 1500\times 5\times 9.81\times 0.213}{60000}$

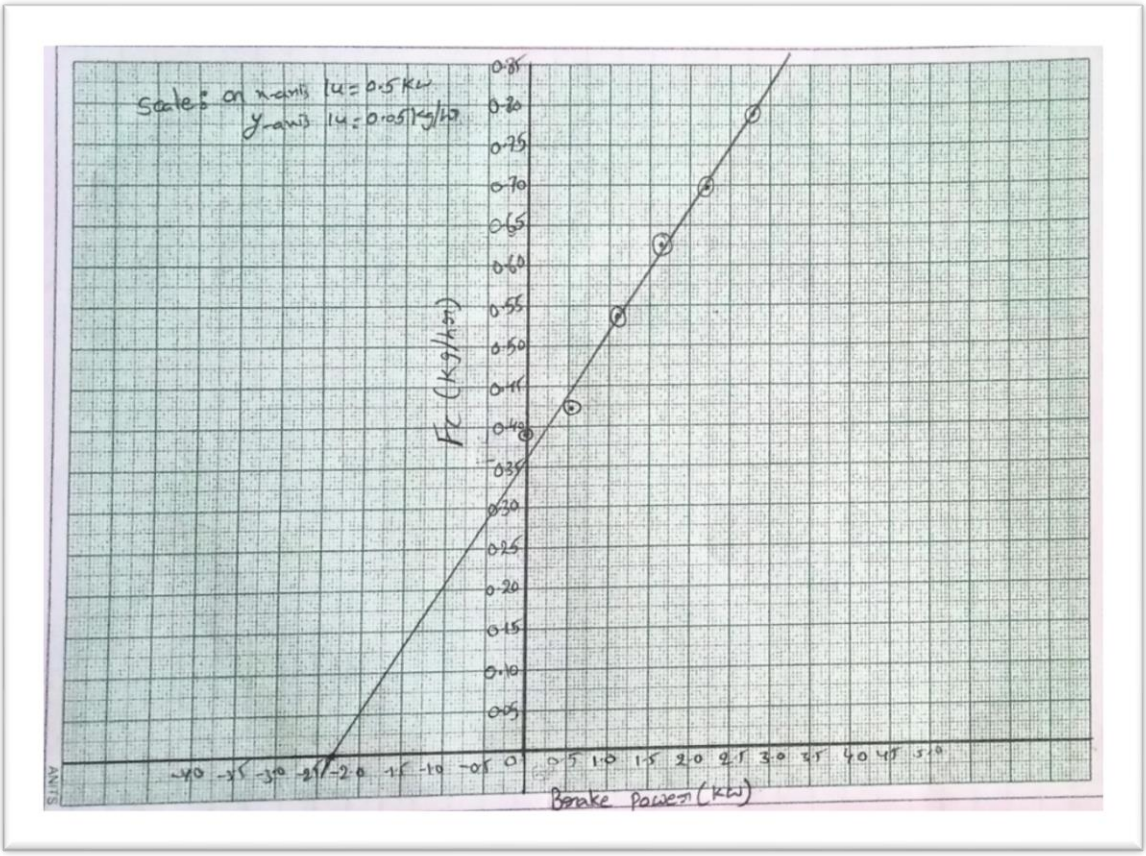
=1.6411 KW

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

$=\frac{10}{48}\times\frac{0.836\times 3600}{1000}$kg/hr

=0.627 kg/hr

Frictional Power from graph (F.P) =2.316 KW



Indicated power (I.P) = B.P +F. P =1.6411+2.316

=3.9571 KW

Specific fuel consumption (SFC) = $\frac{F.C}{B.P}$ kg/KW.hr

$=\frac{0.627}{1.6411}$

=0.3820 kg/KW hr

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

$=\frac{1.6411\times 3600}{0.627\times 44200}$

=0.21318

=21.318%

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

$$=\frac{3.9571\times3600}{0.627\times44200}$$

=0.51401

=51.401%

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

$$=\frac{1.6411}{3.957}$$

=0.41472

=41.472%

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

$$=\frac{3.9571\times60000}{110\times10^{-3}\times\frac{\pi}{4}(80\times10^{-3})^2\times\frac{1500}{2}}$$

