Sudan University of Science & Technology

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Effect of Using Gasoline-Jatropha Blend on Performance of Two-Stroke Combustion Engines

تأثير إستخدام خليط الجازولين - الجاتروفا علي أداء ماكينات الإحتراق ثنائية الأشواط

A Thesis Submitted to the College of Graduate Studies and Scientific Research, in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Mechanical Engineering by courses and dissertation

Presented By:

Abubker Yousif Elteyab Osman

Supervisor: Dr. Tag Elssir Hassan Hussan

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الاية

قال تعالى :

﴿اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ ۖ
الْمِصْبَاحُ فِي زُجَاجَةٍ ۖ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن
شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونَةٍ لَّا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ
تَمْسَسْهُ نَارٌ ۚ نُّورٌ عَلَىٰ نُورٍ ۗ يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاءُ ۚ وَيَضْرِبُ اللَّهُ
الْأَمْثَالَ لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ ﴿35﴾﴾

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To my colleagues, I express appreciation for creativity, discipline, competence and friendship.

Dedication

To my parents and family, whose support is abundant, and whose love is nourishing.

ABSTRACT

In this work, laboratory experiments were carried out at the Military University of Kerrari for a two-stroke single-cylinder engine, Specification of engine (Engine Model is Bajaj auto, Maximum Power and Maximum Torque equal to 4.63 k w and 9 N.m respectively). A mixture of gasoline and jatropha oil was used as an alternative fuel for fuel used as a standard gasoline-Fuchs engine oil, model was used to reduce the ratio of exhaust emissions by determining optimal mixing ratio and maintaining good performance. Gas analyzers for gas emission analyses, and a device to measure the speed of the engine rotation, tacometer, was used, and readings were taken in the experiments at different speeds of rotation and different mixing ratios of fuel and oil.

The gases analyzed are: NO_x, CO, CO_2, and HC. At speeds of 1500-2500 RPM, there was decrease in the amount of NO_x and CO_2 emitted from exhaust gases, when increasing rotational velocity.

In the case of carbon monoxide (CO) and hydrocarbons (HC), it was found to increase by increasing the rotational speed. However; when increasing the ratio of mixing oil to gasoline, there was an increase in the amount of nitrogen oxides (NO_x), carbon dioxide (CO_2), hydrocarbons (HC) and carbon monoxide (CO).

The dynamometer was used to measure the torque and the fuel consumption rate per second, the results were used in the calculation of the indicated power, brake power, machine's thermal and mechanical efficiency.

Then the output was analyzed through the statistical analysis program. The analysis found the following results:

Blend B20(The mixture consist of 80% gasoline and 20% lubricant oil) through the different ratios of mixtures give the best results for the best mixture in terms of good performance of the brake and indicated power and the mean effective pressure, thermal efficiency, mechanical efficiency and fuel consumption.

المستخلص

تم اجراء تجارب معملية في جامعة كرري العسكرية لمحرك احادي الاسطوانة ثنائي الاشواط ,مواصفات الماكينة(طراز المحرك نوع باجاج ,القدرة القصوي والعزم الاقصي يساوي 4.63 k w 9N.m علي التوالي)استخدم خليط من (البنزين وزيت الجاتروفا) كوقود بديل للوقود المستخدم (البنزين وزيت ماكينة ماركةفوكس) كنموذج قياسي وذلك لتقليل نسبة انبعاثات العادم عن طريق تحديد نسبة الخلط الامثل والمحافظة علي أداء جيد للماكينة.

استخدم جهاز تحليل غازات العادم (gas analyzer) وجهاز لقياس سرعة دوران المحرك (التاكوميتر) ، اخذت القراءات في التجارب عند سرعات دوران مختلفة ونسب خلط مختلفة للوقود والزيت .

الغازات التي تم تحليلها هي : اكاسيد النيتروجين (NO_x) و اول اكسيد الكربون (CO) و ثاني اكسيد الكربون (CO_2) والهايدروكربونات (HC).

عند مدى سرعات (1500-2500 RPM) وجد ان هنالك نقصان في كمية كل من اكاسيد النيتروجين (NO_x) وثاني اكسيد الكربون (CO_2) المنبعثة من غازات العادم وذلك عند الزيادة في السرعة الدورانية .

اما في حالة اول اكسيد الكربون (CO) والهايدروكربونات (HC) وجد انها تزيد بزيادة السرعة الدورانية.

اما عند الزيادة في نسب خلط الزيت الى البنزين وجد ان هنالك زيادة في كمية كل من اكاسيد النيتروجين (NO_x) وثاني اكسيد الكربون (CO_2) والهايدروكربونات (HC) واول اكسيد الكربون (CO) .

أستخدم جهاز الداينوميتر(dynamometer) لقياس العزم الناتج، معدل استهلاك الوقود ، ومن ثم حساب القدرة البيانية ،الفرملية للماكينة وحساب الكفاءة الحرارية و الميكانيكية للماكينة ، تم تحليل الناتج من خلال برنامج التحليل الاحصائي، وجدت من خلال التحليل النتائج التالية:-

الخليط B20 (خليط يتكون من80% من البنزين و20% من زيت التزييت) من خلال النسب المختلفة للخلائط أعطي أفضل نتائج لافضل خليط من حيث الاداء الجيد للقدرة الفرملية والقدرة البيانية ومتوسط الضغط الفعال والكفاءة الحرارية والكفاءة الميكانيكية واستهلاك الوقود.

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List of Abbreviations

Abbreviation	Full text
CO	Carbon monoxide(% volume)
CO2	Carbon dioxide (% volume)
NO	Nitrogen monoxide (ppm)
HC	Unburnt Hydrocarbons (ppm)
ppm	Part per million
RVP	Reid Vapour Pressure.
TAN	Total acid number
FFA	Free fatty acid
F.P	Friction power (kw)
B.P	Brake power (kw)
I.P	Indicated Power (kw)
T.F.C	Total fuel consumption (kg/sec)
B.M.E.P	Break mean effective pressure (bar)
ἡmech	Mechanical efficiency (%)
L	Stroke (m)
A	Area (m2)
h	pressure differential of the air swept by the engine in inch of water
N	Speed (RPM)
ἡ B.T	Brake thermal efficiency (%)
F.I.P.	Fuel intake power (kw)
B.S.F.C.	Break specific fuel consumption (kg/sec-kw)
ἡmech	Mechanical efficiency (%)
Cd	Coefficient of discharge for orifice.
Vol%.	Percentage of volume
CCE	Copper coated spark ignition engine
UBHC	Un-burnt hydrocarbons
ASTM	American society for testing and materials
B1O	The mixture consist of 90% gasoline and 10% lubricant oil
B15	The mixture consist of 85% gasoline and 15% lubricant oil
B2O	The mixture consist of 80% gasoline and 20% lubricant oil
B25	The mixture consist of 75% gasoline and 25% lubricant oil
B30	The mixture consist of 70% gasoline and 30% lubricant oil
BF2O	The mixture consist of 80% gasoline and 20% Fuchs oil(standard)

Chapter I

Introduction

1.1 Overview

Auto Rickshaws are good low cost public transport three-wheeled vehicles that are extensively used in many Asian countries as taxis of people and goods. Although the vehicle design is well suited to the environment in which it operates, it is a crude and inefficient design. Due to poor vehicle maintenance and the use of inefficient two- or four-stroke engines with very little pollution control, auto rickshaws present a grave pollution problem in major cities.(Mulhall, Lukic et al. 2010)

Emissions from the large and rapidly growing number of two- and three-wheel vehicles are a major source of air pollution in Sudan. Because they are less expensive than other vehicles, two- and three-wheelers play an important role in the transport market in Sudan. Three-wheel vehicles, which include small taxis such as auto rickshaws and larger vehicles that hold as many as a dozen passengers, are used commercially. Until this year, nearly all three-wheelers and the majority of the two-wheelers had two-stroke engines. Apart from emissions considerations, these two-stroke engine vehicles are much noisier than their four-stroke equivalents, an issue that draws much attention, but is beyond the scope of this research.(Shah and Nagpal 1997, Kojima, Brandon et al. 2000, Pillai and Joseph 2011)

1.2 Research Background

A simple two -stroke engine contains a piston whose face is shaped, an exhaust port on one side of the cylinder and an intake port on the other side. The downward movement of the piston first open the exhaust port, allowing most of the Exhaust to be expelled and then uncovers the inlet port through which the air-fuel mixture is entering into the cylinder. The piston then moves upwards, compressing the mixture which is ignited by the spark plug, driving the piston down.

The two -stroke cycle of an internal combustion engine has only two strokes (linear movements of the piston) instead of four, although the same four operations (intake, compression, power, exhaust) still occur. It is usually found in low power applications like lawn mowers, mopeds, small outboard motors. Its advantages over four-stroke are:

1. They do not have valves, which simplifies their construction and lowers their weight.
2. They fire once every revolution, while 4-stroke engine fires once every other revolution that gives them better power to weight ratio.
3. They can work in any orientation, which can be important in handheld devices (like chainsaws) as there is no oil reservoir dependent upon gravity.

However, the two -stroke engine has significant disadvantages compared to 4-stroke engines that are summarized in:

1. There is no dedicated lubrication system; the lubricant is mixed with fuel. Two -stroke engines therefore do not last as long as 4-stroke as their parts wear out faster.
2. 2-stroke engines do not use fuel efficiently. Each time a new charge of air-fuel is loaded into the combusting chamber, a part of it leaks out through the exhaust port.
3. The burning of lubricating oil and the exhaust of un-burnt fuel makes them more polluting than a 4-stroke engine of similar power.

These disadvantages limit Two-stroke engines to be used only in applications where the motor is not used very often and high power to weight ratio is important. The two -stroke engine emits significant amount of particulate matter (PM), un-burnt hydrocarbons (HC), Carbon Monoxide (CO) and Nitrogen Oxides (NOx). The emissions of CO and NOx by Two-stroke engines is much lower compared to 4-stroke engines.

Particulate Matter (PM): Lubricating oil is less combustible than gasoline, some of the oil that is mixed with gasoline will survive to be emitted in the exhaust. This is further worsened locally as engine oil mixed is up to twice the manufacturers' recommendations (4%). It is estimated that particulate emissions from a single Two-stroke motorcycle is comparable to those from a diesel truck or bus. PM, particularly the finer ones, are associated with respiratory problems.

