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SINGLE CYLINDER FOUR STROKE DIESEL ENGINE TAKING BIO-DIESEL MADE BY WASTE COOKING OIL IN DIFFERENT RATIO WITH DIESEL AND THE READINGS OF DIESEL ENGINE

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CHAPTER-1
INTRODUCTION.

1.1 Overview

In this chapter I am studying about the background of alternative sources of petroleum based fuels and studying about methodology of making biodiesel by the use of waste cooking oil through transesterification process, and I also explain the objective of my research work.

1.2 Background

The depletion of world petroleum sources and increased environmental concerns has stimulated recent interest in alternative sources for petroleum based fuels. Biodiesel produced from vegetable oil or animal fats by transesterification with alcohol like methanol and ethanol is recommended for use as a substitute for petroleum-based diesel mainly because biodiesel is an oxygenated, renewable, biodegradable and environmentally friendly bio-fuel with similar flow performance and low emission profile. The used cooking oil has been classified as waste, while its potential as a liquid fuel through physical and chemical conversion remains highly interesting. It is increasingly attracting much interest because of its great potential to be used as a diesel substitute known as biodiesel. Direct process via transesterification of cooking oils will give biodiesel. One of the advantages of these fuels is reduced exhaust gas emissions. Experience has shown that vegetable oil based fuels can significantly reduce exhaust gas emissions, including carbon monoxide (CO), carbon dioxide (CO2), and particulate matter (PM). Because of their less concentration of sulfur, the sulfur dioxide greases cannot only reduce the burden of the government in disposing the waste, maintaining public sewers and treating the oily wastewater, but also helps in lowering the production cost of biodiesel significantly. Furthermore, biodiesel fuel has been shown to be successfully produced from waste cooking oils by an alkali-catalyzed transesterification process and can be considered as alternative fuel in diesel engines and other utilities. There is need to convert waste cooking oil from kitchen waste into biodiesel and transesterification is the most suitable process for this conversion. Present study is carried out to investigate performance and emission characteristics of blended waste cooking oil methyl esters with mineral diesel in different compositions.[2]

Increasing uncertainty about global energy production and supply, environmental concerns due to the use of fossil fuels, and the high price of petroleum products are the major **reasons to search for alternatives to petro diesel. Lean [17] claimed that the global supply of oil and natural gas from the conventional sources is unlikely to meet the growth in energy demand over the next 25 years. In this perspective, considerable attention has been given towards the production of biodiesel as a diesel substitute. Moreover, biodiesel fuel has become more attractive because of its environmental benefits [17], due to the fact that plants and vegetable oils and animal fats are renewable biomass sources. Biodiesel represents a largely closed carbon dioxide cycle (approximately 78%), as it is derived from renewable biomass sources. Compared to petroleum diesel, biodiesel has lower emission of pollutants, it is biodegradable and enhances the engine lubricity and contributes to sustainability. Biodiesel has a higher cetane number than diesel fuel, no aromatics, no sulfur, and contains 10-11% oxygen by weight [6]. Use of neat (unprocessed) vegetable oils in the compression ignition engines is reported to cause several problems due to its high viscosity [17]. Biodiesel which is accepted as an attractive alternative fuel is prepared by transesterification of vegetable oils and animal fats with an alcohol in presence of a catalyst. However, the land use for production of edible oil for biodiesel feedstock competes with the use of land for food production. Moreover, the price of edible plant and vegetable oils is usually higher than petro diesel. The use of waste cooking oil as biodiesel feedstock reduces the cost of biodiesel production since the feedstock costs constitutes approximately 70-95% of the overall cost of biodiesel production. Hence, the use of waste cooking oils and non-edible oils should be given higher priority over the edible oils as biodiesel feedstock.**

1.3 Methodology

Preparation of waste cooking oil methyl ester: The raw material (i.e. waste cooking oil) was collected from Gwalior. The used cooking oil was filtered to remove food residues and solid particle by using layer of cheesecloth in a drum. In order to avoid soap formation due to water the filtered fried oil was dried at 60°C for 10 min using a heating mantle or gas stove. To the preheated mixture of waste fried oil and methanol, NAOH was added. The amount of sodium hydroxide needed was 7.7 g per litter by titration with waste fried oil. Two-hundred mill litre of methanol is used against 1000ml of waste cooking oil (molar ratio 6:1). This solution was stirred at 600 rpm for 15 min and heated approx 30 min continuously after that glycerine was allowed to settle for 24 h. The ester layer was separated from the glycerol layer in a separating drum. Crude ester layer consists of methyl ester, unreached oil and methanol of glycerol, catalyst residue, and small amount of produced soap. In the separating funnel, this layer was washed with hot water, until the washings were neutral. This ester was dried and filtered. [2]

1. 4 Objectives

The aim of the present study is to production of biodiesel from waste cooking oil and evaluation of performance test of different blends of biodiesel with diesel in a CI engine. The following are the major objectives to fulfil the aim of present study.

1. Extraction of biodiesel oils by Waste cooking oil through transesterification process.
2. Performance evaluation of CI engine using different blends of Waste cooking oil biodiesel and diesel.

1.5 Thesis Organisation

Chapter 1 - In this chapter I am studying about the background of alternative sources of petroleum based fuels and studying about methodology of making biodiesel by the use of waste cooking oil through transesterification process, and I also explain the objective of my research work.

Chapter 2 - In this chapter I studied different research papers to find out the which vegetable oils or waste cooking oil uses earlier as a blend in different ratio with diesel for analysing performance of diesel engine on the basis of different parameters.

Chapter 3 - In this chapter all the experimental work carried out, studying about experiment setup and performing the experiment on single cylinder 4-stroke diesel engine, taking biodiesel made by waste cooking oil in different ratio with diesel and record the performance readings of diesel engine.

Chapter 4 - In this chapter all the calculations related work performed. The observation values collected from the experiment which perform on diesel engine, taking and calculate the thermodynamic parameters value by using different formulas. Then the graph is plotted on the basis of different ratio of blend.

Chapter 5 - In this chapter all the results obtained by using different blend ratio are analysed and the best blend ratio on which diesel engine performance reached on its optimum values are obtained.

CHAPTER-2
LITERARUTE REVIEW

2.1 Overview

In this chapter I studied different research papers to find out the which vegetable oils or waste cooking oil uses earlier as a blend in different ratio with diesel for analysing performance of diesel engine on the basis of different parameters.

2.2 Literature Review

Kumari et. al.[1] have presented experimental investigation on "Waste Cooking Oil BioDiesel, Crude Plastic Oil and Their Blends for the Synthesis of Low Cost High Energy Fuels" Plastic is an artificial polymer which is having a wide application in manufacturing industries and consumer products as it is light weight, economical, strong, convenient and durable. Plastic is a non-biodegradable material because of which it is very harmful to the environment. Plastics have use in various spheres of economy - infrastructure, construction, agriculture, consumer goods, telecommunications, packaging, etc. Because of growing plastic industries the amount of plastic waste has also increased which is a major problem in front of environmental researchers.

Parekh et. al.[2] have presented experimental investigation on "Emission and Performance of diesel engine using waste cooking oil blend" One of the bio fuels whose use is rapidly growing is biodiesel. One of the economical sources for biodiesel production which doubles in the reduction of liquid waste and the subsequent burden of sewage treatment is waste cooking oil (WCO). However, the products formed during frying process, such as free fatty acid and some polymerized triglycerides, can affect the transesterification reaction and the biodiesel properties. This works about the engine performance and emissions characteristics of WCO biodiesel on diesel engine. Overall, the engine performance of the WCO biodiesel and its blends was only little poorer than diesel. From the view of emissions, NOx emissions were slightly higher in WCO than diesel while un-burnt hydrocarbon (UBHC) emissions were lower for WCO than diesel fuel. There were no noticeable differences between WCO biodiesel and fresh oil biodiesel as their engine performances and emissions characteristics.

Patel et. al.[3] have presented experimental investigation on "Performance Analysis of C.I. Engine Using Diesel and Waste Cooking Oil Blend" To meet increasing energy requirements, there have been growing interests in alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines. Biodiesels are offer a very promising alternative to diesel oil since they are renewable and have been similar properties. One of the economical sources for biodiesel production which doubles in the reduction of liquid waste and the subsequent burden of sewage treatment is waste cooking oil (WCO). However, the products formed during frying process have affected the transesterification reaction and the biodiesel properties. These experiments about the performance analysis of C.I. engine using diesel and waste cooking oil blend.

Tan et. al.[4] have presented experimental investigation on "Performance and emission study on waste cooking oil biodiesel and distillate blends for micro turbine application**"** Biodiesel is defined as domestic renewable energy resource, which can be derived from natural oils through the transesterification.. Waste cooking oil (WCO) was used as the raw material to produce biodiesel in order to reduce wastes polluting the environment. This paper studies the technical potential of WCO biodiesel to be used as an alternative fuel for micro turbine. The ASTM D6751 and ASTM D2881 standards were selected as references to evaluate the compatibility with distillate to be used as a micro turbine fuel. The performance and emission tests were conducted employing a 30 kW microturbine, without any modification, using biodiesel and distillate blends up to maximum of 20% biodiesel mixing ratio.

Mane et. al.[5] have presented experimental investigation on "Comparative performance analysis of diesel and waste cooking oil (WCO) biodiesel on single cylinder engine" Biodiesel has become more attractive recently because it is made from renewable resources as well as it achieved desired emission standards. Waste cooking oil (WCO) disposal is also a problem because it cannot reuse for cooking, which causes undesirable affect on human health. The processing cost of biodiesel is the main issue to commercialization of the product. The production of biodiesel from waste vegetable oil offers significant benefits on economic aspect, environmental aspect and waste management of cooking oil. From an economic point of view; the production of biodiesel is very easy and simplified process. The study focuses on comparison performance parameters of diesel and waste vegetable biodiesel on single cylinder engine.

Chhetri et. al.[6] have presented experimental investigation on "Waste Cooking Oil as an Alternate Feedstock for Biodiesel Production**"** As crude oil price reach a new high, the need for developing alternate fuels has become acute. Alternate fuels should be economically attractive in order to compete with currently used fossil fuels. In this work, biodiesel (ethyl ester) was prepared from waste cooking oil collected from a local restaurant in Halifax, Nova Scotia, Canada. Ethyl alcohol with sodium hydroxide as a catalyst was used for the transesterification process. The fatty acid composition of the final biodiesel esters was determined by gas chromatography.

Sharma et. al.[7] In this research, Biodiesel was prepared by the process of transesterification, from waste cooking refined soyabean oil. Thereafter, an experimental investigation was carried out on a 4 - stroke Compression ignition engine, with single cylinder which is fueled with blends of Biodiesel and petro diesel. 6 blends of biodiesel were taken for investigating performance characteristics of engine, under different conditions of load. Blend B20 of biodiesel was found most suitable among all blends of biodiesel and petro diesel.

Gad et. al.[8] In this study, a comparative study had been done between blends of biodiesel derived from UCO and diesel fuels. Diesel- UCO biodiesel blends of 10 and 20% was prepared. Experimental investigations were tested in a four strokes, single cylinder, diesel engine at a constant speed of 1500 rpm and variable loads. Diesel-biodiesel blends showed an increase in fuel consumption and specific fuel consumption in comparison with diesel fuel. Biodiesel blends showed a decrease in engine thermal efficiency about diesel fuel. At full load, CO2 emissions for biodiesel blends achieved an increase about diesel fuel. There were reductions in HC and CO emission for biodiesel blends compared to diesel fuel. It is recommended to use used cooking oil biodiesel up to 20% with diesel fuel without any engine modifications.