=572644 N/m^2

=5.726 bar

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

$$=\frac{1.6411\times60000}{110\times10^{-3}\times\frac{\pi}{4}(80\times10^{-3})^2\times\frac{1500}{2}}$$

=237452 N/m^2

=2.374 bar

TABLES

Table 6.1: Observations for Pure Diesel

S. No	Load on brake drum(W-S) kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power (kW)	Indicated power (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	69	0.445	0	2.84	-	0	54.698	0	4.107	0
2.	1.6	57	0.538	0.525	3.363	1.025	8.358	53.516	15.618	4.864	0.759
3.	3.4	52	0.590	1.115	3.956	0.528	16.204	57.426	28.217	5.727	1.614
4.	5	49	0.626	1.641	4.481	0.415	22.445	61.289	36.622	6.480	2.373
5.	6.8	45	0.682	2.231	5.071	0.355	28.034	63.706	44.005	7.335	3.227
6.	8.4	38	0.808	2.757	5.597	0.310	29.243	59.366	49.258	8.094	3.987

Table 6.2: Observations for B5 Blend

S. No	Load on brake drum(W-S)kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power(kW)	Indicated power (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	70	0.427	0	2.814	-	0	53.33	0	4.107	0
2.	1.6	58	0.516	0.525	3.339	0.983	8.24	52.427	15.725	4.864	0.76
3.	3.4	50	0.599	1.115	3.929	0.536	15.104	53.196	28.395	5.727	1.614
4.	5	45	0.665	1.641	4.455	0.405	19.991	54.270	36.836	6.480	2.374
5.	6.8	40	0.748	2.231	5.045	0.335	24.167	54.637	44.231	7.335	3.230
6.	8.4	37	0.809	2.757	5.571	0.293	27.614	55.800	49.488	8.094	3.989

Table 6.3: Observations for B10 Blend

S. No	Load on brake drum(W-S) kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power (kW)	Indicated power (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	77	0.3908	0	2.316	-	0	48.268	0	3.351	0
2.	1.6	71	0.423	0.525	2.841	0.805	10.110	54.7	18.482	4.111	0.759
3.	3.4	55	0.547	1.115	3.431	0.490	16.609	51.082	32.51	4.966	1.614
4.	5	48	0.627	1.641	3.957	0.382	21.318	51.401	41.472	5.726	2.374
5.	6.8	43	0.699	2.231	4.547	0.313	25.969	52.917	49.075	6.581	3.229
6.	8.4	38	0.792	2.757	5.073	0.287	28.352	52.169	54.346	7.341	3.989

Table 6.4: Observations for B15 Blend

S. No	Load on brake drum(W-S) kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power (kW)	Indicated power (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	81	0.372	0	2.55	-	0	55.89	0	3.689	0
2.	1.6	66	0.456	0.525	3.075	0.8701	9.37	54.91	17.07	4.449	0.759
3.	3.4	57	0.528	1.115	3.662	0.473	15.37	56.54	30.46	5.299	1.614
4.	5	51	0.591	1.641	4.191	0.360	22.64	57.83	39.15	6.063	2.374
5.	6.8	44	0.685	2.231	4.781	0.307	26.57	56.93	46.67	6.918	3.229
6.	8.4	39	0.773	2.757	5.307	0.280	29.09	56.00	51.95	7.678	3.989

Table 6.5: Observations for B20 Blend

S. No	Load on brake drum(W-S) kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power (kW)	Indicated power (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	0.368	0	2.27	-	0	50.861	0	3.284	0
2.	1.6	73	0.413	0.525	2.795	0.788	10.474	55.753	18.787	4.044	0.759
3.	3.4	53	0.570	1.115	3.385	0.510	16.161	49.035	32.958	4.9	1.614
4.	5	44	0.686	1.641	3.911	0.378	19.730	49.769	41.960	5.653	2.374
5.	6.8	40	0.755	2.231	4.501	0.338	24.393	49.204	49.576	6.513	3.229
6.	8.4	37	0.816	2.757	5.027	0.296	27.873	50.823	54.844	7.237	3.989