HC emissions result from the elements of the air-fuel mixture that fail to burn in the engine due to leakage through the exhaust port, weak compressing causing partial combustion and misfiring (About 30% of the fuel comes out of the exhaust un-burnt in 2-stroke engines). . Two stroke engines have much higher emissions of PM and HC than 4-stroke engines of similar power and size. In the USA, motorcycle manufacturers switched to making 4-stroke engines in 1978, in response to the adoption of strict emission standards. Other European countries and Japan followed suit.

Some gasoline components like benzene are carcinogens, while others combine with NOx to form ozone. Ozone affects the respiratory system, reduces visibility, damages vegetation and contributes to photochemical smog

In the last decade, motorcycles have become important as a means of transport in Nigeria. Estimated annual supply of new motorcycles into Nigeria is one million units annually. Almost all of these have 2-stroke engines. Emissions from 2-stroke engines can be reduced by rigorous inspection and maintenance programmes and used of lubricating oil of correct quality and quantity. But the best option is to ban the use of 2-stroke engines in new motorcycles in favour of 4-stroke engines. 4-stroke engines may be slightly more expensive, but are cheaper to run as they are more fuel efficient and last longer.

1.3 Problem Statement

The motorcycles and Rickshaws, due to being equipped with 2-stroke engines, are the most inefficient vehicles in complete burning of fuel and thus contribute most to emission of air pollutants in the environment. The major pollutants from two-stroke engines are Carbon Monoxide (CO), Nitrogen Oxides (NOx), Hydrocarbons (HC) and Particulate Matter (PM). Their presence in the environment causes a number of respiratory diseases and other illnesses

1.4 Research aim and objectives

This research aims to examine the performance of motor rickshaw engine and reduce its emissions fuelled by gasoline and jatropha oil. The specific objectives are:

- To determine the basic physical and chemical fuel properties of gasoline-jatropha oil blends.
- To investigate the rickshaw engine performance and exhaust emissions using fuel blended with jatropha oil.

1.5 Scope of the Research

The scope of this research will cover the investigation of rickshaw engine performance and exhaust emissions when utilizing fuel blended with Jatropha oil. The blend ratios will be investigated are B10, B15, B20 B25 and B30.The engine performance parameters will be measured are brake power, indicated power, brake mean effective pressure, mechanical efficiency, brake specific fuel consumption, and brake thermal efficiency.

1.6 Research Significance

Three wheels vehicles locally known by Rickshaw has become one of the most prevalent means of transport in Sudan, and has a great role in solving the jam traffic and provide jobs for many young people. The low cost and small size of the bi-cylinder two stroke engine used in Richshaw make it a superior choice. The engine does not incorporate a separate lubrication system, lubrication process done through a material oil fuel ratio.

In power stroke the oil fuel mixture will burned and results in harmful exhaust. Toxic carbon monoxide is a result of the unburnt fuel. This is the main reason of the emission and the fuel losses.

1.7 Outline of the dissertation

The work required for the completion of this dissertation is discussed throughout number of different chapters.

Chapter 1 is a general introduction to the thesis describing the background technology and international legislation that form the reasons for the undertaking of this research.

Chapter 2 reviews the literature of relevant previous research and technological developments in the field of internal combustion engines, and highlights areas requiring further research and development; which are then pursued in the remainder of the thesis. This chapter introduce the main idea and information about two stroke engines, why it had been a popular choice relaying to its advantages and application. The main concept is the principles of operation; these were briefly explained in terms of diagrams and mathematical relationships.

The emission problem, with respect to some relevant researches several ways to measure the performance had been discussed and their positives and negatives effects.

Chapter 3 details the experimental in Kerrari University, This chapter talks deep about the solutions of the emission caused by two stroke engines, the factors that affecting the performance and how to choose the best fuel-oil mixtures.

Start studying the different mixtures and their effect on the performance of the engine and emission reduction had been done.

Fuchs oil mixture (fuel-oil mixture) had been chosen to be the reference of the optimum performance measures.

This chapter talks about the experimental setup, the calculation for the component was direct and included as well as the specification of the main component.

The code is included in the appendices.

For the rest of the chapter the blends specification are discussed and arranged to be ready for the test.

Chapter 4 had been used to track and capture the signals, for the analysis and comparison purposes some standard

Chapter 5 summarises and discusses all the conclusions from preceding chapters. The main findings and outcomes of the work are listed and areas of possible research discussed.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

A two-stroke diesel engine is a diesel engine that works in two strokes. A diesel engine is an internal combustion engine that operates using the Diesel cycle. Invented in 1892 by German engineer Rudolf Diesel, it was based on the hot-bulb engine design and patented on February 23, 1893. During the period of 1900 to 1930, four-stroke diesel engines enjoyed a relative dominance in practical diesel applications. Charles F. Kettering and colleagues, working at the various incarnations of Electro-Motive and at the General Motors Research Corporation during the 1930s, advanced the art and science of two-stroke diesel technology to yield engines with much higher power-to-weight ratios than the two-stroke diesels of old. This work was instrumental in bringing about the dieselization of railroads in the 1940s and 1950s. [Willard W. Pulkrabek, (2012)].

All diesel engines use compression ignition, a process by which fuel is injected after the air is compressed in the combustion chamber, thereby causing the fuel to self-ignite. By contrast, gasoline engines utilize the Otto cycle, or, more recently, the Atkinson cycle, in which fuel and air are mixed before entering the combustion chamber and then ignited by a spark plug.

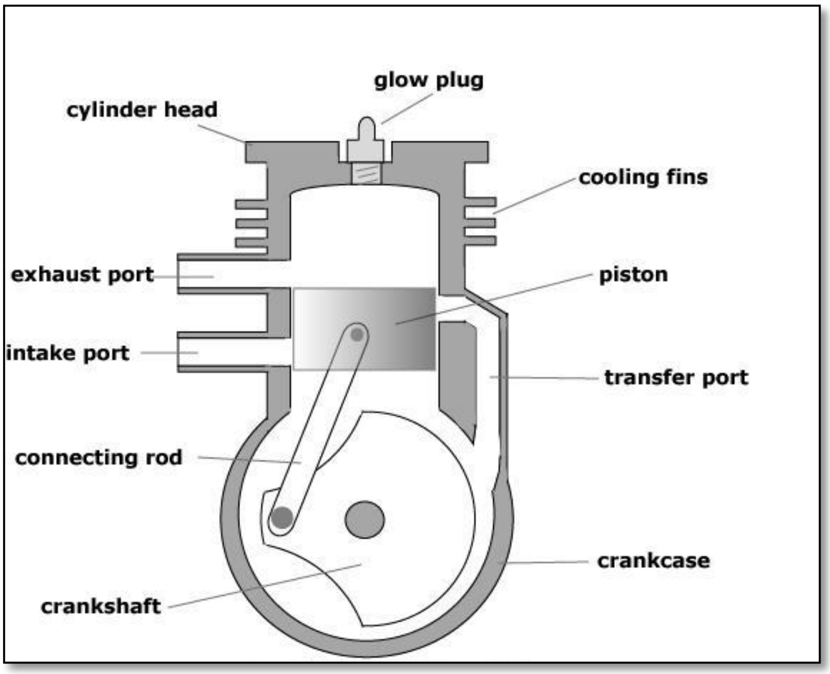


Figure 2.1: Two-stroke engine

2.2 Advantages and Disadvantages of Two Stroke Engines

Two-stroke engines have certain advantages. They produce more power and more compact than the four-stroke engine, and they are lightweight and less costly. On the other hand, some fuel gets wasted in a two-stroke engine, decreasing its efficiency. In the case of two-stroke engines, for every two strokes of the piston inside the cylinder, one power stroke is produced. In four-stroke engines, power is produced once during four strokes of the piston. For the same size engine, the power produced by the two-stroke engine is more that the four-stroke engine. Ideally the power produced by the two-stroke engine is double that of the four-stroke engine, but in actual practice it is only about 30% more than four-stroke engine. Also, since the power produced by the two-stroke engine is higher, these engines are small and compact in size. Since there are no valves in the two-stroke engine and only ports, they are cheaper and require less maintenance. With two-stroke engines, the torque produced on the crankshaft is more uniform because the power is produced during every alternate stroke of the piston.

When the inlet valve of the engine is opened for intake of the air-fuel mixture, the exhaust valve is also open. Although there is deflector between the inlet and exhaust areas of the engine, some fresh air-fuel mixture always escapes through the exhaust area. Thus part of the fuel that would have produced power goes wasted. This increases the fuel consumption and reduces the engine's overall efficiency. The two-stroke engine does not operate with the same efficiency at different speeds. When the carburetor's throttle valve is partly opened, the air-fuel mixture taken inside the cylinder is not sufficient to drive out all the exhaust gases, leaving some of the exhaust gases inside the cylinder even during the combustion stroke. This causes non-uniform burning of the fuel and inconsistent efficiency at different speeds.

One disadvantage that applies to both diesel and petrol two-stroke engines is the extensive cooling and lubricating requirements of the two-stroke engines. Since in two-stroke engines power stroke is produced after every stroke, a large amount of heat is generated within them. To reduce the temperature of the engine and keep the moving parts well-lubricated, good lubrication and cooling systems for the engine are required.

2.3 Emission and Exhaust Gases

Two-stroke engines typically have lower fuel efficiency than four-stroke engines, with as much as 15–40 percent of the fuel-air mixture escaping from the engine through the exhaust port. These “scavenging losses” contain a high level of unburned gasoline and lubricant, which increases emissions of hydrocarbons and organic lead if gasoline is still leaded. Some of the incompletely burned lubricant and heavier portions of gasoline are emitted as small oil droplets, which in turn increase visible smoke and particulate emissions.(Kojima, Brandon et al. 2000)

Reducing Emissions from Two-Stroke Engines Emissions from the existing fleet of two-stroke gasoline engines can be reduced by:

a) Ensuring that drivers use the correct type and quantity of lubricant.
b) Improving vehicle maintenance.
c) Improving the quality of gasoline.

For new vehicles, emissions can be reduced by:

d) Redesigning two-stroke engines to decrease scavenging losses and the amount of lubricant needed
e) Installing catalytic converters to further reduce tailpipe emissions.

Some of these measures can be achieved through regulation. Others require mass education of drivers, vehicle owners, regulators, and even the public, which has a role in bringing political pressure to bear on the problem.