Bakori et. al.[9] In order to maintain the environmental condition, renewable energy sources must be introduced to a new development. Biodiesel are fuels that made up from renewable sources and its characteristics are usually same as diesel. This study deal with the experimental work carried out on the 4-stroke single cylinder diesel engine with biodiesel/diesel blends on performance of engine. The engine parameter like speed, specific fuel consumption, power and torque with rope brake dynamometer at different load conditions.

Raqueeb et. al.[10] Biodiesel is proved to be the best replacement for diesel because of its unique properties like significant reduction in green house gas emissions, non-sulfur emissions, non-particulate matter pollutants, low toxicity and biodegradability. This paper reviews the pretreatment step, the physical and chemical properties of waste cooking oil, Esterification, Transesterification and production of Biodiesel from waste cooking oil by various methods and catalysts reported so far. The factors affecting the process parameters reported are studied and the point of interest focuses on their Alcohol to oil ratio, Reaction temperature, Catalyst both qualitative and quantitative scope. The optimum condition is investigated and the exhaust emissions of Biodiesel and Petroleum diesel are compared.

Said et. al.[11] This paper reviews the various types of heterogeneous solid catalyst in the production of biodiesel via the transesterification of WCO. The catalysts used can be classified according to their state presence in the transesterification reaction as homogeneous or heterogeneous catalysts. Homogeneous catalysts act in the same liquid phase as the reaction mixture, whereas heterogeneous catalysts act in a solid phase with the reaction mixture. Heterogeneous catalysts are non-corrosive, a green process and environmentally friendly. They can be recycled and used several times, thus offering a more economic pathway for biodiesel production. The advantages and drawbacks of these heterogeneous catalysts are presented. Future work focuses on the application of economically and environmentally friendly solid catalysts in the production of biodiesel using WCO as the raw material.

Chhabra et. al.[12] A single step batch transesterification process of waste cooking oil to obtain biodiesel fuel was studied in order to optimize the process variables such as catalyst concentration, reaction time and reaction temperature which affect the product yield during transesterification process. The variable that was fixed throughout the whole experiment was the molar ratio of methanol to raw oil (6:1).The important properties of waste cooking oil bio-diesel were also determined as per standards. Experiments were conducted using different blends of biodiesel and diesel such as B15, B25, B35 and B45 and its effect on brake power, specific fuel consumption, break thermal efficiency, mechanical efficiency and smoke density etc with respect to the load on the engine were reported. The results of experimental investigation were compared with that of pure diesel. The test results indicate that the B-15 blend of bio-diesel can act as alternative fuel.

Singh et. al.[13] The optimization of production of biodiesel from waste cooking oil from tranesterification process was evaluated on varying the various parameters such as reaction time, KOH concentration and molar ratio. An experimental investigation was carried out to evaluate the performance and emission characteristics of a cooking oil biodiesel blends at various compression ratios like 12, 14 and 16 on a compression ignition engine and important fuel properties were determined. The performance parameters analyzed include BP (Brake Power), BSFC (Brake Specific Fuel consumption), BTE (Brake Thermal Efficiency) and exhaust gas concentration including oxides of nitrogen, HC and CO. The calorific value of optimized waste cooking oil biodiesel was lower than diesel fuel. The flash and fire point of waste cooking oil biodiesel were determined to be 154oC and 160oC respectively which are higher than diesel fuel. The experimental results also showed that the smoke emissions were reduced for all biodiesel mixtures and hydrocarbon (HC) and NOx emissions of B10 blend is lowest among all. There is a slight increase in the carbon monoxide (CO) emission for the B10 blend as compared to B20 and B30. From all the results it was concluded that B10 blend of waste cooking oil biodiesel act as best alternative fuel among all tested fuel at full load condition.

Abdullah et. al.[14] Recycled waste cooking oil is harmful to health, but it is not environmental friendly to dispose used cooking oil just like that. The best solution is to used it for industrial purposes, namely to reproduce into biodiesel. Waste cooking oil is collected from chip cracker Factory in Johor. This project is to produce biodiesel from waste cooking oil using pilot plant and the biodiesel tested in the laboratory. The pilot plants are continuous system to produce biodiesel. The biodiesel was blended with diesel oil to get B5 and B10 grade biodiesel. It produces biodiesel based on the American biodiesel standard ASTM6751. The application of this biodiesel has enabled the company to use its waste cooking oil without having to dispose it and this has save cost to the company. The other advantage is that it has significantly help to preserve environment and as well as conversion of waste to useful energy. The biodiesel plant has also motivated the staff towards thinking about environment and also alternative energy thus sustaining its operation.

Sharma et. al.[15] Waste cooking oils (WCO), which contain large amounts of free fatty acids produced in restaurants, are collected by the environmental protection agency in many parts of the world and should be disposed in a suitable way. Due to the high cost of the fresh vegetable oil, waste cooking oil attracted researcher to produce bio-diesel from waste cooking oil because it is available with relatively cheap price. In this research paper, the Transesterification of waste cooking oil with methanol as well as the main uses of the fatty acid methyl esters is reviewed. The cooking oil was transesterified with methanol using potassium hydroxide as catalyst to obtain bio-diesel by Mechanical Stirrer production technique was carried out. Results which obtained are significantly comparable to pure diesel and gives better performance than conventional diesel fuel.

Jadhav et. al.[16] The paper contains study of diesel engine performance using bio-diesel from waste frying oil. Biodiesel is produced from used frying oil which is obtained from local restaurant and hotels by transesterification process. In the present study neat biodiesel as well as blends of varying proportions of bio-diesel and diesel were used to run C.I. engine. It is found that viscosity of bio-diesel was more which affects the performance of diesel engine. Expectable thermal efficiencies and specific fuel consumption (SFC) were achieved with blends without any operational difficulties. In the present work performance of diesel engine using varying blends of biodiesel like B20, B60 and B100 i.e. neat biodiesel is tested.

2.3 Outcome of Literature Review

Most of the studies were found that dual vegetable biodiesel and its blend so far very few single biodiesel blends of oils have been tried on diesel. Looking after the scope of particular field, I selected the work analysing the performance parameter of diesel engine using waste cooking oil biodiesel blend on 4-stroke diesel engine.

CHAPTER-3
EXPERIMENTAL SETUP

3.1 Overview

In this chapter all the experimental work carried out, studying about experiment setup and performing the experiment on single cylinder 4-stroke diesel engine, taking biodiesel made by waste cooking oil in different ratio with diesel and record the performance readings of diesel engine.

3.2 About the test rig

- **ENGINE-The engine is water cooled single cylinder four stroke constant speed diesel engine 5 HP Make Kirloskar.**
-

Figure 3.2.1: Engine

Table 3.2.1: Engine Specifications

S. no.	Items	Specifications
1	Model	KIRLOSKAR, AV1
2	Compression ratio	19:1
3	Method of starting	Hand starting
4	Type, no. of cylinders	Vertical - 4 stroke, 1 cylinder
5	Bore x stroke(mm)	87.5x110
6	Cubic capacity	624
7	Maximum power	5 Hp
8	Nominal speed	1500 rpm
9	Cooling system	Water-cooled
10	Fuel filter	Present
11	Lube oil filter	Present

Specifications of experimental setup are shown in table:-

- **Rope Brake Dynamometer-**A rope brake dynamometer is supplied with the engine coupled with the flywheel of engine.
- **M.S. Base Frame-**The engine and the dynamometer are mounted on a solid M.S. Channel Base Frame.
- **Load indicator-**It indicates the load in kg range 0-20 kg Make Harrison.
- **Instrumentation for measuring various inputs/outputs-** All instrumentation is incorporated on a control panel. The various factors to be measured are as follows:
  - ♦ **Fuel measurement:** This is done by using burette which is mounted on the control panel. The fuel tank is mounted on panel. The fuel is supplied to engine using a fuel line to fuel injection system. The amount of fuel consumed is determined by the change in the readings shown on the burette. A three - way cock is used both to fill the burette and to allow the fuel to flow to the engine.
  - ♦ **Air flow measurement:** Air flow is measured using an air box Orifice is fixed in the inlet of air box suction pressure difference across the orifice is read on the U-tube manometer mounted on the panel. The outlet of the air suction box goes to the engine through the flexible hose for air suction.
  - ♦ **Temperature measurement:** For heat balance analysis the PT-100 sensors are connected at exhaust gas calorimeter and engine cooling.

3.3 Precautions

- Do not run engine without lubrication oil (oil HD-Type) in ‘Lubrication oil sump.
- Use only diesel as fuel.
- Keep the trainer on rigid surface & well-ventilated room. Keep the trainer at least 1 meter away from the

nearest wall to allow sufficient air circulation.

> Run the engine at no load for around 5 minutes. Do not remove the load suddenly. Load and unload the Engine gradually by adding weights to the weight hanger.

> Before ending the experiment, bring the engine to the no load condition and then stop the engine after running for 2-3 minutes.

> If you are not using the trainer for long time take following.

> Drain the fuel tank, burette and all fuel pipes.

> Do not use de- compressor lever to stop engine.

> There must be sufficient oil in the oil box.

> The rope should be wrapped around the brake drum properly such that it does not slip.

> Ensure zero reading on weighting balance in no load condition. If not adjust it by screw provided on weighting balance.

> Do not start the engine without cooling water supply to the engine and calorimeter.

3.4 Measurement of Thermodynamics key parameters

3.4.1 Fuel consumption: Knowledge of the fuel consumed by an engine and the time it takes to consume this fuel is essential when assessing the quantities of the engine. For petrol and oil engines, the fuel is run through a special measuring device. This can take the form of a reservoir of fuel of known quantity, and the time for the engine to consume this measured quantity of fuel is taken. Alternatively, the fuel may flow through a special flow meter, which is calibrated to give the fuel consumed by direct reading.

3.4.2 Measurement of speed: Measurement of speed using a shaft encoder with analogue or digital display is in principle quite simple.

3.4.3 Specific fuel consumption and efficiency: In engine tests, the fuel consumption is measured as a flow-mass flow per unit time m. f. A more useful parameter is the specific fuel consumption (sfc) the flue flow rate per unit power output. It measures how efficiency an engine is using the fuel supplied to produce work.

3.4.4 Measurement of power: It is the product of torque and speed raises the important question of sampling time. Engines never run totally steadily and the torque transducer and speed signals invariably fluctuate. An instantaneous snaps reading will not necessarily, or even probably, be identical with a longer - term average. Choice of sampling time and of the number of samples to be averaged is a matter of compromise. Under transient condition there may be no choice but to take snap readings.

3.5 Experimental Procedure

1. Fill the fuel tank with the fuel.
2. Start the cooling water supply to the engine and the calorimeter.
3. Fill the burette with the fuel.
4. Switch on the control panel.
5. Start the engine with cranking handle provided.
6. Note down the readings in the observation table.
7. Load the engine gradually by providing weights on the loading hanger.
8. Note down the reading, for various load.