Table 6.6: Observations for B25 Blend

S. No	Load on brake drum(W-S) kgf	Time for 10cc fuel consumption (Sec)	F.C. (Kg/hr)	Brake power (kW)	Indicated power (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	81	0.374	0	0.45	-	0	54.241	0	3.543	0
2.	1.6	65	0.466	0.525	2.975	0.887	9.334	52.862	17.657	4.303	0.759
3.	3.4	56	0.541	1.115	3.566	0.484	17.033	54.580	31.303	5.158	1.614
4.	5	50	0.606	1.641	4.091	0.369	22.437	55.921	40.128	5.917	2.374
5.	6.8	43	0.705	2.231	4.622	0.315	26.243	55.039	47.680	6.772	3.229
6.	8.4	38	0.797	2.757	5.208	0.289	28.648	54.096	52.950	7.532	3.989

The Frictional Power in case of each blend is determined through the Willian’s Line Method as described earlier. The Willian Line for each blend is obtained from the graphs for Diesel, B5, B10, B15, B20, B25 respectively.

The Frictional Power obtained from the Willan's line method for each fuel blend is as follows:

For Diesel F.P = 2.84 KW
For B5, F. P=2.814 KW
For B10, F. P= 2.316 KW
For B15, F.P = 2.55 KW
For B20, F.P = 2.27KW
For B25, F.P = 2.45 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. By comparing of different blend characteristics values are made to all combinations of conditions.

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. Indicated mean effective pressure

6.4.1 Mechanical Efficiency:Comparison of

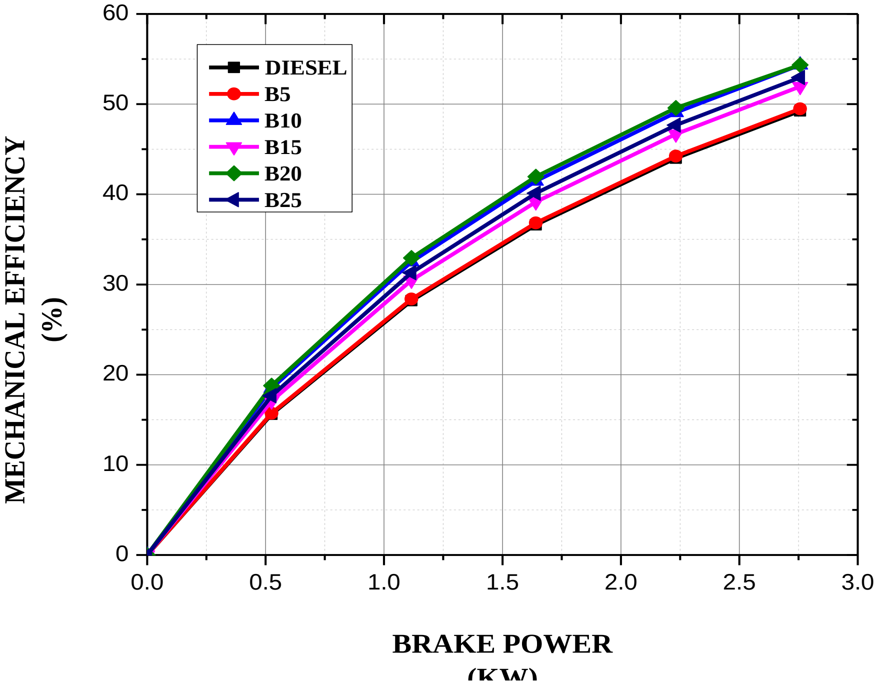
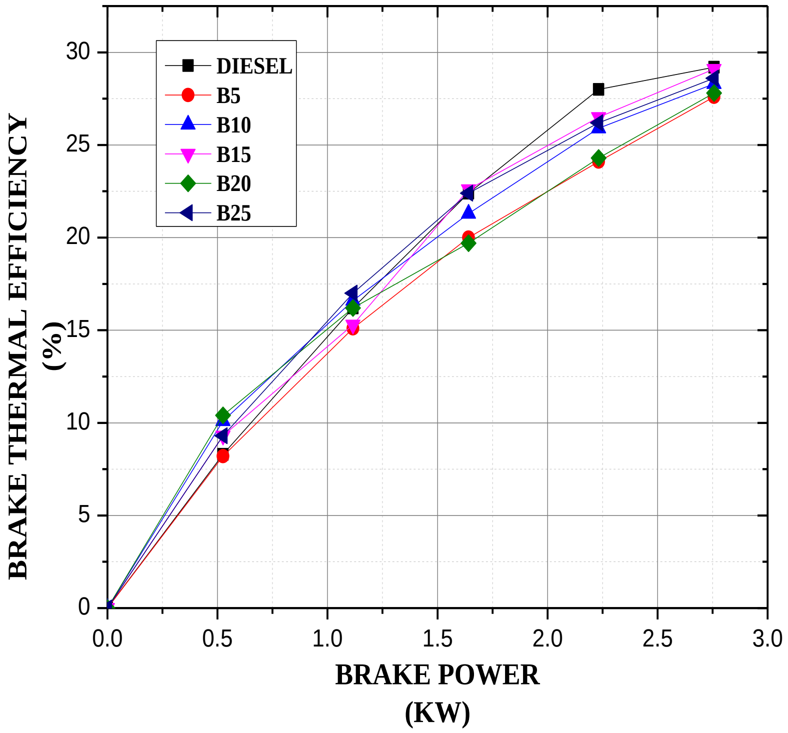