2.4 Pollution

The environmental pollution is an important problem facing human recently, it comes in the top of environmental problems because there is no potentiality to control the air and determine the way of circulation The internal combustion engine which used for of transportation, shipment, planes, industrial and agriculture machines, water pumps, and electrical generators.... etc; in spite of strict and enforcement rules, its responsible of over than 70% of pollution in industrial countries: this pollution come because of machines cheapness, and continuously maintenance absences. [Iosrjen, (2008)]

Scientists divide the pollution in to many kinds:

1. Pollution from industrial resources, it happens because of human as nuclear energy stations, atomic piles.

2. Air pollution from fuel burning, no doubt the fuel burning specially the petroleum and coal create a great amount of different sizes of particles
3. Micro particles what create the smoke, like carbon particles, metal dust, solid oxides, sulfate, and nitrate, usually, the big particles accumulate near burning resources because of the gravity, but the smoke stays a lot of time in the air. The accumulated soil make the color of the area black, beside the damages can cause to the plants, and difficulty in breathing for human and animal, also smoke is inhaled and inter to the respiratory system and cause serious diseases.
4. Other toxic pneumatic compounds: Nitrogen compounds oxygen compounds, halogens, radioactive materials

Air pollution considered as a big environmental problems on danger effect. The researches about air pollution is difficult, because its multi sides environmental problems and the dimensions are undetected.

2.4.1 Air pollution from burning inside the engine

The resultant of complete burning are carbon dioxide and water, and it don't have color or smell but burning often produce many other materials no called polluters. These polluters could be carbon oxide sulfur oxides, nitrogen oxides, volatile ash, hydrocarbons, and acids. In internal engines, burning happens and it's hard to get complete burning, so we found the resultants contain pollutes. To understand why the reaction isn't complete we need to know the circumstances of steady of the reactions which depend on mixing ratio.

Mixing ratio =percentage of air to fuel (air mass / gas mass) [Willard W. Pulkrabek, (2012)]

The burning inside the engine is controlled by air and fuel ratio, and the perfect burning ratio is (1-15) this is the full burning the inside the engine, but it is not steady, so subsequently happens incomplete burning operation

Full chemical formulation for fuel burning:

Standard form for internal burning formulation:

Simple formulation:

$$\mathrm{C_nH_m} + (n + m/4)\,(O_2) \rightarrow nCO_2 + (m/2)\,H_2O \qquad (2.1)$$

Full standard formulation:

$$\mathrm{C_n}H_m + (n+m/4)(O_2+3.79N_2) \rightarrow nCO_2 + (m/2)H_2O + 3.79N_2 \qquad (2.2)$$

2.4.2 Air pollution control

The natural processes to filter the air still long centuries enough to control air pollution, the rain and snow remove polluters from the air also big part of solid polluters falls down to the earth to be absorb, but with increasing in polluters' r natural processes are no longer enough to filter the air, and harm polluters should be controlled. There are many ways to control the air pollution [Drew Kodjak, (2015)]. Some of them are:

1. Separate and accumulate the polluters:

This way separate and accumulate the polluters before it go to climate and the best ways to get rid of polluters in change the production way and move to tight ways, but the difficulty of this technology lead to use different ways to separate the particles by using different devices like filters, electrostatic precipitators, and other mechanical ways like towers and special burning tools, to fit with polluters nature that need to controlled. Solid be particulates can be separated before it go to the air using filter the gas by allowing it to pass through and prevent the solid particulates, also there are more complicated ways such as: the air with solid particulates touch microscopically chips with hot and cold laminas which put side by side, the microscopically chip installed in the cold lamina: when the air pass through laminas, the heat came from the hot lamina push the polluted air to the cold one then the polluted materials stick on the microscopically chip. The Unite States of America applied this way and decreased the polluted solid particulates by 87%. But the polluted gasses can't be collected by this mechanical way a solid particulates because they're not heavier than the air, but it can dissolve in liquids; when the air pass through the particular liquids, particular gasses dissolve in these liquids. It's known that there are liquids remove sulfur dioxide, other remove hydrogen sulfide, and so on.

2. Convert the polluters into nontoxic compounds:

The most important way is by oxidize it. The oxidation used to get rid of some gasses, and rarely used to get rid of solid particulates. Materials contain carbon, hydrogen and oxygen it can be oxidized mechanically. But that will cost a lot; because it will need an extra energy to complete the oxidation: for example, convert the polluted gas exhauster into nontoxic gasses, to complete the conversion process there are two basic ways:

i. Inject the air in the exhaust valve in high heat to oxidize the non-oxidized or partial oxidized materials.

ii. Design the cylinders and adjust the air, fuel ratio, timing the sparks. And any other variables to reduce hydrocarbon and carbon monoxide in exhauster, and this are the common way these days.

iii. Prevention Procedures To Preserve The Air, to avoid pollution dangers, must work in early phase by scientific planning because we don't need the industrial development and modern technology to make deficiency in the environmental health requirements, and the most helpful procedures to reduce the pollution are:

a) Scientific planning must be used when we need to create any industry work, considering the weather and geotectonic, prevent constructing industrial, or chemical buildings near population cities; specially cement industries and electrical power stations because of cities expansion in the future, and environment ability to accommodate the industrial dumps.

b) The burning machines in laboratories and electrical power station should always be observe to reduce the polluters, also monitoring cars and transportation and check their engine periodically.

c) Exchange the old warming means by others with high electrical quality, or high technology.

d) Put laws, rules, and measurements specialized in maximum concentration for air polluters. Especially in civilian and industrial areas; also build an observation stations to monitor the pollution.

e) Solicitude to plant trees and greeneries, because it play an important rule on air purity by reducing the polluters' effect, and improve the environment circumstances around human and animal.

2.5 Measures for Emission

2.5.1 Type and Quantity of Lubricant

In much of South Asia very few drivers of commercial three-wheelers use 2T oil. In Bangladesh the use of excessive amounts of straight mineral oil is the norm rather than the exception among three-wheeler drivers. The sale of straight mineral oil for use in vehicles is not illegal. Changing the behavior of these drivers to use the correct quantity of 2T oil, as well as raising the standards for the type of lubricant that must be used, would make an enormous difference in particulate emission levels. Preliminary tests show that reductions of particulate matter emissions of as much as two-thirds may be achieved through the use of the proper amounts of higher quality lubricants.* At the technical level, metering the correct amount of lubricant directly into gasoline at the pump (the so-called premix in India) is one way of ensuring that the correct type and quantity of lubricant is used. Banning the sale of “loose” oil in favor of the sale of premeasured sealed packets would also help enforce adding the right amount at the petrol pump. The use of higher-quality 2T oil represents cost savings to most two-stroke vehicle drivers. Even though the oil itself is more expensive, analysis has repeatedly shown that 2T oil used in the proper amount costs less than drivers currently pay for larger amounts of lower-grade oils. In addition come non-quantified benefits of longer engine life and lower emissions.(Cairns and Haycock 1996, Kojima, Brandon et al. 2000).

2.5.2 Vehicle Maintenance

The importance of an effective inspection and maintenance program cannot be overemphasized: proper maintenance is critical to both increasing fuel efficiency and reaping the full benefits of emission reduction investments. Simple servicing procedures, cleaning and adjusting the carburetor, adjusting the ignition system, cleaning and adjusting or replacing spark plugs, and cleaning air filters, can reduce exhaust emission levels significantly as well as improve fuel efficiency. Tying the frequency of inspection to the age of the vehicle and the annual number of kilometres travelled could also increase the effectiveness of inspection programs.(Kojima, Brandon et al. 2000, Das, Schmoyer et al. 2001).

2.5.3 Quality of Gasoline

Eliminating the widespread practice of adulterating gasoline with kerosene would reduce emissions. Reducing the gum content and increasing the octane level of gasoline that does not meet the minimum specified by vehicle manufacturers could also cut emissions. High gum content can cause an engine to misfire, damaging the vehicle and significantly increase emissions of hydrocarbons and particulate matter. Low octane can cause knocking and engine malfunction.(Cairns and Haycock 1996, Kojima, Brandon et al. 2000, Bozbas 2008).

2.6 Environmental Performance of New Two-Stroke Vehicles

Reducing scavenging losses. Substantial reductions in scavenging losses have been achieved by designing better port configurations. In India, for example, short-circuiting fuel losses have been reduced from 35 to 14 percent as a result of better engine designs. Several new technologies for reducing scavenging losses are also being tested, but all of these would require an electronic engine management system. While this system would add to the cost of the vehicle, this cost would be partially offset by improved fuel efficiency.(Kojima, Brandon et al. 2000)

1. Installing catalytic converters. Installation of catalytic converters in two- and three-wheelers would reduce exhaust emissions by about half. Vehicles with catalytic converters must use lead free gasoline, however, which is not widely available in some parts of South Asia. The durability of catalytic converters for two-stroke engines is also an issue. For commercial three wheelers catalysts are likely to have to be replaced at intervals ranging from six months to a year to maintain reasonable emission levels. While essentially no data are available to quantify the impact of catalytic converters on reducing particulate emissions from two-stroke engines, estimates indicate that cost-effectiveness may be questionable.(Kojima, Brandon et al. 2000)

Replacing Two-Stroke Gasoline Engines in addition to reducing emissions from two-stroke gasoline engines, both governments and vehicle manufacturers are finding cleaner alternatives to these engines. Options include four-stroke gasoline engines and engines powered by liquefied petroleum gas, compressed natural gas, and electricity. As cleaner vehicles come on the market, the share of the older, more polluting vehicles will fall. In addition, retrofit kits that take advantage of cleaner fuels and lubricants are becoming increasingly available for installation on older two-stroke engine vehicles.(Shah and Nagpal 1997, Kojima, Brandon et al. 2000)>

Many of experimental studies which present evidences of the benefits of magnetic treatment and alternative fuel mixtures were occurred. For motor vehicles and industrial boilers, much fuel economy and noticeable soot suppressions could be approached.(Chavan and Jhavar 2016).