Figure 3.5.1: Waste cooking oil

Figure 3.5.2 Biodiesel formed in Laboratory

Figure 3.5.3: Engine setup

Figure 3.5.4: Heating Mantle

Figure 3.5.5: Tachometer

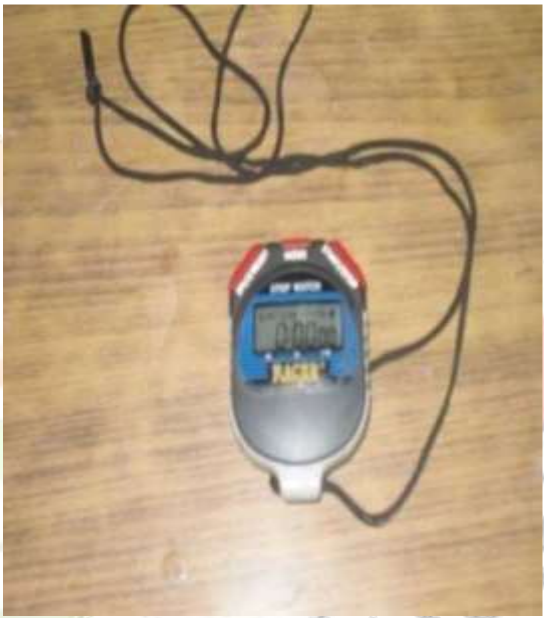


Figure 3.5.6: Stopwatch

CHAPTER-4
OBSERVATIONS, RESULTS AND DISCUSSIONS

4.1 Overview

In this chapter all the calculations related work performed. The observation values collected from the experiment which perform on diesel engine, taking and calculate the thermodynamic parameters value by using different formulas. Then the graph is plotted on the basis of different ratio of blend.

4.2 Observation Table

Abbreviations:

Ti=Exhaust gas temperature at inlet of the calorimeter

T_2=Exhaust gas temperature at outlet of the calorimeter

T_3=Temperature of water at the inlet of calorimeter

T_4=Temperature of water at the outlet of calorimeter

T_5=Temperature of water at the inlet of engine housing

T6=Temperature of water at the outlet of engine housing

Table 4.2.1: Pure Diesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (^{O}C)	T2 (^{O}C)	T3 (^{O}C)	T4 (^{O}C)	T5 (^{O}C)	T6 (^{O}C)
1.	2	0.2	1472	20	110	108	53	26	29	26	36
2.	4	0.4	1470	20	80	130	59	26	30	26	38
3.	6	0.4	1464	20	70	165	69	26	31	26	40
4.	8	0.5	1462	20	56	194	78	26	32	26	42

Table 4.2.2: 95%Diesel, 5% Biodiesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (^{O}C)	T2 (^{O}C)	T3 (^{O}C)	T4 (^{O}C)	T5 (^{O}C)	T6 (^{O}C)
1.	2	*0.2*	1466	20	85	104	56	27	30	27	38
2.	4	*0.4*	1458	20	75	132	65	27	31	27	41
3.	6	0.5	1452	20	70	162	76	27	32	27	43
4.	8	0.5	1446	20	54	186	88	27	34	27	45

Table 4.2.3: 90% Diesel, 10% Biodiesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)
1.	2	0.2	1486	20	90	90	51	25	28	25	36
2.	4	0.4	1476	20	82	110	57	25	29	25	38
3.	6	0.5	1464	20	74	135	66	25	30	25	41
4.	8	0.5	1452	20	57	160	78	25	31	25	43

Table 4.2.4: 85% Diesel, 15% Biodiesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)
1.	2	0.2	1470	20	80	100	56	26	30	26	38
2.	4	0.4	1450	20	74	118	61	26	31	26	41
3.	6	0.5	1442	20	66	140	71	26	32	26	43
4.	8	0.5	1430	20	56	168	83	26	33	26	46

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)
1.	2	0.2	1462	20	90	108	56	25	28	25	37
2.	4	0.4	1446	20	68	120	60	25	29	25	39
3.	6	0.5	1434	20	62	144	70	25	30	25	42
4.	8	0.5	1426	20	55	162	78	25	31	25	43

Table 4.2.6: 75% Diesel, 25% Biodiesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (°C)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)
1.	2	0.2	1428	20	85	104	55	25	30	25	37
2.	4	0.4	1422	20	75	120	61	25	31	25	39
3.	6	0.4	1414	20	62	142	71	25	33	25	42
4.	8	0.5	1410	20	52	166	83	25	34	25	45

Table 4.2.7: 70% Diesel, 30% Biodiesel

Sr. No.	LOAD W(kg)	SPRING LOAD (kg)	N (RPM)	FUEL (ml)	TIME (sec)	T1 (°c)	T2 (°C)	T3 (°C)	T4 (°C)	T5 (°C)	T6 (°C)
1.	2	0.2	1424	20	78	104	56	25	30	25	40
2.	4	0.4	1414	20	70	118	61	25	31	25	42
3.	6	0.4	1410	20	65	147	74	25	32	25	44
4.	8	0.5	1406	20	54	166	84	25	34	25	45

4.3 Analysis of Thermodynamics Performance

The basic performance parameters that were determined for performance evaluation of engine are:

- Brake Power
- Brake thermal efficiency
- Brake specific fuel consumption
- Total fuel consumption

Various formulas that were used for performance evaluation are listed below:

KW

Bp _ 2*n*x^x[(D+d)/2]x(^-5)x9.81 = 60000

Where, D = Dia. of drum = 340mm

d = Dia. of rope = 20mm

(W-S) = net load reading

N = rpm of Crank Shaft

*n = N/2 for Four Stroke

C.V. of diesel = 42.345 MJ/Kg [1]

C.V. of Waste cooking oil = 37.170 MJ/Kg [1]

C.V. of Biodiesel = 39.011 MJ/Kg [1]

Diesel specific gravity = 0.8331[1]

b) Total fuel consumption, TFC =^x *time* *(specificgravity)* ^{kg}/*sec* 1000 [4.2]

BSFC $\frac{TFC}{BP}$ x 3600 kg/kw-hr [4.3]

a) Brake Power

[4.1]

c) Fuel consumption,

$$BTE = \frac{BP}{TFC x CV} \text{ X } 100 \quad [4.4]$$

d) Brake thermal efficiency,

Table 4.3.1: Calorific values of different composition of biodiesel blend

Biodiesel Blend	Calorific Value (MJ/kg)
Pure Diesel	42.34
5 B	42.17
10 B	42.01
15 B	41.84
20 B	41.67
25 B	41.51
30 B	41.34

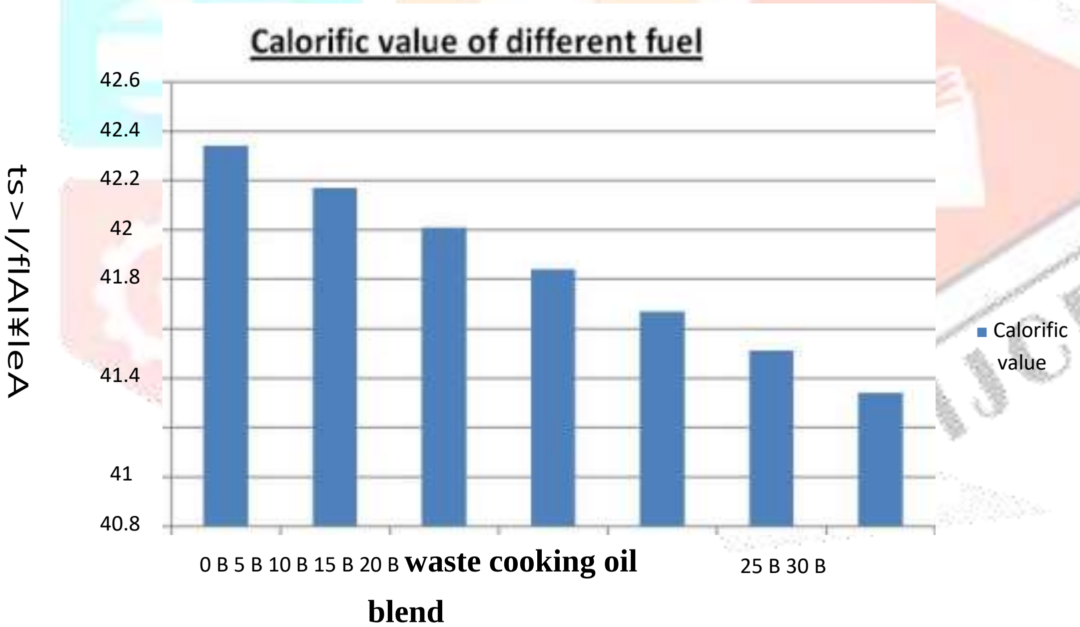


Figure 4.3.1: Graphical representation of calorific values of different composition of biodiesel blend

Table 4.3.2: Total Fuel Consumption & BP of Different blending ratio with Diesel

0 B		5 B		10 B		15 B		20 B		25 B		30 B	
TFC	BP (kW)	TFC	BP (kW)	TFC	BP (kW)	TFC	BP (kW)	TFC	BP (kW)	TFC	BP (kW)	TFC	BP (kW)
1.51	0.489	1.96	0.487	1.86	0.494	2.10	0.489	1.87	0.486	1.99	0.475	2.23	0.473
2.08	0.978	2.22	0.970	2.04	0.982	2.27	0.964	2.48	0.935	2.25	0.946	2.42	0.940
2.38	1.488	2.35	1.475	2.26	1.482	2.54	1.465	2.72	1.457	2.73	1.463	2.61	1.459
2.97	2.026	3.09	2.000	2.94	2.001	3.00	1.982	3.06	1.976	3.25	1.954	3.14	1.948

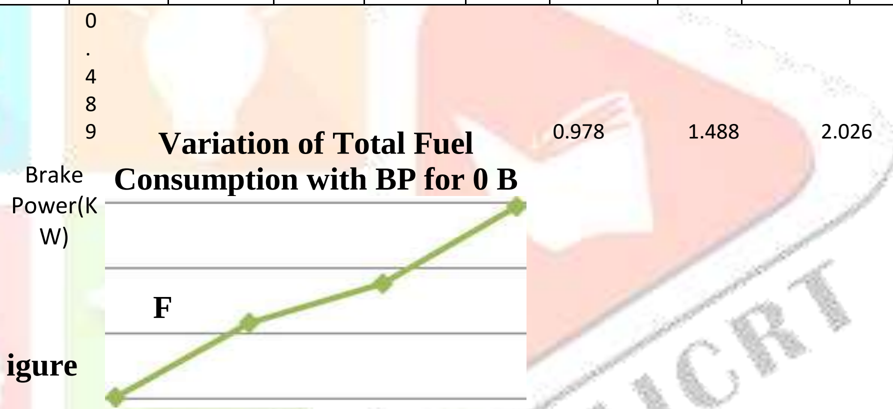


Figure 4.3.2: Variation of Total Fuel Consumption with BP for 0 B **Figure 4.3.2** Shows that the variation in total fuel consumption with BP for 0 B, it is observed that the value of the total fuel consumption is increased as the brake power increases.