Fig 6.9: Brake Power Vs Mechanical Efficiency

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 Fig 6.9. 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.

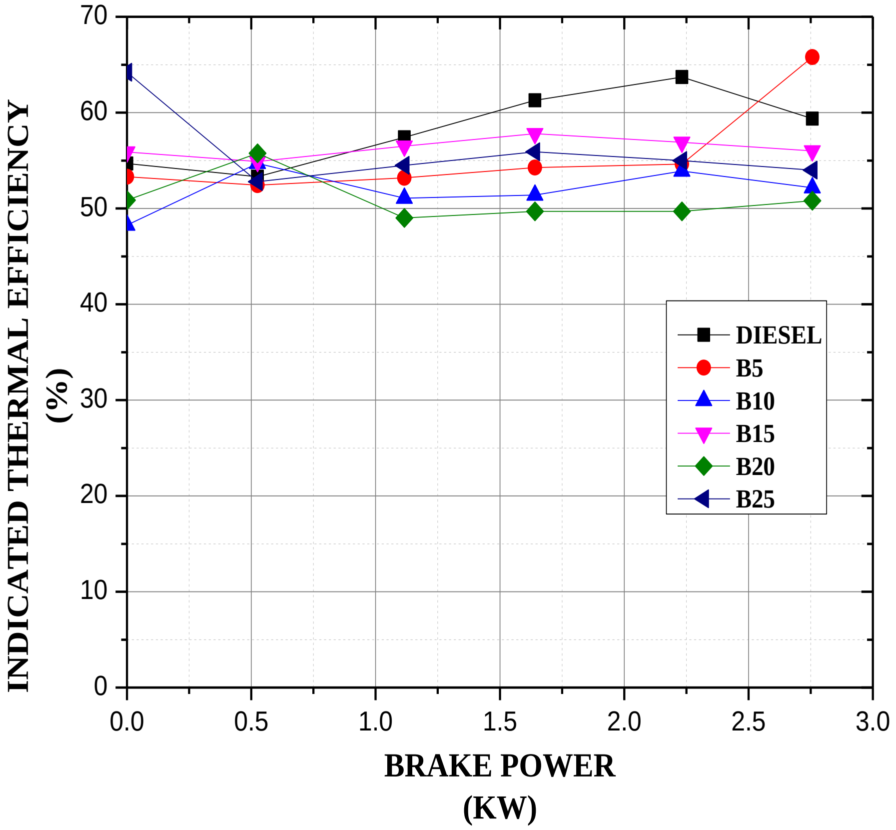
6.4.2 Comparison of Brake Thermal Efficiency:

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. B5 offers least Brake Thermal Efficiency.