2.6.1 Magnetic Treatment

Experiments from Iraq (Faris, Al-Naseri et al. 2012) used ***permanent magnets*** with different intensity (2000, 4000, 6000, 9000) Gauss, which installed on the fuel line of the two-stroke engine, and study its impact on gasoline consumption, as well as exhaust gases. For the purpose of comparing the results necessitated the search for experiments without the use of magnets. The overall performance and exhaust emission tests showed a good result, where the rate of reduction in gasoline consumption ranges between (-1) %, and the higher the value of a reduction in the rate of 1 % was obtained using field intensity 6000 Gauss as well as the intensity 9000 Gauss. It was found that the percentages of exhaust gas components (CO, HC) were decreased by 30%, 40% respectively, but CO_2 percentage increased up to 10%. The aim of the study is to investigate the effect of the fuel magnetisation on the performance of diesel engine. It has been observed that on magnetisation viscosity of hydrocarbon fuel decreases due to declustering of the Hydrocarbon fuel molecules which results in better atomization of the fuel and efficient combustion of air fuel mixture. This enhances thermal efficiency and improves the fuel economy of I.C engine. The magnetic field applied along the fuel line immediately before fuel injector. The magnetic field of different intensity (E.g. 2000, 3000, *4000 Gauss)* is applied with the help of permanent magnet or Electro-magnetic coil and its effect on fuel consumption as well as on exhaust gas emission will be studied and compared with performance without application of magnetic field. At different load conditions the experiments are conducted to analyse the fuel consumption, thermal efficiency and exhaust gas analyser is used to measure the exhaust gas emission such a NOX, HC, CO and CO_2(Chaware).

A comprehensive experimental study on the effect of ***electromagnetic field on the ionization and combustion of fuel in an internal combustion engine*** was presented. The major aim is for the user economy and environmental friendly especially as it may affect climate change. The experimental set up consist a HGA 200 computerized exhaust gas analyzer, one cylinder 4 stroke engine, a copper wire wound round a hollow cylindrical rod which is connected to a DC 12 V battery. The exhaust product was channeled to the HGA 200 for proper analysis of the exhaust constituent. The set up was allowed to run for one hour without the electromagnetic device to serve as a base line for comparison. Series of test runs were conducted using the device along the fuel line of the engine. Results obtained during the test, gave a 50% reduction in the hydrocarbon constituent of the exhaust product in PPM and 35% reduction in the carbon monoxide.

These results clearly indicate that the introduction of an electromagnetic field within the fuel line of an I.C engine enhances the combustion process thereby economizing fuel consumption and reducing gas emission making it environmental friendly engine. They study suggest that the materials for the inlet manifold and the top cylinder of the engine be made from a magnetic material. This will create a permanent magnet around the combustion chamber for proper mixing and the burning of the fuel(Okoronkwo, Nwachukwu et al. 2010).

Particulate Matter (PM) is one of the major harmful substances in diesel exhaust gas. ***Technologies like the Diesel Particulate Filter (DPF) and Diesel Oxidation Catalyst (DOC)*** have been positioned at the exhaust to reduce the quantity of harmful substances released to the environment. The paper highlighted the factors that affect combustion in diesel engines and the potential of the introduction of electromagnetic field in the combustion chamber on the improvement of the diesel engine efficiency and reduction in the quantity of Particulate Matter (PM) produced(Uguru-Okorie and Dare 2013).

The work deals with ***fuel ionization by using magnetic field*** which will ensure complete combustion of air-fuel mixture. Incomplete combustion in engine is due to improper mixing of hydrocarbon and oxygen molecule. In I.C. engine incomplete combustion produced large amount of emission gasses like CO, HC & NOX etc. & incomplete combustion fuel gives lower efficiency. This attempt is made in this work to improve the combustion efficiency of internal combustion engines by adopting a magnetic fuel ionization method in which the fuel is ionized due to the magnetic field. To overcome these issues electromagnets are developed called as electro-magnetic fuel conditioner. This help aligns and orientation of hydrocarbon molecules, better atomization of fuel. Use of such electromagnet mounted in path of fuel lines improves mileage & reduces emission of vehicle. These experiments are conducted at different engine loading conditions. The work in particular is very significant on account of its impact on the global automobile market(Karande, kumar Kore et al.).

2.6.2 Alternative Fuel Mixtures:

Biofuel proposed to be the less cost and most environmental friendly fuel. The main task of this project is to use biofuel to get an alternative fuel mixture for the two-stroke engine (Rickshaw) and evaluate both the engine performance of the engine and the reduction of the emission by measuring greenhouse gases.(Bozbas 2008)>

The study discusses performance and exhaust emissions from spark-ignition engine fueled with ***ethanol methanol gasoline blends***. The test results obtained with the use of low content rates of ethanol methanol blends (3e10 vol. %) in gasoline was compared to ethanol gasoline blends, methanol gasoline blends and pure gasoline test results. Combustion and emission characteristics of ethanol, Methanol and gasoline and their blends were evaluated. Results showed that when the vehicle was fueled with ethanol methanol gasoline blends, the concentrations of CO and UHC (unburnt hydrocarbons) emissions were significantly decreased, compared to the neat gasoline. Methanol gasoline blends presented the lowest emissions of CO and UHC among all test fuels. Ethanol gasoline blends showed a moderate emission level between the neat gasoline and ethanol methanol gasoline blends, e.g., ethanol gasoline blends presented lower CO and UHC emissions than those of the neat gasoline but higher emissions than those of the ethanol methanol gasoline blends. In addition, the CO and UHC decreased and CO2 increased when ethanol and/or methanol contents increased in the fuel blends.

Furthermore, the effects of blended fuels on engine performance were investigated and results showed that methanol gasoline blends presents the highest volumetric efficiency and torque; ethanol gasoline blends provides the highest brake power, while ethanol methanol gasoline blends showed a moderate level of volumetric efficiency, torque and brake power between both methanol gasoline and ethanol gasoline blends; gasoline, on the other hand, showed the lowest volumetric efficiency, torque and brake power among all test fuels(Elfasakhany, A 2015).

The paper deals with emissions of trans esterification ***Jatropha-Palm blended biodiesel as fuel for 4-stroke single vertical cylinder diesel engine***. The engine emissions of Carbon Monoxide (CO), Carbon Dioxide (CO2) and Nitrogen Oxides (NOx) were analyzed and discussed. All tests were carried out at varied load conditions which were 0.13, 0.15, 0.17, 0.19 and 0.21 kW. The results revealed that higher CO, CO2 and NOx produced from all biodiesel blended as compared to Diesel Fuel (DF). This might be due to the higher oxygen content in the biodiesel structure and also higher exhaust temperature during combustion which promotes the formation of more hazardous gases(Yunus, Rashid et al. 2013).

As a renewable, sustainable and alternative fuel for compression ignition engines, biodiesel instead of diesel has been increasingly fueled to study its effects on engine performances and emissions in the recent 10 years. But these studies have been rarely reviewed to favor understanding and popularization for biodiesel so far, the ***effect of biodiesel on engine power***, economy, durability and emissions including regulated and non-regulated emissions, and the corresponding effect factors are surveyed and analyzed in detail. The use of biodiesel leads to the substantial reduction in PM, HC and CO emissions accompanying with the imperceptible power loss, the increase in fuel consumption and the increase in NOx emission on conventional diesel engines with no or fewer modification. And it favors to reduce carbon deposit and wear of the key engine parts. Therefore, the blends of biodiesel with small content in place of petroleum diesel can help in controlling air pollution and easing the pressure on scarce resources without significantly sacrificing engine power and economy. However, many further researches about optimization and modification on engine, low temperature performances of engine, new instrumentation and methodology for measurements, etc., should be performed when petroleum diesel is substituted completely by biodiesel(Xue, Grift et al. 2011).

A 5.2 kW diesel engine with alternator was used to test ***jatropha biodiesel and its blends***. A pilot plant was developed for biodiesel production from different vegetable oils and used for this study. In the case of jatropha biodiesel alone, the fuel consumption in the diesel engine was about 14 per cent higher than that of diesel. The percent increase in specific fuel consumption ranged from 3 to 14 for B20 to B100 fuels. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuels efficiencies. For jatropha biodiesel and its blended fuels, the exhaust gas temperature increased with increase in load and amount of biodiesel. The highest exhaust gas temperature was observed as 463ºC for biodiesel among the three load conditions. The diesel mode exhaust gas temperature was observed as 375ºC. The CO2 emission from the biodiesel fuelled engine was slightly higher than diesel fuel as compared with diesel. The carbon monoxide reduction by biodiesel was 16, 14 and 14 per cent at 2, 2.5 and 3.5 kW load conditions. The NOx emissions from biodiesel was increased by 15, 18 and 19 per cent higher than that of the diesel at 2, 2.5 and 3.5 kW load conditions respectively(Ramesh and Sampathrajan 2008).

The performance of single cylinder water-cooled diesel engine using Multi-DM-32 diesel additive and ***methyl-ester of Jatropha oil*** as the fuel was evaluated for its performance and exhaust emissions. The fuel properties of biodiesel such as kinematic viscosity, calorific value, flash point, carbon residue and specific gravity were found. Results indicated that B25 have closer performance to diesel and B100 had lower brake thermal efficiency mainly due to its high viscosity compared to diesel. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuels efficiencies. For Jatropha biodiesel and its blended fuels, the exhaust gas temperature increased with increase in power and amount of biodiesel. However, its diesel blends showed reasonable efficiencies, lower smoke, CO_2 and CO. Multi- DM-32 additives with methyl ester of Jatropha offer fuel conservation as well as reduce pollution(Rao, Voleti et al. 2009).

From the previous studies it found that the magnatisation will deliver a good performance and reduce the fuel consumption. The results showed a remarkable reduction in the percentages of exhaust gas components (CO, HC), but CO_2 percentage increased.

Alternative fuel-oil mixture has been tested in four-stroke engine using biodiesel, jatropha and methanol.The blends of biodiesel with small content in place of petroleum diesel can help in controlling air pollution and easing the pressure on scarce resources without significantly sacrificing engine power and economy. As a conclusion for a two stroke engine the magnetization and gasoline-jatropha blends can solve the emissions and fuel consumption problem.

Chapter III

RESEARCH METHODOLOGY

The work of this research is carried out using experimental work. Summary of the research work is presented in the methodology flowchart as shown in Figure 3.1.