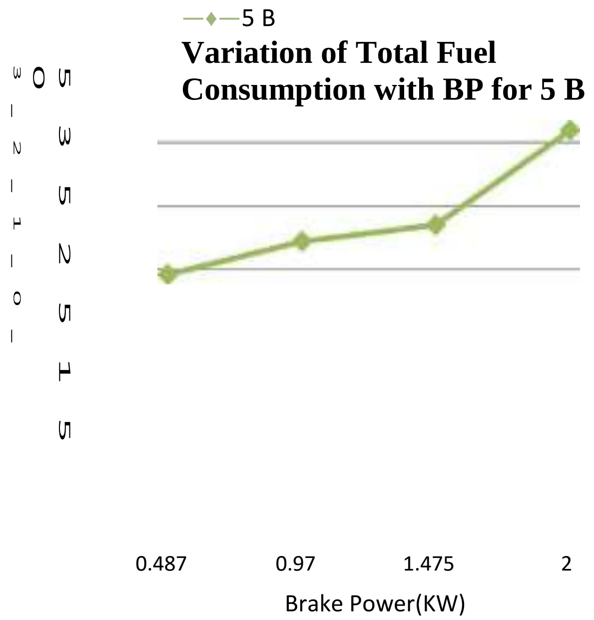
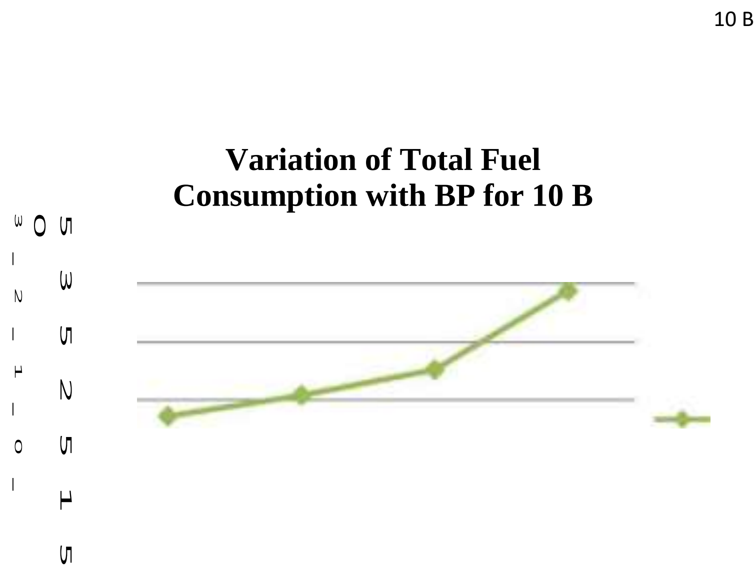


Figure 4.3.3: Variation of Total Fuel Consumption with BP for 5 B

Figure 4.3.3, Shows that the variation in total fuel consumption with BP for 5B. it is observed



that the value of the total fuel consumption is increased as the brake power increases.

15 B

Variation of Total Fuel Consumption with BP for 15 B

0.494 0.982 1.482 2.001

Brake Power(KW)

Figure 4.3.4: Variation of Total Fuel Consumption with BP for 10 B

Figure 4.3.4, Shows that the variation in total fuel consumption with BP for 10B. It is observed that the value of the total fuel consumption is increased as the brake power increases.

Figure 4.3.6, Shows that the variation in total fuel consumptio
observed that the value of the total fuel consumption is increase
increases.

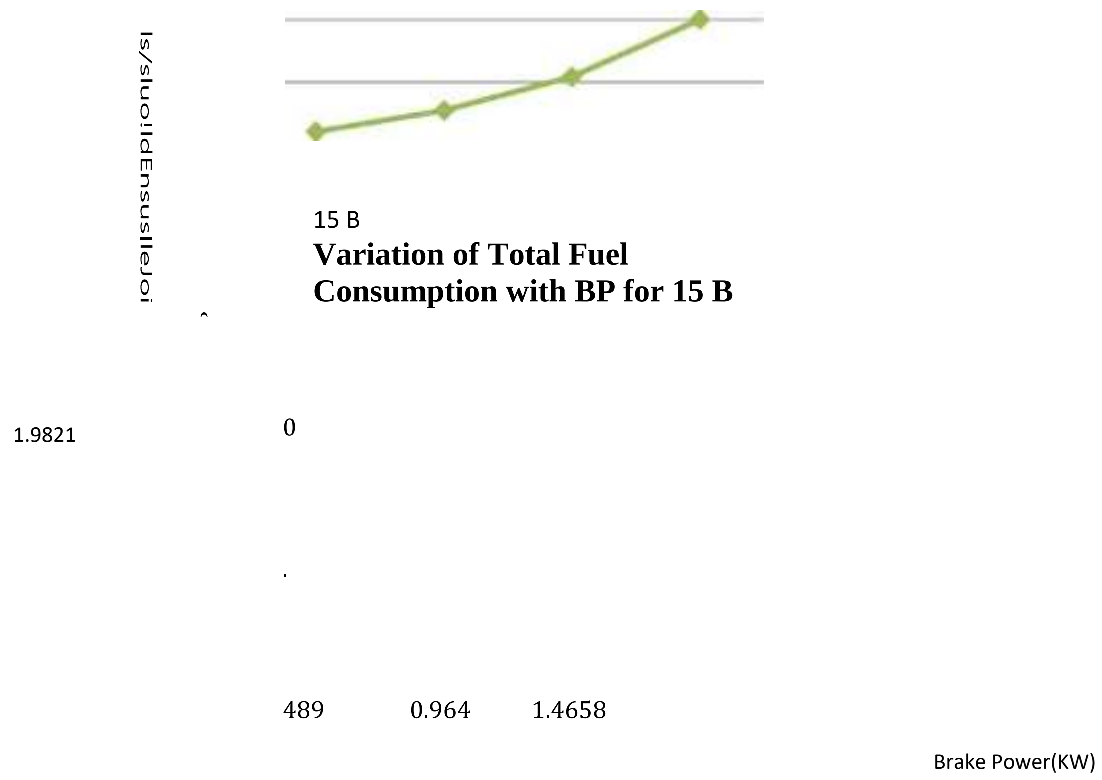


Figure 4.3.5: Variation of Total Fuel Consumption with BP for 15 B

Figure 4.3.5, Shows that the variation in total fuel consumption with BP for 15B. It is observed that the value of the total fuel consumption is increased as the brake power increases.

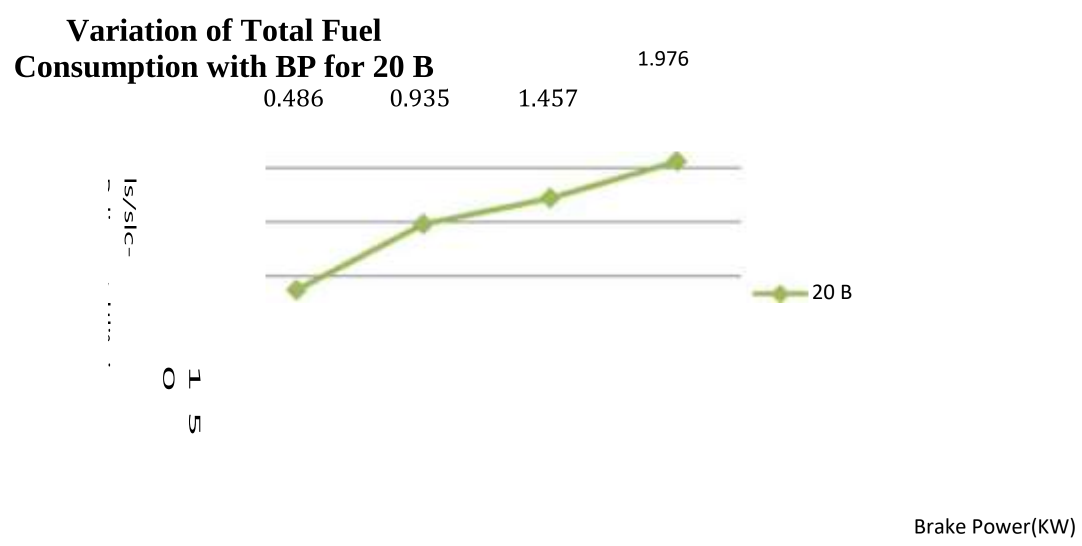


Figure 4.3.6: Variation of Total Fuel Consumption with BP for 20 B

Figure 4.3.6, Shows that the variation in total fuel consumptio
observed that the value of the total fuel consumption is increase
increases.

25 B

Variation of Total Fuel Consumption with BP for 25 B

1.954

0.475 0.946 1.463

Brake Power(KW)

Figure 4.3.7: Variation of Total Fuel Consumption with BP for 25 B

0.946 1.457

Variation of Total Fuel Consumption with BP for 30 B

Brake Power(KW)

30 B

0.473 1.948

Figure 4.3.7, Shows that the variation in total fuel consumption with BP for 25B. It is observed that the value of the total fuel consumption is increased as the brake power increases.

Figure 4.3.8: Variation of Total Fuel Consumption with BP for 30 B

Figure 4.3.8, Shows that the variation in total fuel consumptio
observed that the value of the total fuel consumption is increase
increases.

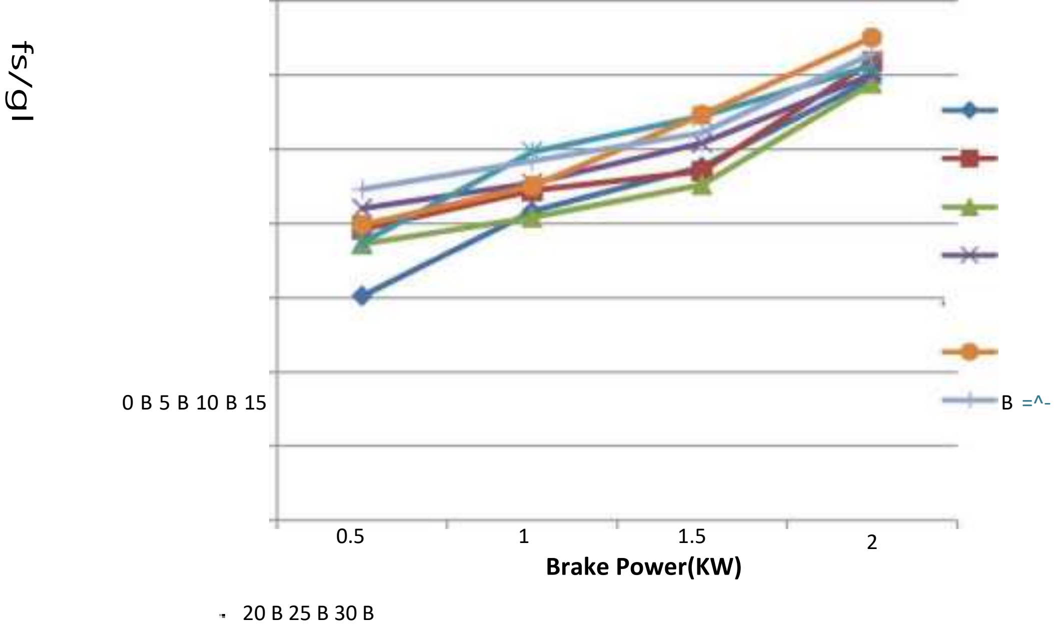


Figure 4.3.9: Variation of Total Fuel Consumption with BP for different fuels Figure 4.3.9, Shows that the variation in total fuel consumption with BP for different fuels. It is observed that the value of the total fuel consumption is increased at 5B but decrease at 10B after that total fuel consumption increases from 10B to 30B, We get minimum total fuel consumption at 10B.

Table 4.3.3: BSFC & Break Powers of different blending ratio with Diesel

0 B		5 B		10 B		15 B		20 B		25 B		30 B	
BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)	BSFC (kg/kW-hr)	BP (kW)
1.11	0.489	1.45	0.487	1.35	0.494	1.54	0.489	1.38	0.486	1.50	0.475	1.69	0.473
0.76	0.978	0.82	0.970	0.74	0.982	0.84	0.964	0.95	0.935	0.85	0.946	0.92	0.940
0.57	1.488	0.57	1.475	0.54	1.482	0.62	1.465	0.67	1.457	0.67	1.463	0.64	1.459
0.52	2.026	0.55	2.000	0.52	2.001	0.54	1.982	0.55	1.976	0.59	1.954	0.59	1.948

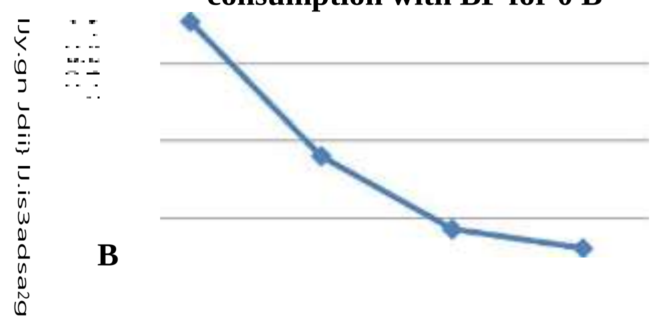


Figure 4.3.10: Variation of Brake specific fuel consumption with BP for 0

Figure 4.3.10, Shows that the variation in Brake specification f
0 B. it is observed that the value of the Brake specification fuel
the brake power increases.