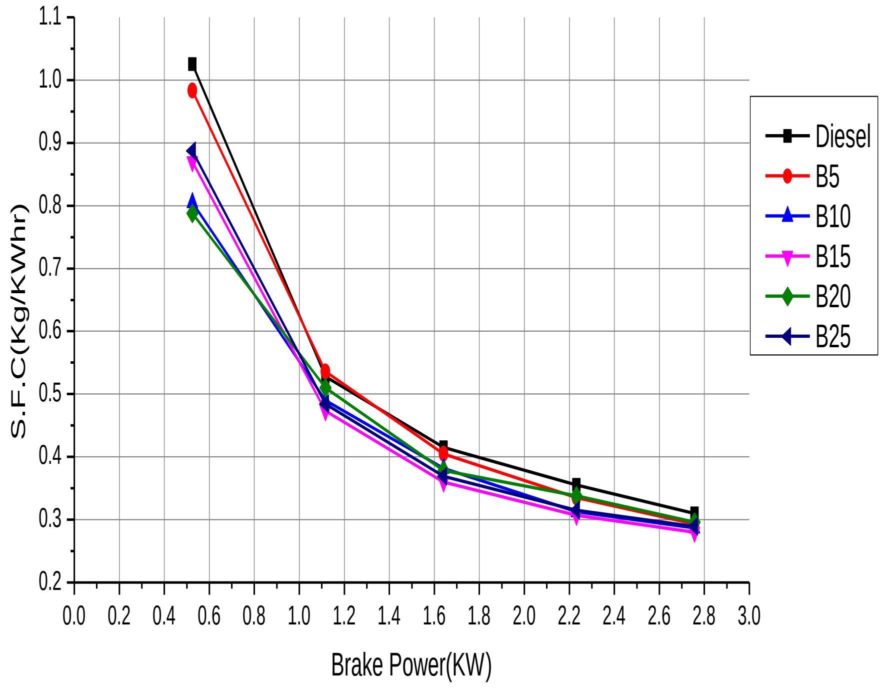
6.4.3 Comparison of Indicated Thermal Efficiency:

The values of Indicated Thermal Efficiency at different brake powers are plotted. B5 blend offers the maximum Indicated Thermal Efficiency of all the mixtures and it seems to be the best mixture, while B20 offers the minimum Indicated Thermal Efficiency.



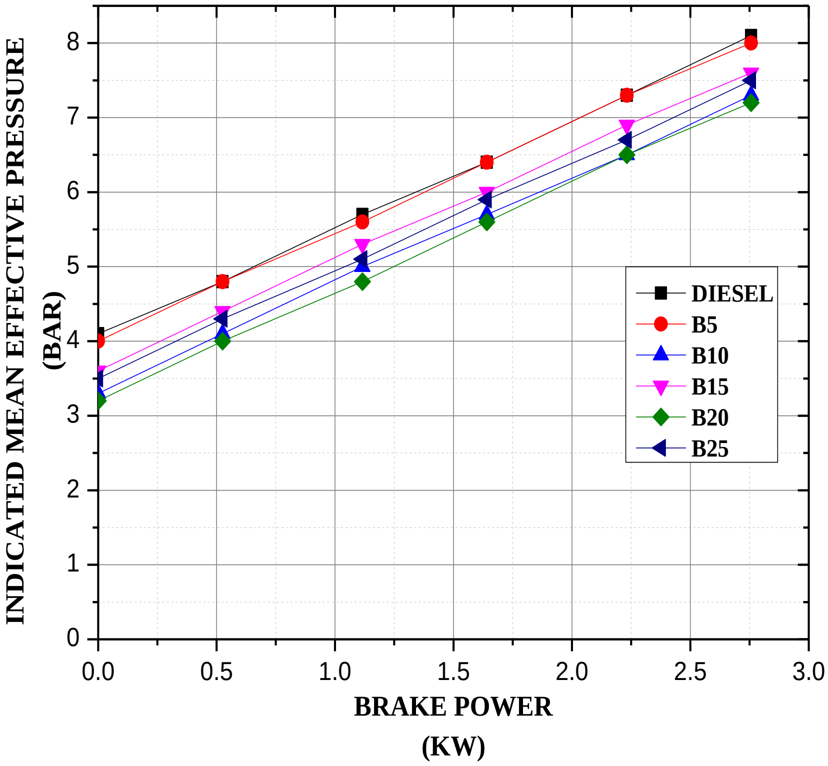
6.4.4 Comparison of Specific Fuel Consumption:

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 are plotted. B15 blend offers the least Specific Fuel Consumption of all the mixtures while Diesel has the maximum Specific Fuel Consumption.



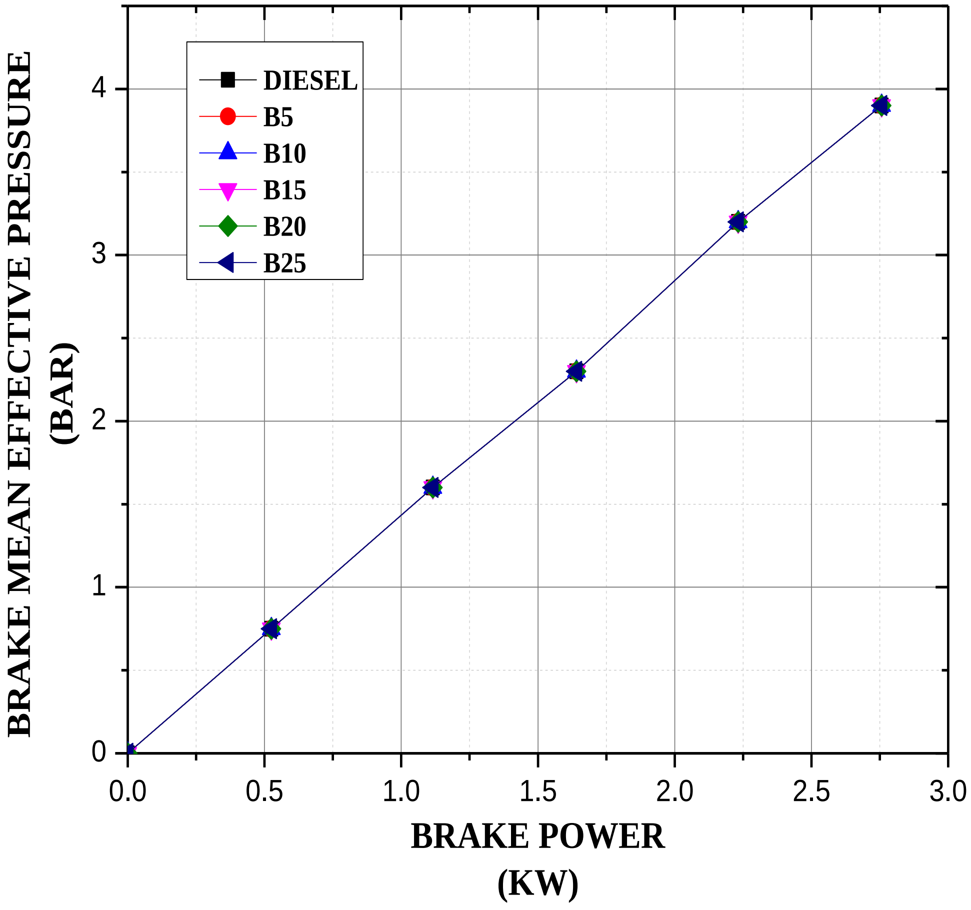
6.4.6 Comparison of Indicated Mean Effective Pressure:

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. 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 B10 offers the maximum Indicated Mean Effective Pressure.