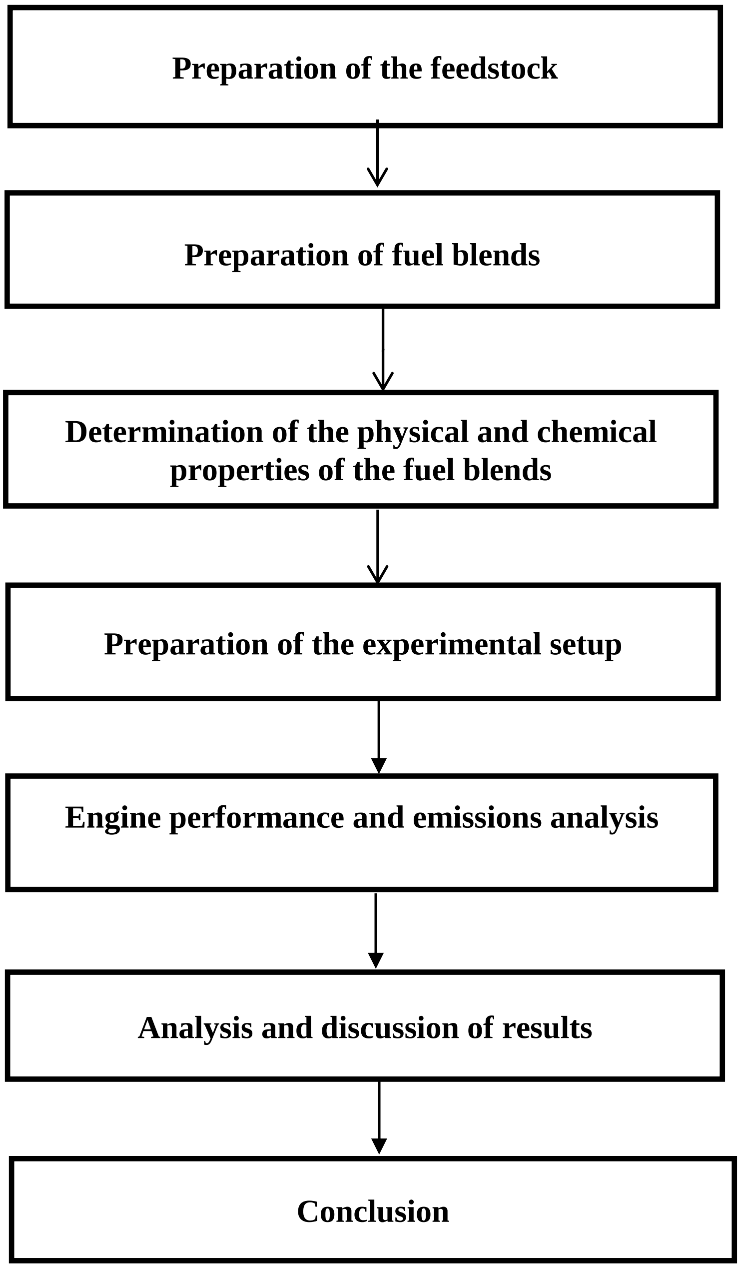


Figure 3.1: Flow chart of the research methodology

3.1 Preparation of the feedstock

Jatropha cruces seeds were provided from the centre of Sudan. After extraction using a mechanical expeller, the oil was processed for testing its properties at. The main physiochemical properties of the CJO sample were determined as per standard methods and reported in Table 3.1.

Table 3.1: Physiochemical properties of crude jatropha oil (CJO)

Properties	Range
Density @ 15^{o}C (g/ml)	0.9199
viscosity@40^{o}C (mm^2/s)	41.43
Water content %	0
Calorific value (MJ/Kg)	43.757
Flash point (^{o}C)	212

3.2 Preparation of fuel Blends

The jatropha oil was blended with benzene .The blends were made in the ratios of B10, B15, B20, B25 and B30 on volumetric basis. For instance, a B10 blend contains 10% v/v of oil and 90% v/v Gasoline. Then the blended fuels stored in a high dense poly ethylene (HDPE) containers. Table 3.2 shows the composition of fuel blends.

Table 3.2: Fuel blends composition

Blends	Jatropha oil	Fuchs 0il	Gasoline ml
B10	50 ml	50 ml	500
B15	33.3 ml	33.3 ml	500
B20	25 ml	25 ml	500
B25	20 ml	20 ml	500
B30	16.7 ml	16.7 ml	500

3.3 Determination of the physical and chemical properties of the fuel blends

Different blends of jatropha oil and gasoline fuel will be prepared for experiment and the chemical and physical properties of the fuel blends will be measured such as Density, Viscosity, Water content, and Calorific value.

3.4 Engine and Emissions Tests

The engine used for this experimental investigation was Bajaj auto, 1 cylinder two stroke engine. The basic engine specifications are shown in Table 3.3. The test rig of the engine is shown in Figure 3.1. The engine was coupled to an electrical dynamometer to measure the output. To measure the exhaust emission gases, a multi gas exhaust analyzer was used. The probe of the emission analyzer was placed inside the exhaust tail pipe of the engine in order to sample the exhaust emissions. All the emissions data were recorded from the analyzer screen display as shown in Figure 3.2. To get the average values, all tests were repeated three times. The experimental investigation was carried out using fuel blends of (B10, B15, B20, B25 and B20). The engine was run at various speeds range from 1500 rpm to 2500 rpm at different engine load condition of 0, 60, and 80.

Table 3.3: Specification of engine

Engine Model	**Bajaj auto**
Maximum Power , kw	4.63 k w
Maximum Torque , NM	9 N. m
Swept Volume	145cc
Bore	57mm
Stroke	57mm
Number of cylinder	One

Figure 3.2: Engine test rig

Figure 3.3: Gas Analyzer

Other performance parameters that were not measured by dynamometer were calculated using the equations below.

1-The Brake power (B.P):

$$B.P = \frac{2\pi NT}{60} \qquad (kW)$$

Where:

T ≡ Torque (N.m)

N ≡ Speed (RPM)

2- Friction Power of the engine (F.P)

$$(F.P) = \text{Voltage}(V) * \text{curent } (I) * \text{Motor Efficincy}(\varphi) \qquad (KW)$$

3-Indicated Power (I.P.) = B.P. + F.P. (KW)

4-The Brake Mean Effective pressure (B.M.E.P):

$\mathrm{B.M.E.P} = \frac{60*\mathrm{Brake\ Power}}{100*A*L*N}$ (Bar)

Where:

A≡ Area of engine bore = 0.00255 m^2

L≡ Stroke length (m) = 0.057 m

N ≡ Speed engine (RPM)

5- The mechanical efficiency:

$$\dot{\eta}\mathrm{mech} = \frac{\mathrm{Brake\ Power}}{\mathrm{Indicated\ Power}}\ 100\%$$

6- The Brake Specific Fuel Consumption:

B.S.F.C=

(Total fuel consumption (T.F.C) (kg/sec)) / (Brake Power) kg/sec-kw

7-Brake Thermal Efficiency=

T.F.C.in kg/sec * calorific value of fuel

$$\dot{\eta}_{\mathrm{B.T.}} = \frac{\mathrm{Brake\ Power}}{\mathrm{Fuel\ Intake\ Power}} * 100$$

Where:

Fuel intake power= T.F.C in kg/s*calorific value of fuel (kW)

$\text{8-Air Fuel ratio} = \frac{\mathrm{Air\ Intake\ \ in}\ {}^{Kg}/_{sec}}{\mathrm{T.F,C}\ \ {}^{Kg}/_{sec}}$

Where:

Air intake = Air intake m3/s *density of air kg/m3

Fuel Consumption T.F.C.

Chapter IV

Results Analysis and Discussion

This chapter explained engine performance and exhaust emission of all blends (B10, B15, B20, B25 and B30) at various engine speeds. Brief discussion on the results obtained under the study is presented in the following paragraphs.

4.1 Properties of Tested Fuel:

The chemical properties of fuel benzene\jatropha oil were studied and the properties measured were compared with the ASTM specification and the results are presented in table.

4.1.1 Density

Density is the mass of a unit volume of a liquid or a solid and can be expressed in units of grams per litter (g/L). The density of gasoline\jatropha is important because it gives an indication of the delay between the injection and combustion of the fuel in engine (ignition quality) and the energy per unit mass (specific energy). According to these standards, density should be tested at the temperature reference of 15 $^{\circ}$C. From table 4.1 and fig (4.1) it is clear that density increased as the percentage of gasoline\jatropha increased in the blends.

Table 4.1: Density of gasoline\jatropha blend

Blends	Density @ 15 °C(kg/m³)
B10 (90% gasoline + 10% jatropha)	706.667
B15 (85% gasoline + 15% jatropha)	718.889
B20 (80% gasoline + 20% jatropha)	741.111
B25 (75% gasoline + 25% jatropha)	747.778
B30 (70% gasoline + 30% jatropha)	767.222

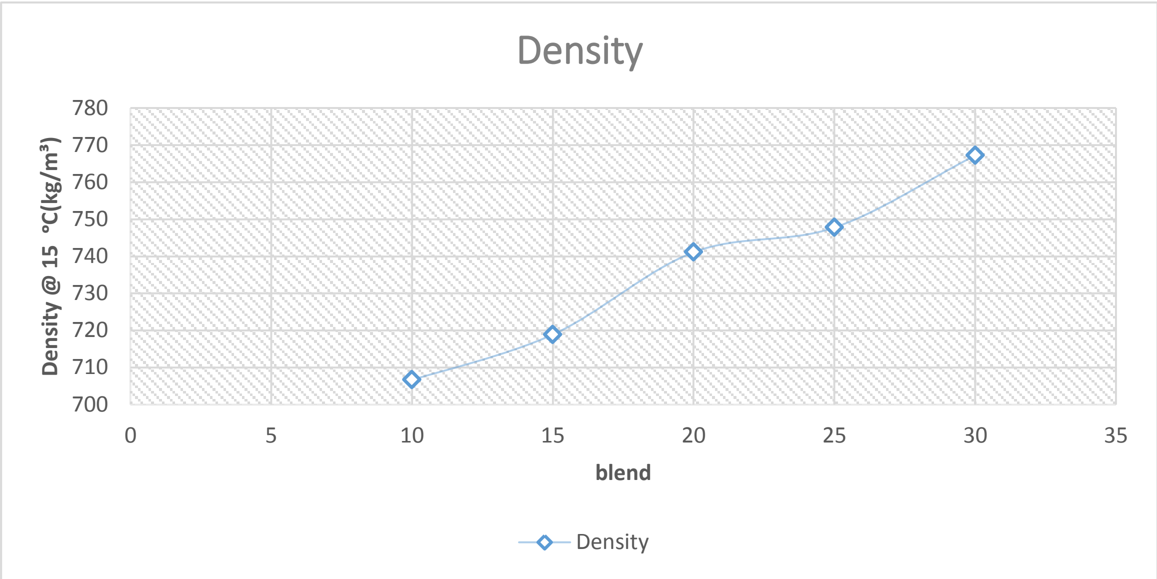


Fig (4.1) Density of gasoline\jatrophablend

4.1.2 Kinematic viscosity

Kinematic viscosities of all blends meet the ASTM D445 specifications. Table 4.2 and the fig (4.2) illustrated that kinematic viscosity (KV) increases as the percentages of the blends increases.