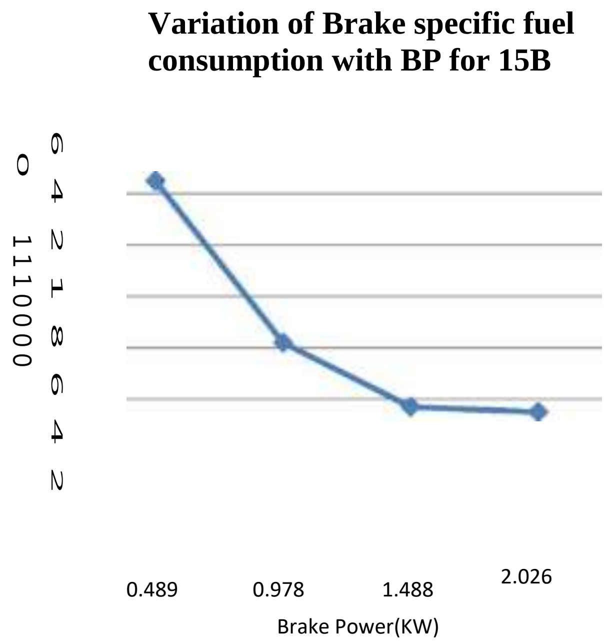


Figure 4.3.11: Variation of Brake specific fuel consumption with BP for 5 B

Figure 4.3.11, , Shows that the variation in Brake specification fuel consumption with BP for 5B. it is observed that the value of the Brake specification fuel consumption is decreased as the brake power increases.

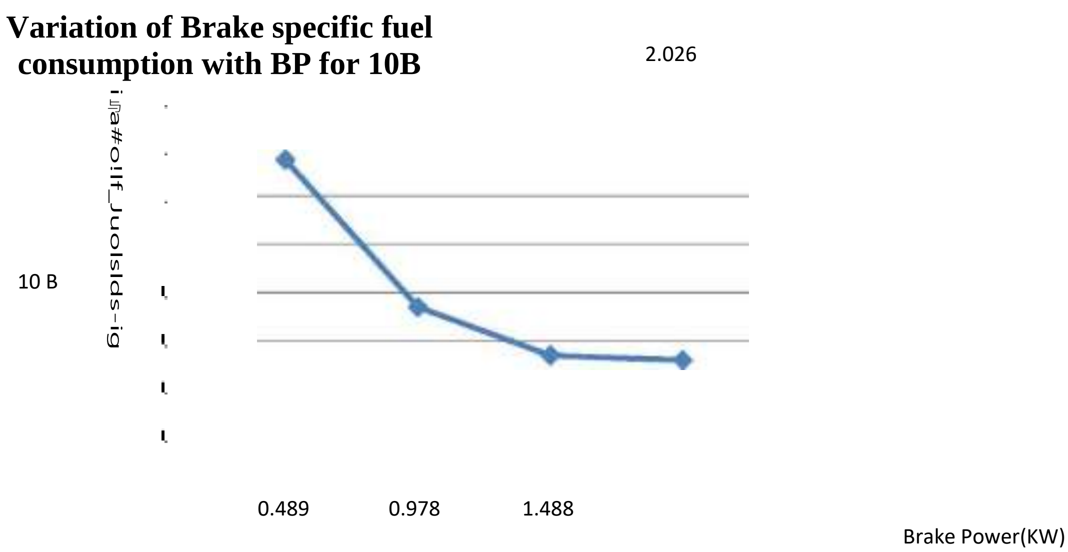


Figure 4.3.12: Variation of Brake specific fuel consumption with BP for 10 B

Figure 4.3.14, Shows that the variation in Brake specification f
20B. it is observed that the value of the Brake specification fue
the brake power increases.

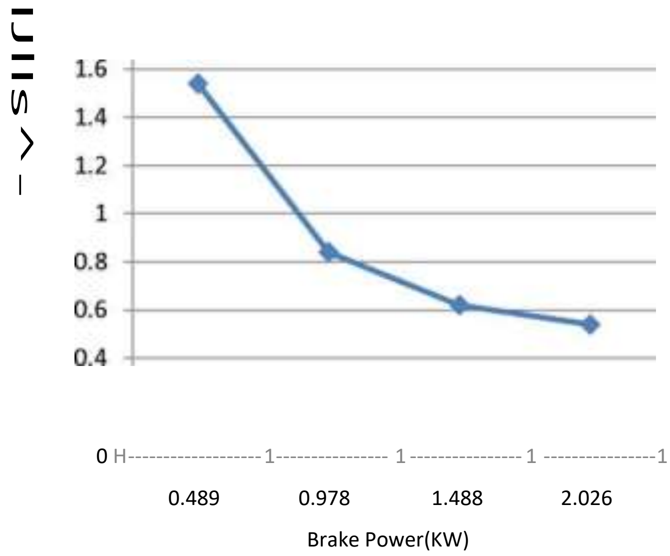


Figure 4.3.13: Variation of Brake specific fuel consumption with BP for 15 B

Figure 4.3.13, Shows that the variation in Brake specification fuel consumption with BP for 15B. it is observed that the value of the Brake specification fuel consumption is decreased as the brake power increases.

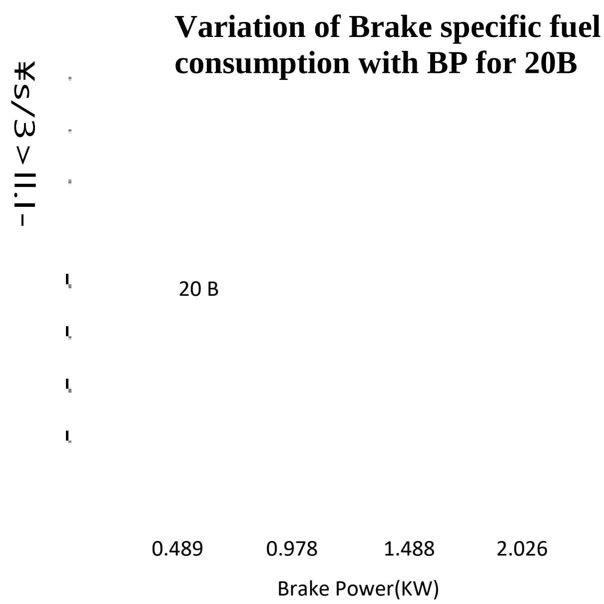


Figure 4.3.14: Variation of Brake specific fuel consumption with BP for 20 B

Figure 4.3.12, Shows that the variation in Brake specification f
10B. it is observed that the value of the Brake specification fue
the brake power increases.

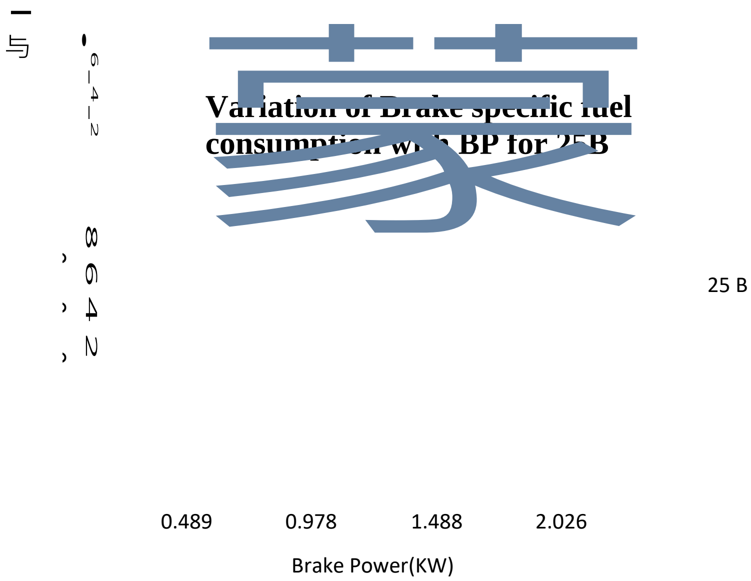


Figure 4.3.15: Variation of Brake specific fuel consumption with BP for 25 B

Figure 4.3.15, Shows that the variation in Brake specification fuel consumption with BP for 25B. it is observed that the value of the Brake specification fuel consumption is decreased as the brake power increases.

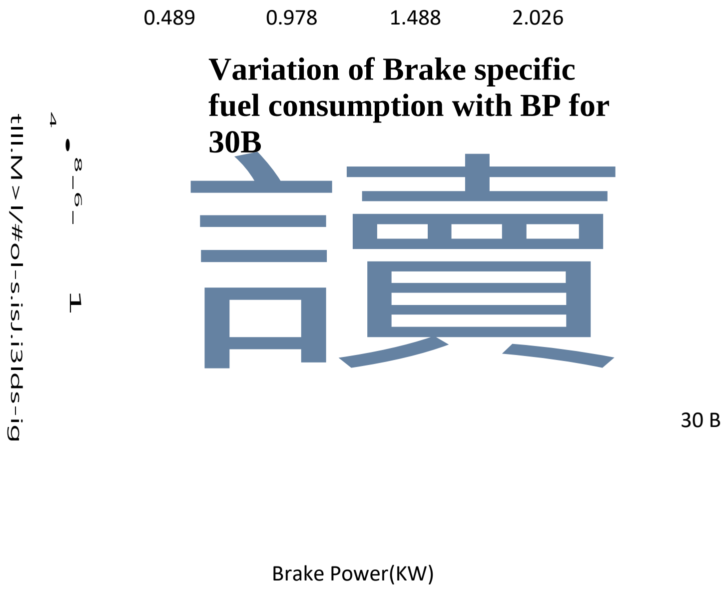


Figure 4.3.16: Variation of Brake specific fuel consumption

Figure 4.3.16, Shows that the variation in Brake specification f
30B. It is observed that the value of the Brake specification fue
the brake power increases

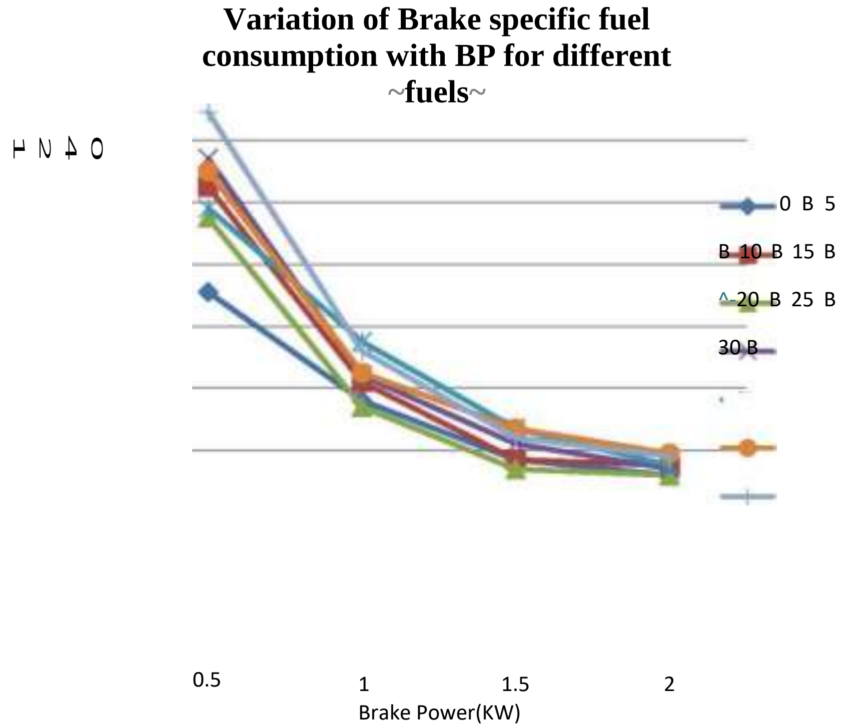


Figure 4.3.17: Variation of Brake specific fuel consumption with BP for different fuels

Figure **4.3.17,** Shows that the variation in Brake specific fuel consumption with BP for different fuels. It is observed that the value of the Brake specific fuel consumption is increased at 5B but decrease at 10B after that Brake specific fuel consumption increases from 10B to 30B, we get minimum Brake specific fuel consumption at 10B.