6.4.6 Comparison of Break 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.



6.4.7 Comparison of Frictional Mean Effective Pressure:

The Fig 6.15 shows the graph for Frictional Mean Effective Pressure (F.M.E.P) for the various fuel blends and diesel. The maximum FMEP is obtained for the Diesel while B20 fuel has the minimum FMEP comparatively.

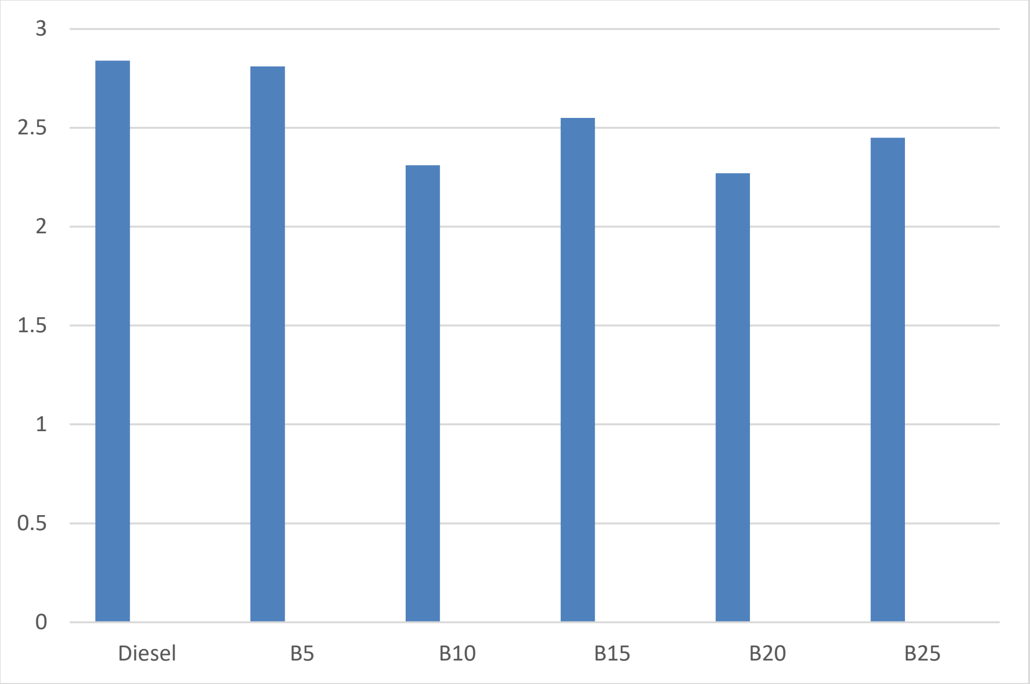


Fig 6.15: Blends Vs F.M.E.P

CHAPTER - VII

7. CONCLUSIONS

An experimental study is conducted to evaluate and compare the use of Jatropha seed 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 pressure etc. were computed. Further the performance characteristics were also plotted.

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 B20 offers the highest mechanical efficiency.
- Comparing the specific fuel consumption for each particular blend, it was observed that B15 has least specific fuel consumption.
- B5 blend offers the maximum Indicated Thermal Efficiency of all the mixtures and it seems to be the best mixture, while B20 offers the minimum Indicated Thermal Efficiency
- 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 B10 offers the maximum Indicated Mean Effective Pressure.
- It can therefore be concluded that B20 blend containing 80% diesel and 20% Jatropha seed oil is the best blend.

Future scope:

The present-day demand can’t be reached by the existing reserves of fossil fuels and efficiency of conversion of this fuel energy to maximum extent is still in the development stages and lot of interest is being created for the topic of alternatives fuels. This substitute for these fossil fuels should have the following features:

- Shouldn’t deplete the existing resources at faster rate and make them available for our future generations.
- Usage of this substitute should have less environmental impacts than present fuels.
- The production of these fuels should be on large scale to meet our present needs efficiently.
- Since biofuels burn faster and cleaner than fossil fuels, it will release greenhouse gases at a lower and slower rate.

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