Table 4.2 Kinematic viscosity of gasoline\jatropha blend

Blends	Kinematic viscosity @ 40 °C(mm²/s)
B10 (90% gasoline + 10% jatropha)	41.601
B15 (85% gasoline + 15% jatropha)	55.793
B20 (80% gasoline + 20% jatropha)	57.338
B25 (75% gasoline + 25% jatropha)	60.773
B30 (70% gasoline + 30% jatropha)	69.742

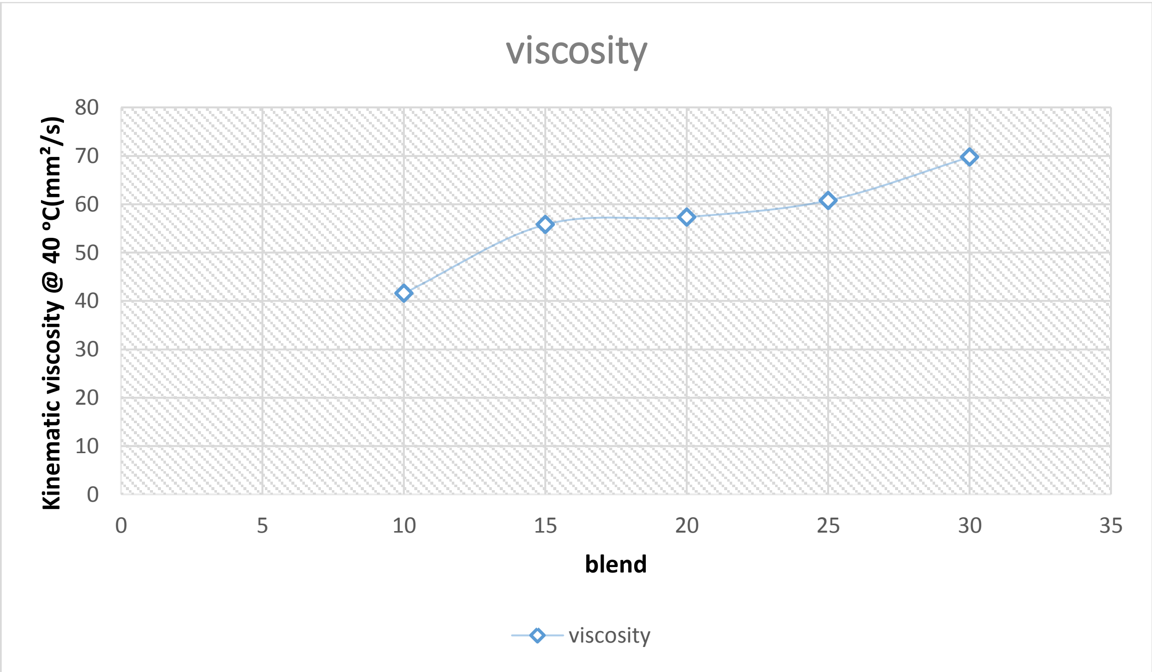


Fig 4.2 Kinematic viscosity of gasoline\jatrophablend

4.1.3 Octane Number

From table (4.3) and the fig (4.3) the octane number of gasoline\jatropha blend decreases

Table 4.3octane number of gasoline\jatropha blend

Blends	**Octane Number**
B10 (90% gasoline + 10% jatropha)	94
B15 (85% gasoline + 15% jatropha)	92.5
B20 (80% gasoline + 20% jatropha)	92
B25 (75% gasoline + 25% jatropha)	91.5
B30 (70% gasoline + 30% jatropha)	91

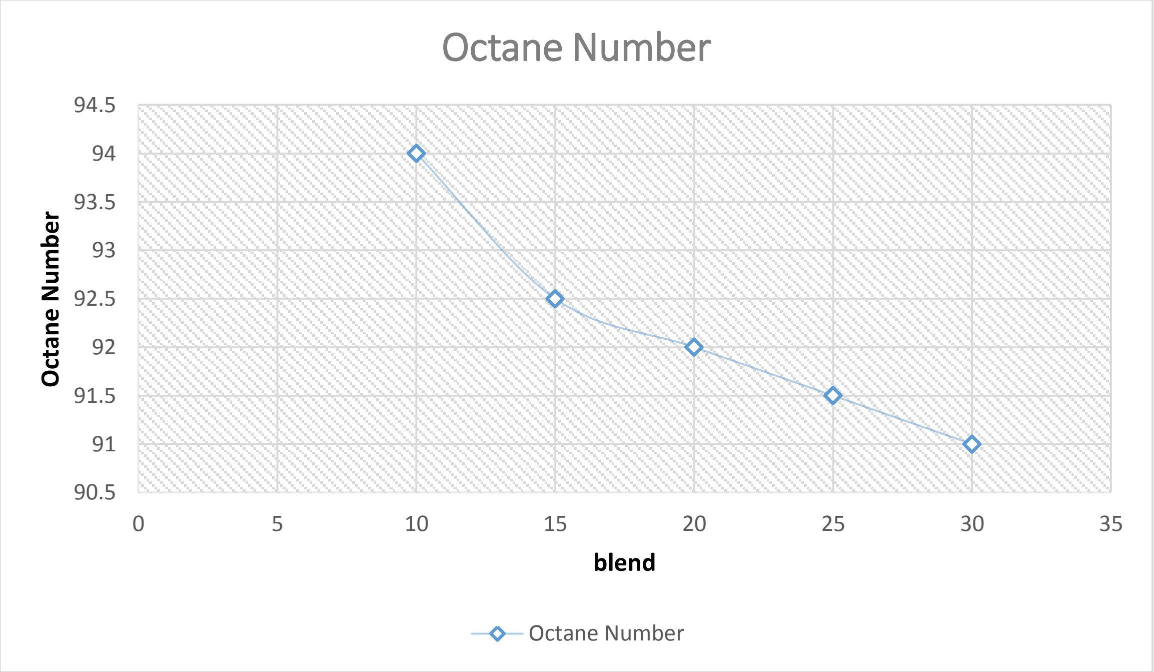


Fig 4.3octane number of gasoline\jatropha blend

4.1.4 Calorific value

From table (4.4) and the fig (4.4) the caloric value of gasoline\jatropha blend is decreases from 45.1 to 43

Table 4.4calorific valueofgasoline\jatropha blend

Blends	Calorific value(MJ/kg)
B10 (90% gasoline + 10% jatropha)	45.1
B15 (85% gasoline + 15% jatropha)	45.05
B20 (80% gasoline + 20% jatropha)	44.9
B25 (75% gasoline + 25% jatropha)	44.05
B30 (70% gasoline + 30% jatropha)	43

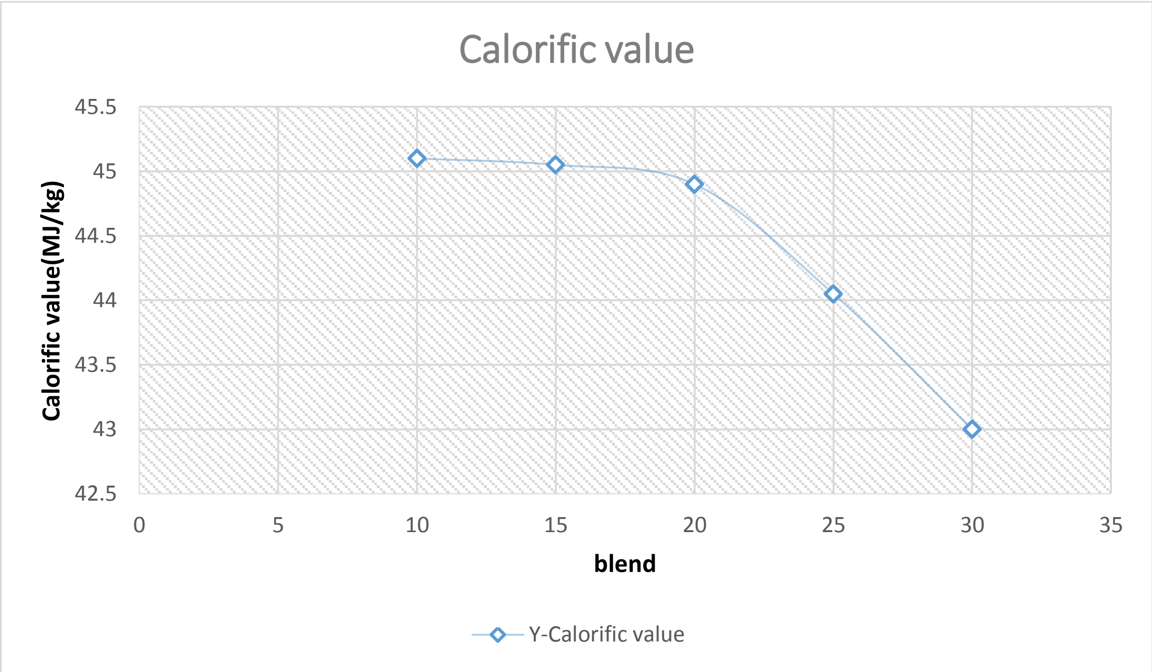


Fig 4.4calorific value ofgasoline\jatrophablend

4.2 Engine Performance

The experimental setup was made using the existing facilities and equipment in Kerrari. These were modified according to the need and requirement for experimental work. The gasoline\jatropha blends produced above was used for engine test in the form of different blends with gasoline . In this study, engine performance was evaluated in terms of brake power (BP), indicated power, brake mean effective pressure, mechanical efficiency, brake specific fuel consumption (BSFC) and thermal efficiency (ɳth).