Table 4.3.4: BTE & Break Powers of different blending ratio with Diesel

0 B		5 B		10 B		15 B		20 B		25 B		30 B	
BTE %	BP (kW)	BTE	BP (kW)	BTE	BP (kW)	BTE	BP (kW)	BTE	BP (kW)	BTE	BP (kW)	BTE	BP (kW)
7.6	0.489	6.6	0.487	6.3	0.494	5.4	0.489	6.2	0.486	5.7	0.475	5.1	0.473
11.1	0.978	11.4	0.970	11.4	0.982	9.9	0.964	9.0	0.935	10.1	0.946	9.4	0.940
14.7	1.488	15.3	1.475	15.6	1.482	13.7	1.465	12.8	1.457	12.9	1.463	13.5	1.459
16.1	2.026	15.3	2.000	16.2	2.001	15.5	1.982	15.4	1.976	14.4	1.954	15.0	1.948

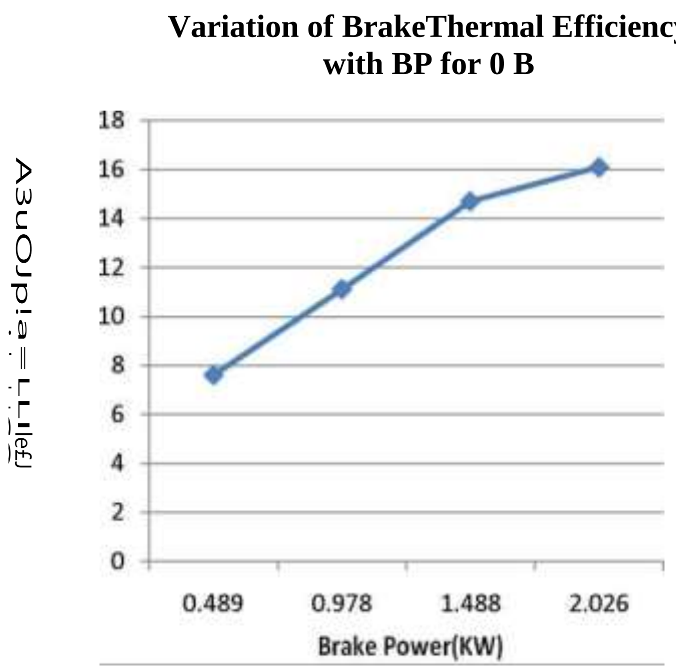


Figure 4.3.18: Variation of Brake Thermal Efficiency with BP for 0 B **Figure 4.3.18** Shows that the variation in Brake thermal efficiency with BP for 0B. it is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

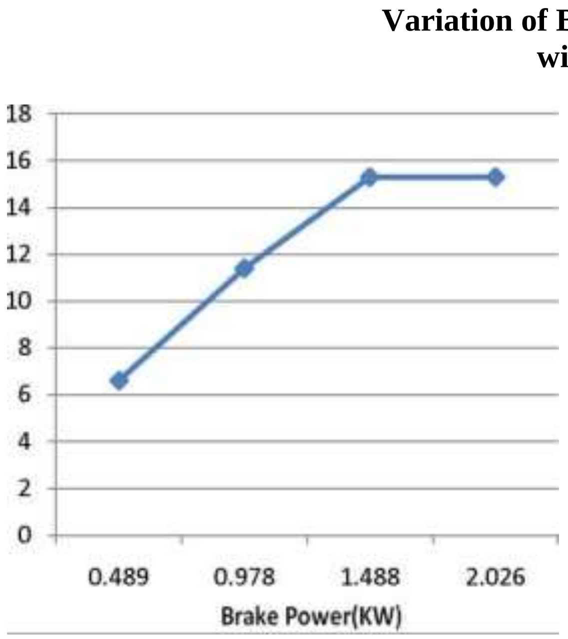


Figure 4.3.19: Variation of Brake Thermal Efficiency with BP for 5 B Figure 4.3.19, Shows that the variation in Brake thermal efficiency with BP for 5B. It is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

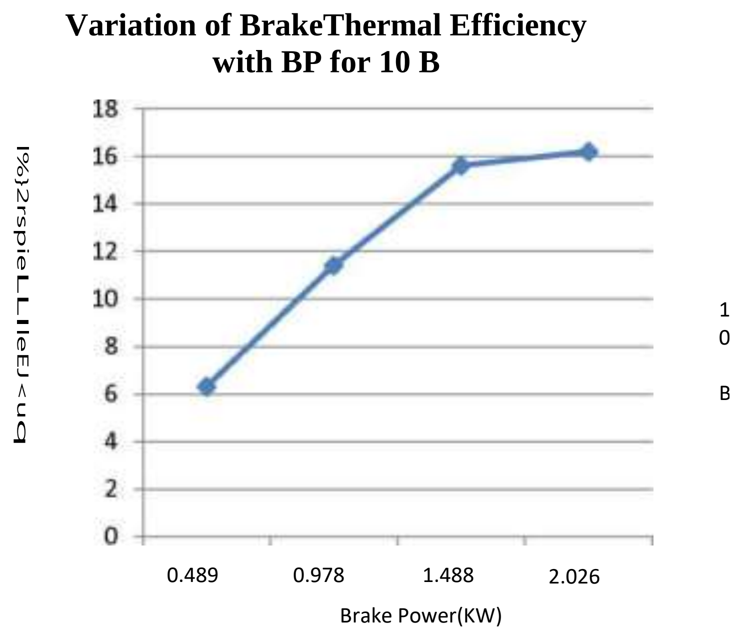


Figure 4.3.20: Variation of Brake Thermal Efficiency with BP for 10 B Figure 4.3.20, Shows that the variation in Brake thermal efficiency with BP for 10B. It is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

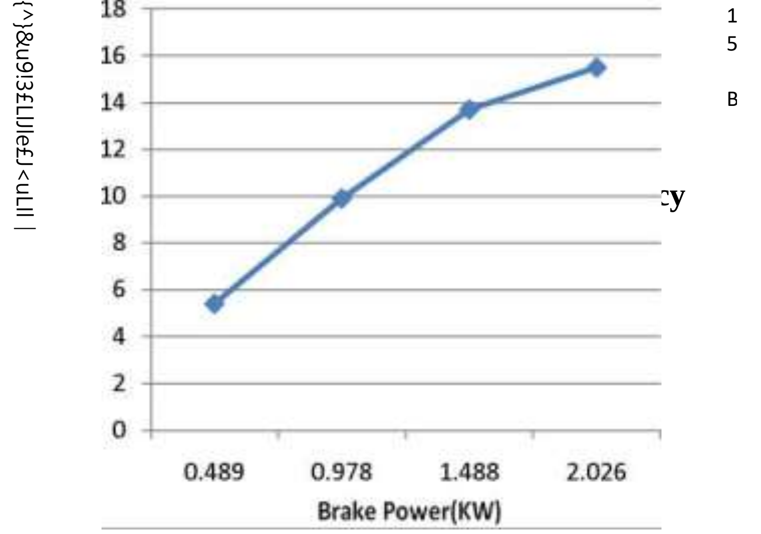


Figure 4.3.21: Variation of Brake Thermal Efficiency with BP for 15 B Figure 4.3.21, Shows that the variation in Brake thermal efficiency with BP for 15B. It is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

Variation of BrakeThermal Efficiency with BP for 20 B

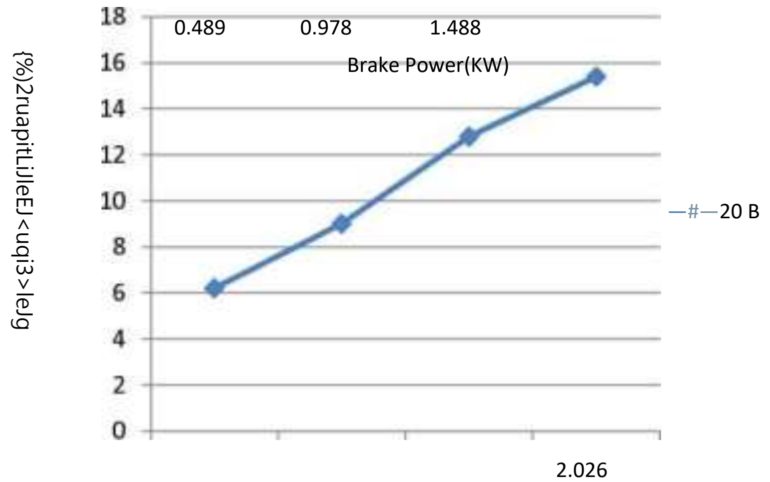


Figure 4.3.22: Variation of Brake Thermal Efficiency with BP for 20 B

Figure 4.3.22, Shows that the variation in Brake thermal efficiency with BP for 20B. It is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

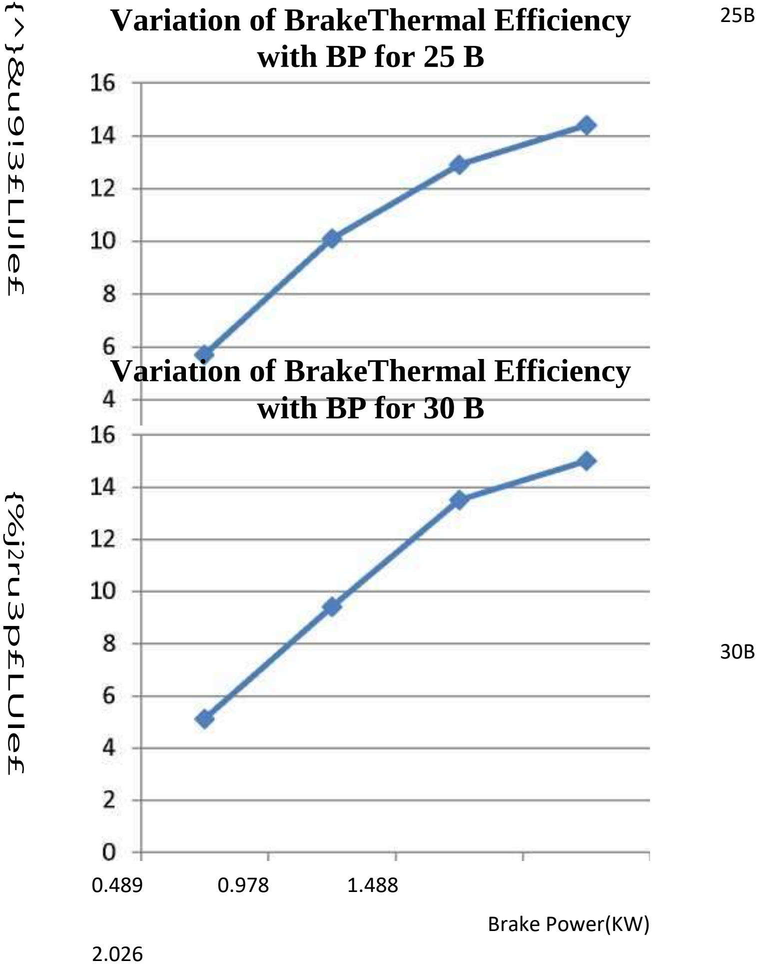


Figure 4.3.23: Variation of Brake Thermal Efficiency with BP for 25 B Figure 4.3.23, Shows that the variation in Brake thermal efficiency with BP for 25B. It is observed that the value of the Brake thermal efficiency is increases as the brake power increases.