4.2.1 Brake Power (B.P.)

The brake Power as seen in table (4.5)using gasoline\jatropha blends and table (4.6)using gasoline\fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.5) to (4. 10):-

Table (4.6) Brake power (KW) - gasoline\Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.385043	0.51339	0.641738
	B15	0.385043	0.51339	0.641738
	BF20	0.385043	0.51339	0.641738
	B25	0.38504	0.51339	0.64173
	B30	0.38504	0.51339	0.64173
60% load , 1.5 kw	B10	0.50055	0.82142	1.2193
	B15	0.519807	0.847094	1.155128
	BF20	0.53906	0.872763	1.28347
	B25	050055	0.77008	1.09095
	B30	0.53906	0.82142	1.2193
80% load , 2 kw	B10	0..69307	1.0781	1.47599
	B15	0.673824	1.103789	1.54017
	BF20	0.69308	1.12945	1.60434
	B25	0.65457	1.02678	1.47599
	B30	0.65457	1.02678	1.47599

Table (4.5) Brake power (KW) - gasoline\jatropha blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.385043	0.51339	0.641738
	B15	0.385043	0.51339	0.641738
	B20	0.385043	0.51339	0.641738
	B25	0.385043	0.51339	0.641738
	B30	0.385043	0.51339	0.641738
60% load , 1.5 kw	B10	0.500555	0.821424	1.219301
	B15	0.519807	0.847094	1.155128
	B20	0.53906	0.872763	1.283475
	B25	0.500555	0.770085	1.090954
	B30	0.53906	0.821424	1.219301
80% load , 2 kw	B10	0.693077	1.078119	1.475996
	B15	0.673824	1.103789	1.54017
	B20	0.693077	1.129458	1.604344
	B25	0.654572	1.02678	1.475996
	B30	0.654572	1.02678	1.475996

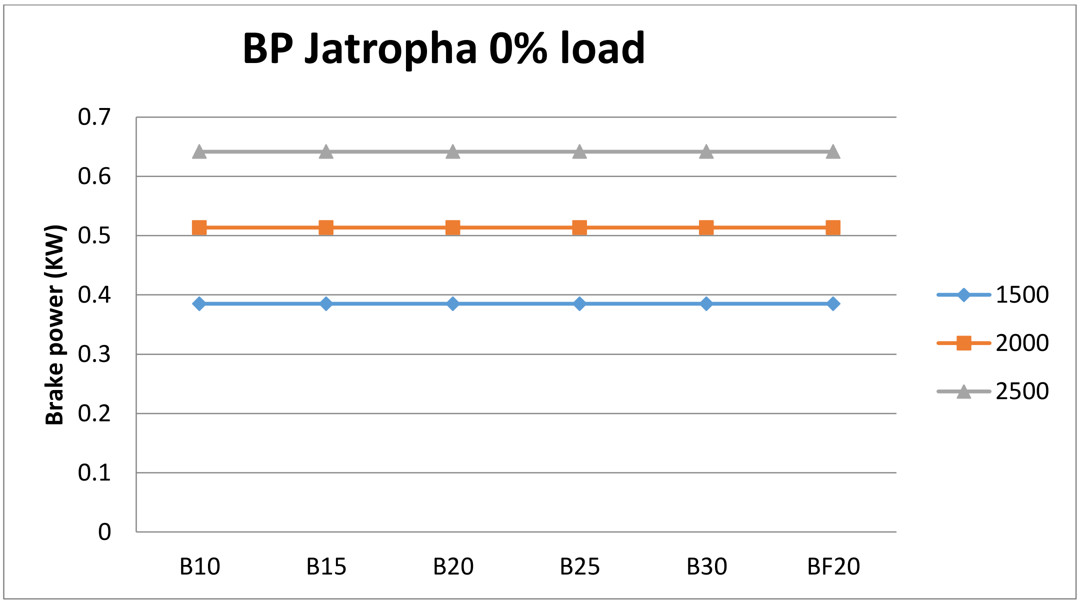


Figure 4.5 BP of gasoline\jatropha blend

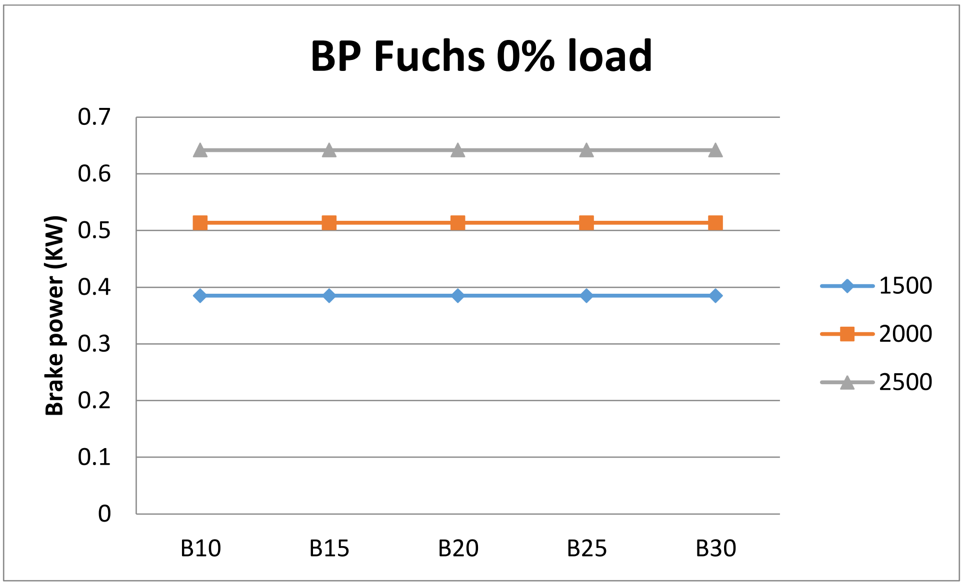
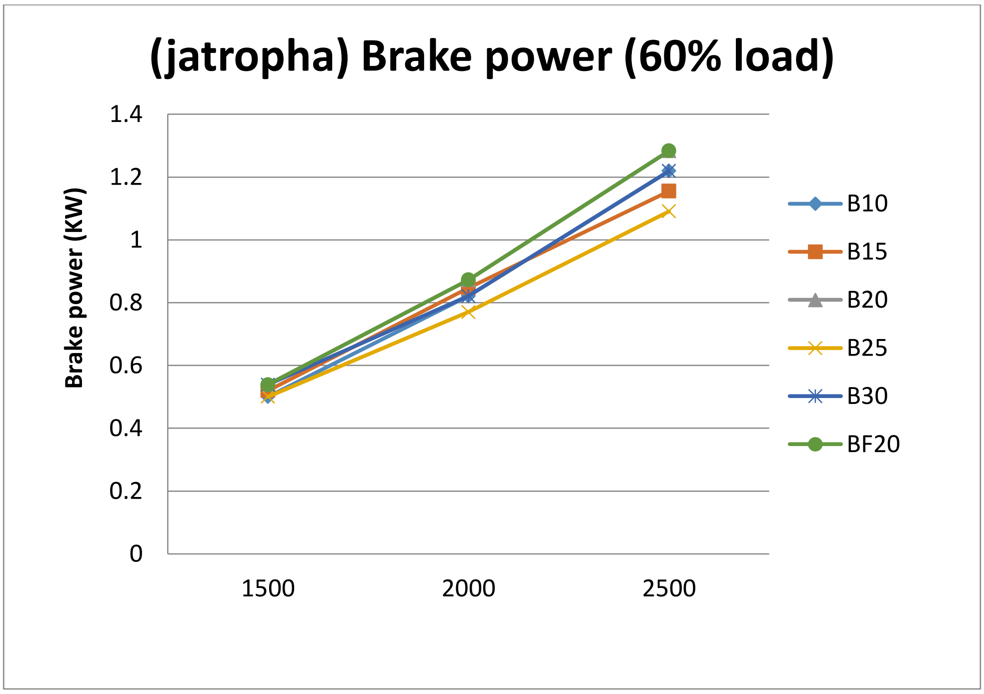


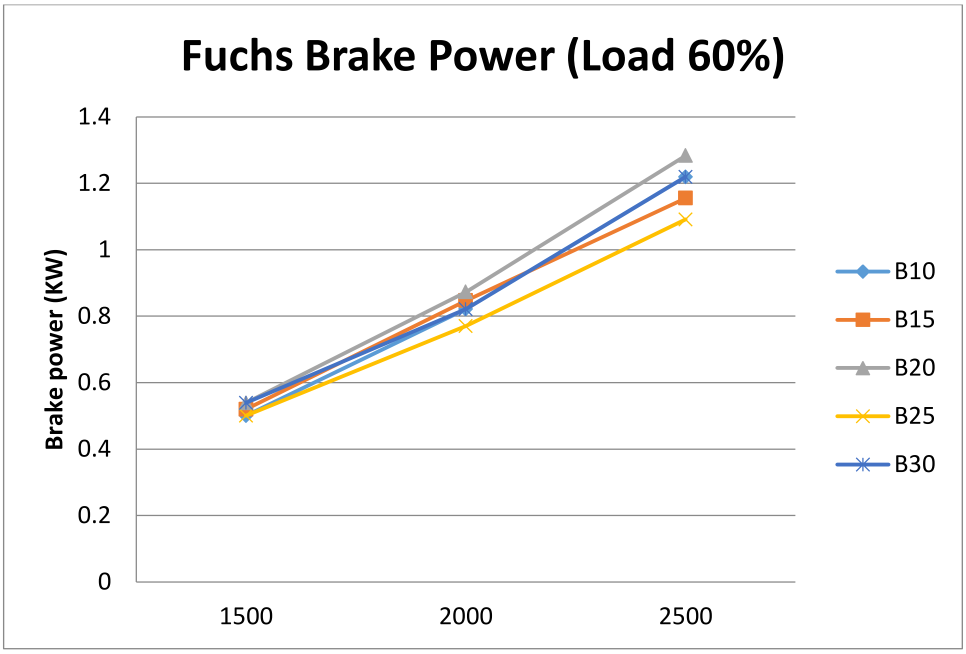
Figure 4.6 BP of gasoline\Fuchs blend

Figures (4.5) and (4.6) shows value of the brake power for no load, through the gasoline\jatropha blend and gasoline\Fuchs blend increase the brake power with continuous pattern with increasing speed due to increased torque with increase speed.