Figure 4.3.24: Variation of Brake Thermal Efficiency with I

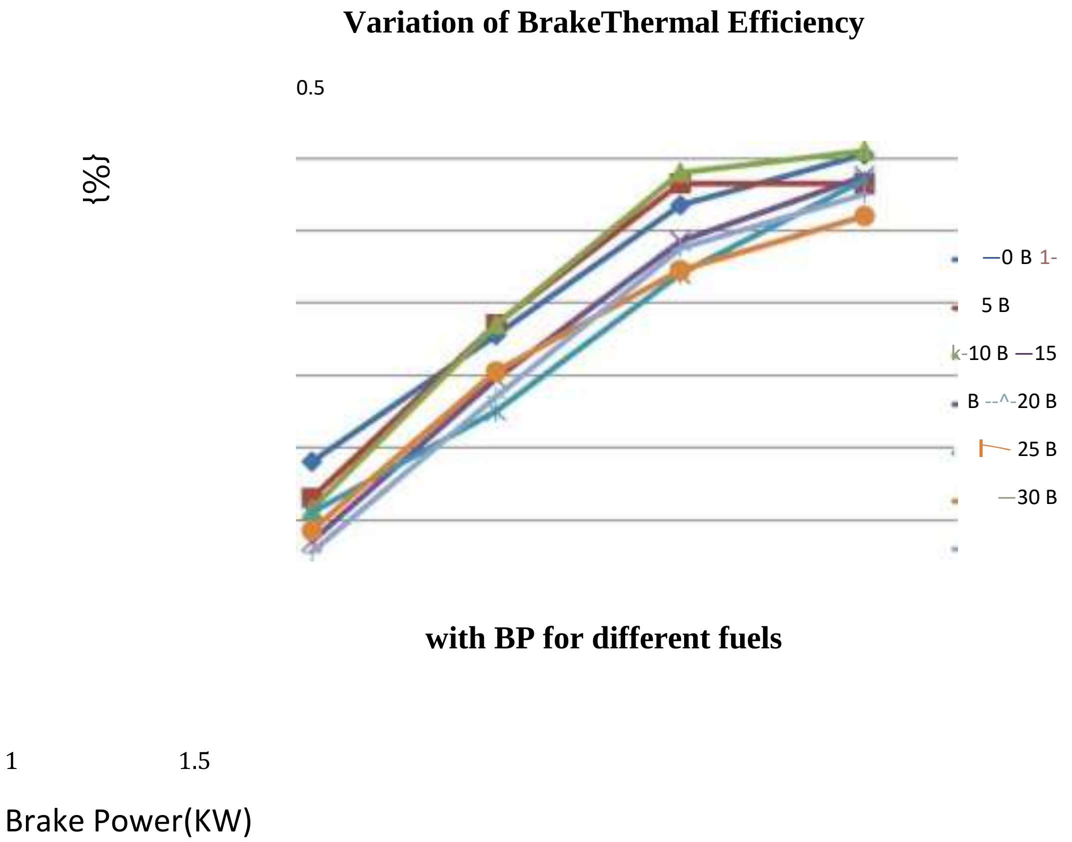


Figure 4.3.25: Variation of Brake Thermal Efficiency with BP for different fuels

Figure 4.3.25, Shows that the variation in Brake thermal efficiency with BP for different fuels. It is observed that the value of the Brake thermal efficiency is decreased at 5B but increased at 10B after that Brake thermal efficiency decreases from 10B to 30B, We get maximum total Brake thermal efficiency at 10B.

Table 4.3.5: Exhaust Gas Temperatures & Break Powers of different blending ratio with Diesel

10 B		15 B		20 B		25 B		30 B	
em erat re C)	BP (kW)	Temperature (°C)	BP (kW)	Temperature (°C)	BP (kW)	Temperature (°C)	BP (kW)	Temperature (°C)	BP (kW)
08	0.494	110	0.489	115	0.486	118	0.475	119	0.473
29	0.982	130	0.964	135	0.935	140	0.946	144	0.940
65	1.482	166	1.465	168	1.457	167	1.463	168	1.459
93	2.001	196	1.982	198	1.976	199	1.954	199	1.948

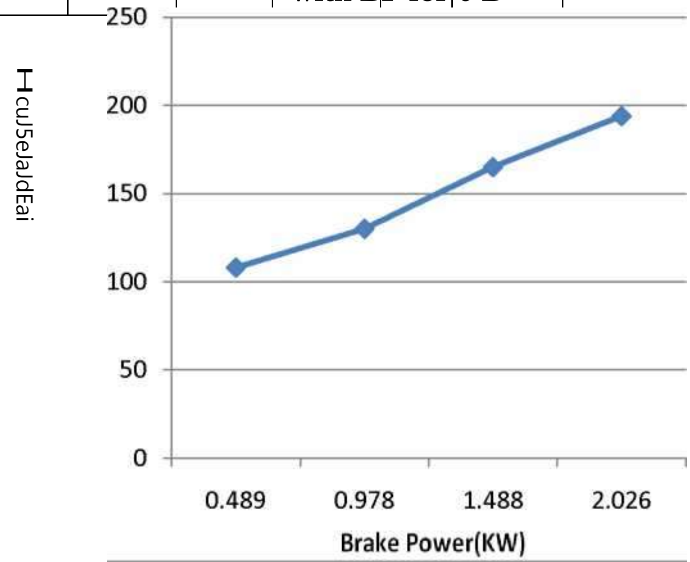


Figure 4.3.26: Variation of Exhaust gas temperature with B

Figure 4.3.26, Shows that the variation in exhaust gas tempera observed that the value of the exhaust gas temperature is increa increases.

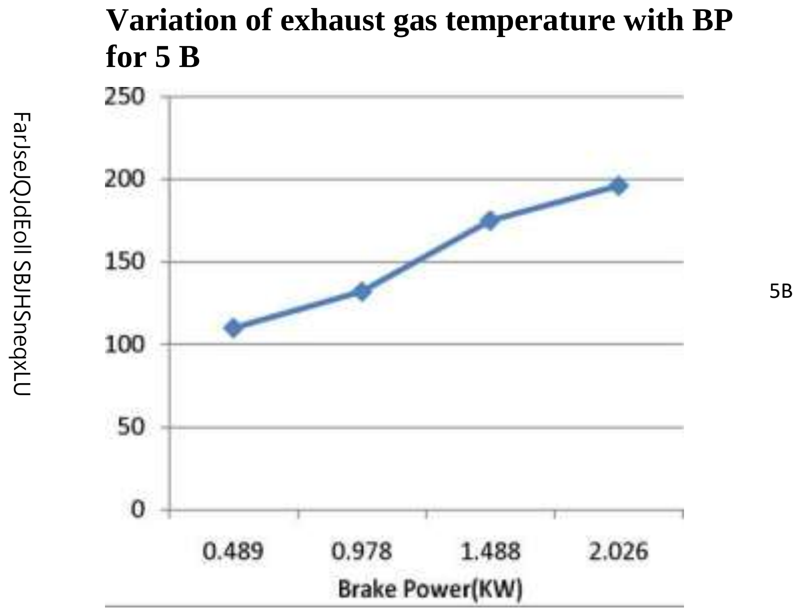


Figure 4.3.27: Variation of Exhaust gas temperature with BP for 5 B Figure 4.3.27, Shows that the variation in exhaust gas temperature with BP for 5B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

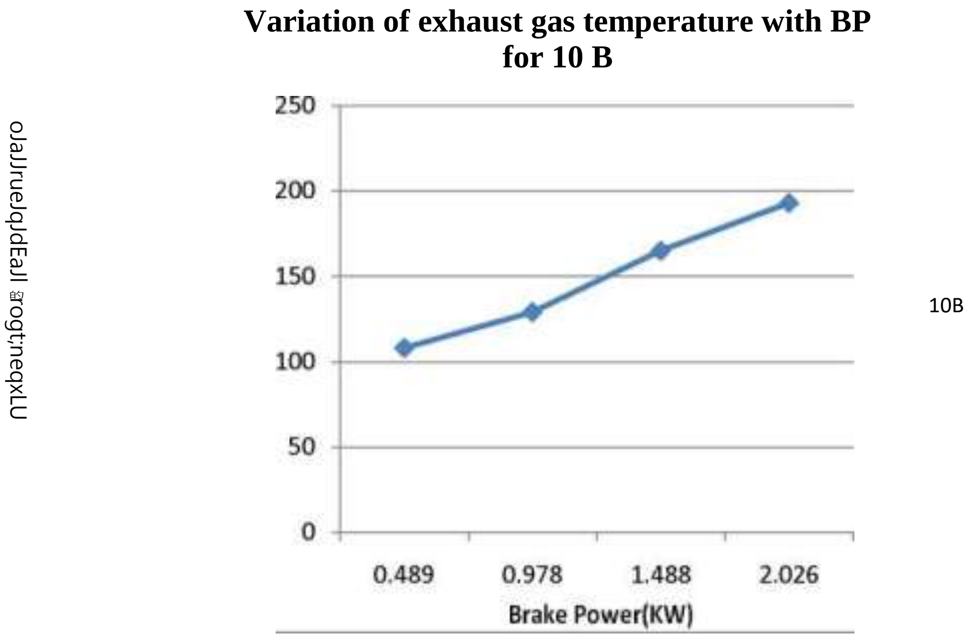


Figure 4.3.28: Variation of Exhaust gas temperature with BP for 10 B Figure 4.3.28, Shows that the variation in exhaust gas temperature with BP for 10B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

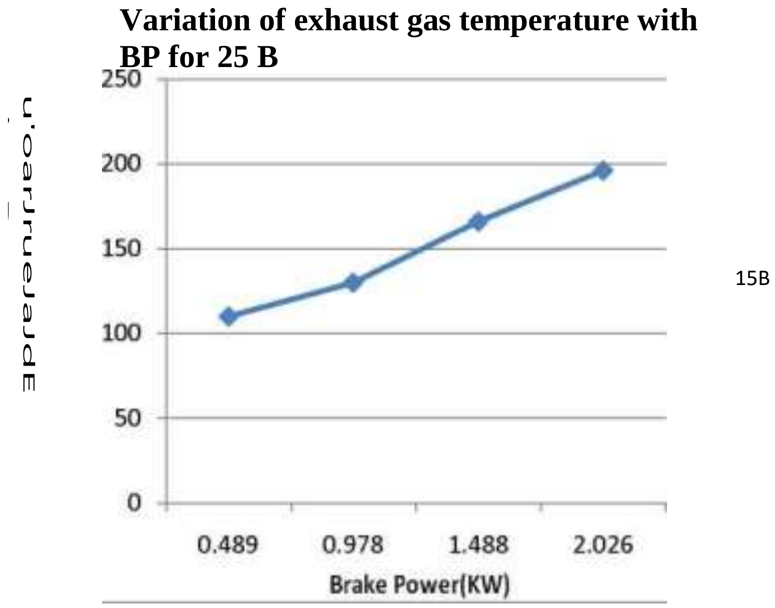


Figure 4.3.29: Variation of Exhaust gas temperature with BP for 15 B Figure 4.3.29, Shows that the variation in exhaust gas temperature with BP for 15B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

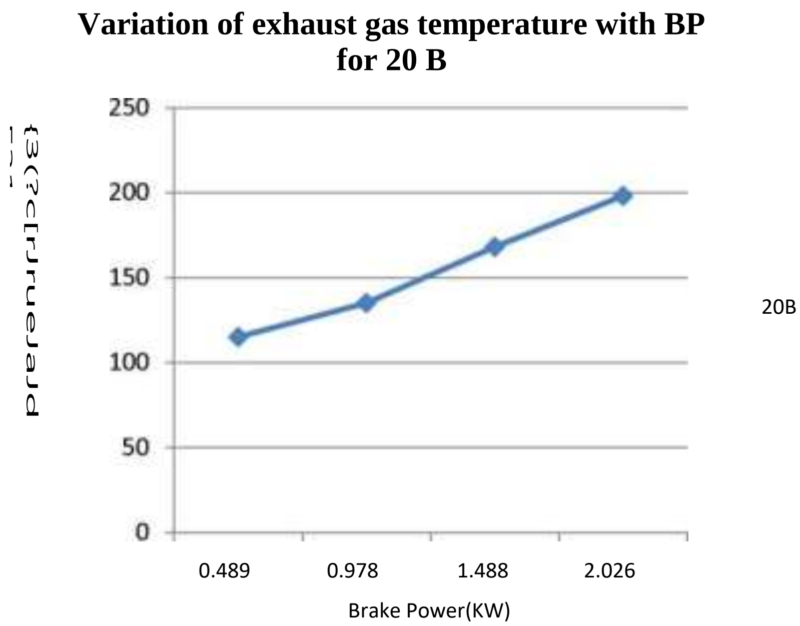


Figure 4.3.30: Variation of Exhaust gas temperature with BP for 20B

Figure 4.3.30, Shows that the variation in exhaust gas temperature with BP for 20B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

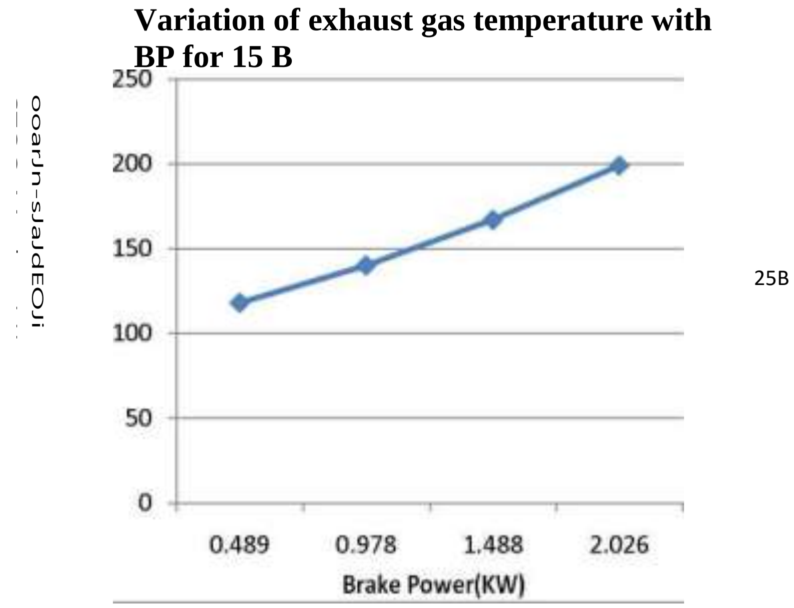


Figure 4.3.31: Variation of Exhaust gas temperature with BP for 25 B **Figure 4.3.31,** Shows that the variation in exhaust gas temperature with BP for 25B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

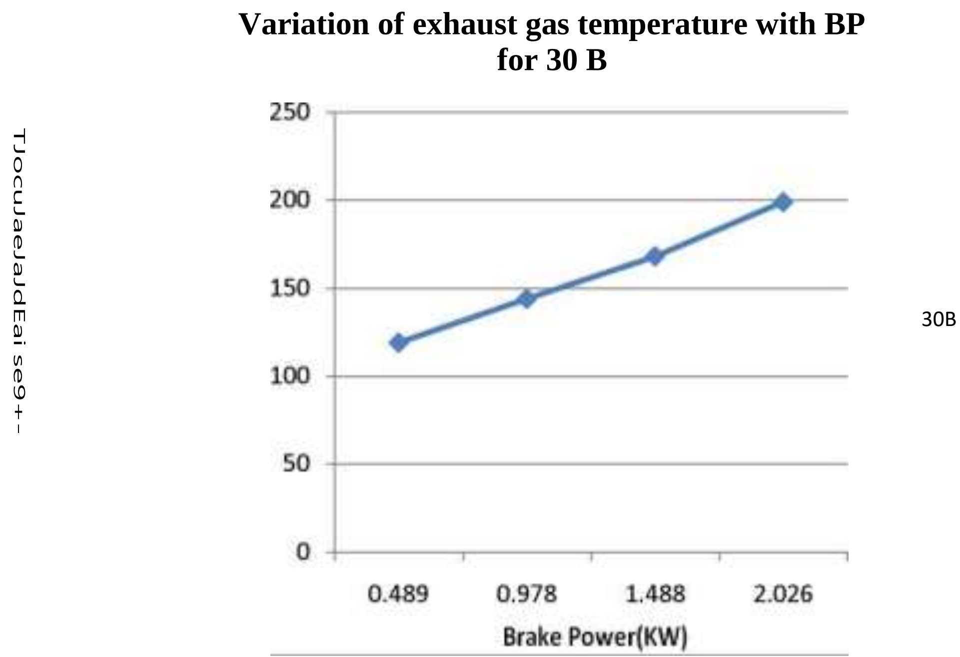


Figure 4.3.32: Variation of Exhaust gas temperature with BP for 30 B

Figure 4.3.32, Shows that the variation in exhaust gas temperature with BP for 30B. It is observed that the value of the exhaust gas temperature is increases as the brake power increases.

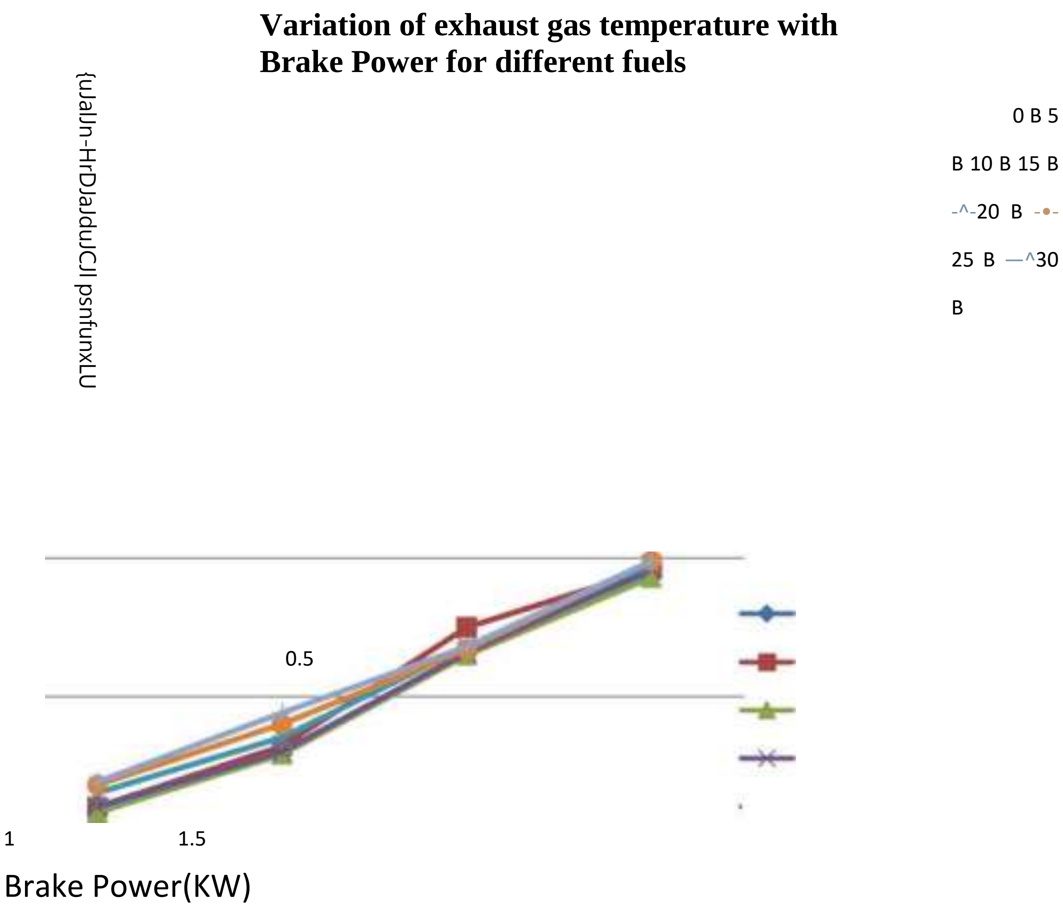


Figure 4.3.33: Variation of Exhaust gas temperature with Brake Power for different fuels

Figure 4.3.33, Shows that the variation in exhaust gas temperature with BP for different fuels. It is observed that the value of the exhaust gas temperature is increased at 5B but decrease at 10B after that exhaust gas temperature increases from 10B to 30B, We get minimum exhaust gas temperature at 10B.

4.4 Result obtained

The value of the total fuel consumption and Brake specific fuel consumption are increased at 5B but decrease at 10B after that total fuel consumption and Brake specific fuel consumption increases from 10B to 30 B, We get minimum total fuel consumption and Brake specific fuel consumption at 10B.

The value of the Brake thermal efficiency is decreased at 5B but increased at 10B after that Brake thermal efficiency decreases from 10B to 30 B, We get maximum total Brake thermal efficiency at 10B.

The value of the exhaust gas temperature is increased at 5B but decrease at 10B after that exhaust gas temperature increases from 10B to 30 B. We get minimum exhaust gas temperature at 10B.

RUNNING COST OF ENGINE WITH DIFFERENT BLENDS

Fuel	Cost (Rs./lr.)
Diesel	66.00
Waste Cooking Oil	70.00
5 B	66.20
10B	66.40
15B	66.60
20B	66.80
25B	67.00
30B	67.20

CHAPTER-5
CONCLUSION AND FUTURE SCOPE

5.1 Overview

In this chapter all the results obtained by using different blend ratio are analysed and the best blend ratio on which diesel engine performance reached on its optimum values are obtained.

5.2 Conclusion

The value of the total fuel consumption and Brake specific fuel consumption are increased at 5B but decrease at 10B after that total fuel consumption and Brake specific fuel consumption increases from 10B to 30 B, We get minimum total fuel consumption and Brake specific fuel consumption at 10B.

The value of the Brake thermal efficiency is decreased at 5B but increased at 10B after that Brake thermal efficiency decreases from 10B to 30 B, We get maximum total Brake thermal efficiency at 10B.

The value of the exhaust gas temperature is increased at 5B but decrease at 10B after that exhaust gas temperature increases from 10B to 30 B. We get minimum exhaust gas temperature at 10B.

In this research work it is observe that the blend of 10B (90% Diesel and 10% Biodiesel) can be used successfully in 4- stroke single cylinder diesel engine without any noticeable degradation in performance and without any alteration or modification in existing compression ignition engine.

The performance of diesel engine by using 10B (90% Diesel and 10% Biodiesel) is found very near to diesel engine.

5.3 Future Scope

- Analysis of composition of exhaust emission can be done.
- Combustion Analysis can also be done.
- Thermal analysis of various elements of engine may also be done.

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