Speed (RPM)

Figure 4.7 BP of gasoline\jatropha blend

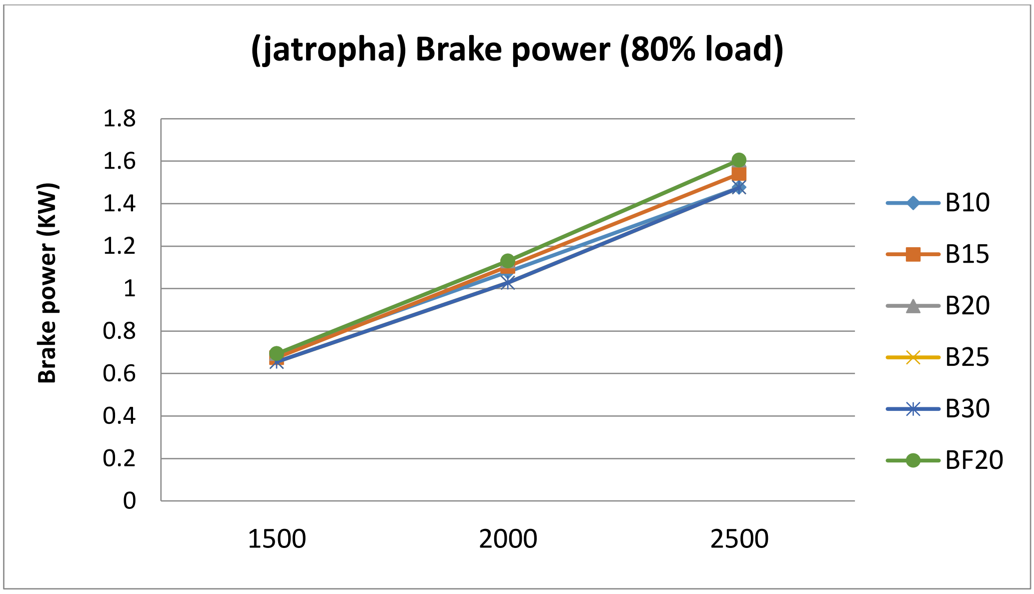


Speed (RPM)

Figure **4.8** BP of gasoline\Fuchs blend

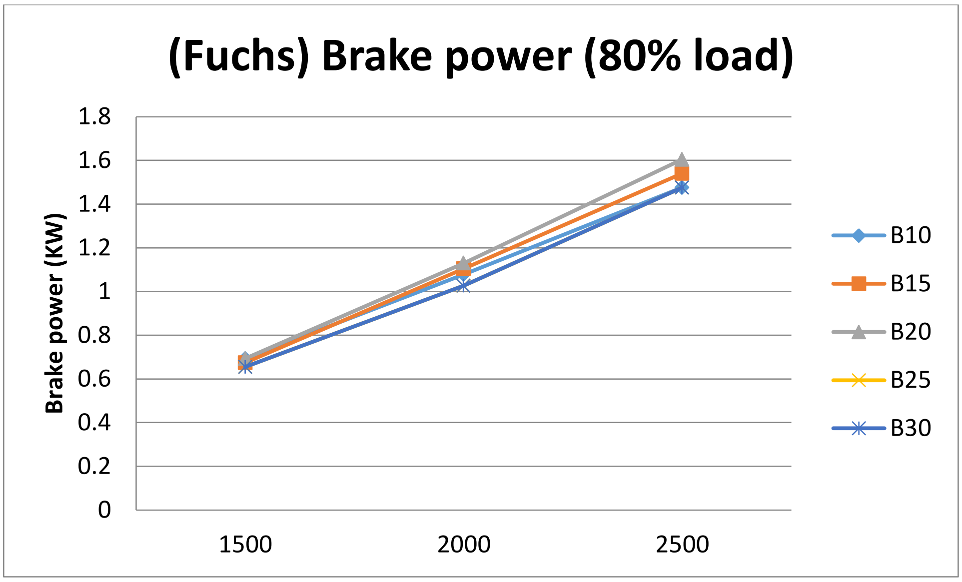
Figures (4.7) and (4.8) shows value of the brake power for60% load, through the gasoline\jatropha blend and gasoline\Foucs blend increase the brake power for the blend B20 for gasoline\jatropha blend that match for gasoline\foucs blend more than the blend B10 which is more than blends B15 and B25

The value of the blend B20 at gasoline\jatropha blend and gasoline\foucs blend at the same about 1.21 kw



Speed (RPM)

Figure **4.9** BP of gasoline\jatropha blend



Speed (RPM)

Figure **4.10** BP of gasoline\Fuchs blend

Figures (4.9) and (4.10) shows value of the brake power for80% load, through the gasoline\jatropha blend and gasoline\Foucs blend increase the brake power for the blend B20 for gasoline\jatropha blend that match for gasoline\Foucs blend more than the blend B10 which is more than blends B15 and B25

The value of the blend B20 at gasoline\jatropha blend and gasoline\Fuchs blend at the same about 1.61 kW.

Show in figures of increase of all brake power when the increase at load.

4.2.2 Indicated Power (I.P.)

The indicated power as seen in table (4.7)using gasoline\jatropha blends and table (4.8)using gasoline\Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.11) to (4. 16):

Table (4.7) Indicated Power (KW) - gasoline\jatropha blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.48289	0.65399	0.807988
	B15	0.48289	0.6549	0.80798
	B20	0.48574	0.65399	0.79849
	B25	0.488593	0.64639	0.803238
	B30	0.486693	0.65589	0.813688
60% load , 1.5 kw	B10	060125	0.994324	1.47314
	B15	0.60017	1.03861	1.41048
	B20	0.625415	1.045663	1.544915
	B25	0.602205	0.974905	1.361514
	B30	0.63881	1.015604	1.514846
80% load , 2 kw	B10	0.88621	1.403494	1.958976
	B15	0.85432	1.42916	2.0467
	B20	0.877187	1.49368	2.09616
	B25	0.854072	1.37999	1.985481
	B30	0.855972	1.41514	2.024621

Table (4.8) Indicated Power (KW) - gasoline\Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.482893	0.66444	0.813688
	B15	0.484793	0.66254	0.810838
	BF20	0.488593	0.66254	0.816538
	B25	0.493343	0.65209	0.819388
	B30	0.499993	0.65684	0.828888
60% load , 1.5 kw	B10	0.587005	1.036599	1.540591
	B15	0.598467	1.023699	1.437753
	BF20	0.62836	1.060293	1.594695
	B25	0.586055	0.94916	1.406829
	B30	0.61658	1.047904	1.582391
80% load , 2 kw	B10	0.842892	1.523289	2.070031
	B15	0.835324	1.523309	2.07939
	BF20	0.874907	1.591633	2.148504
	B25	0.844667	1.509	2.021866
	B30	0.779592	1.53579	2.098151

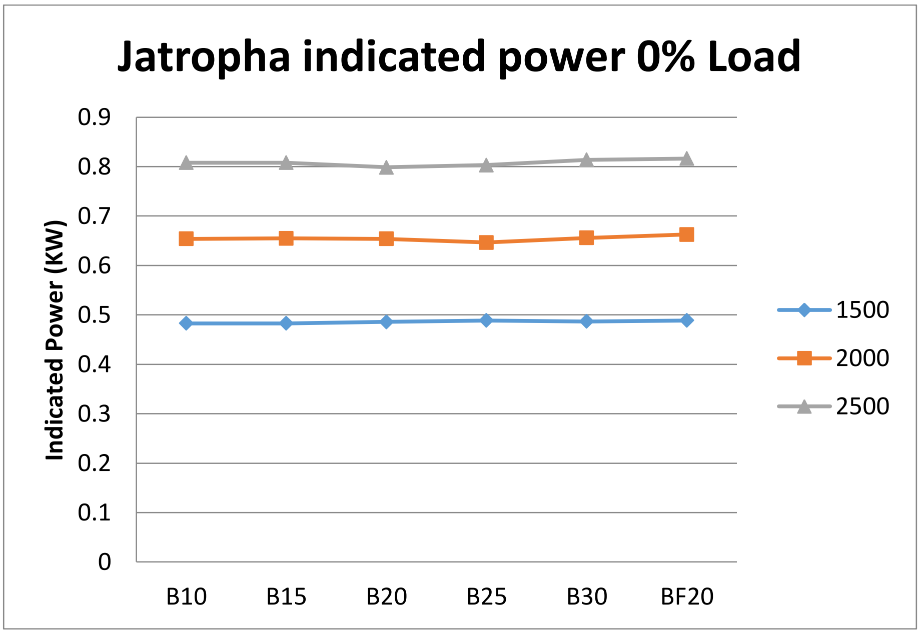


Figure 4.11 IP of gasoline\jatropha blend

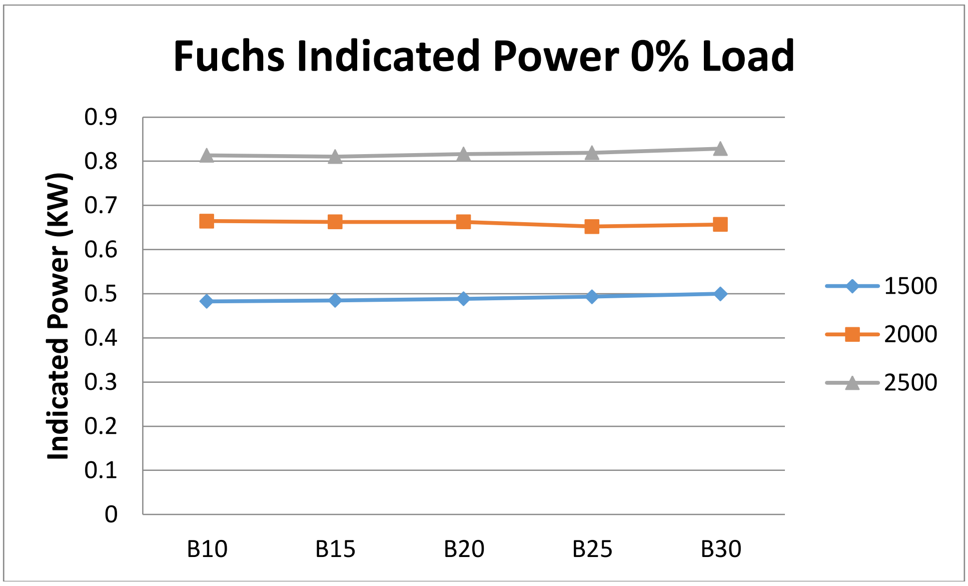
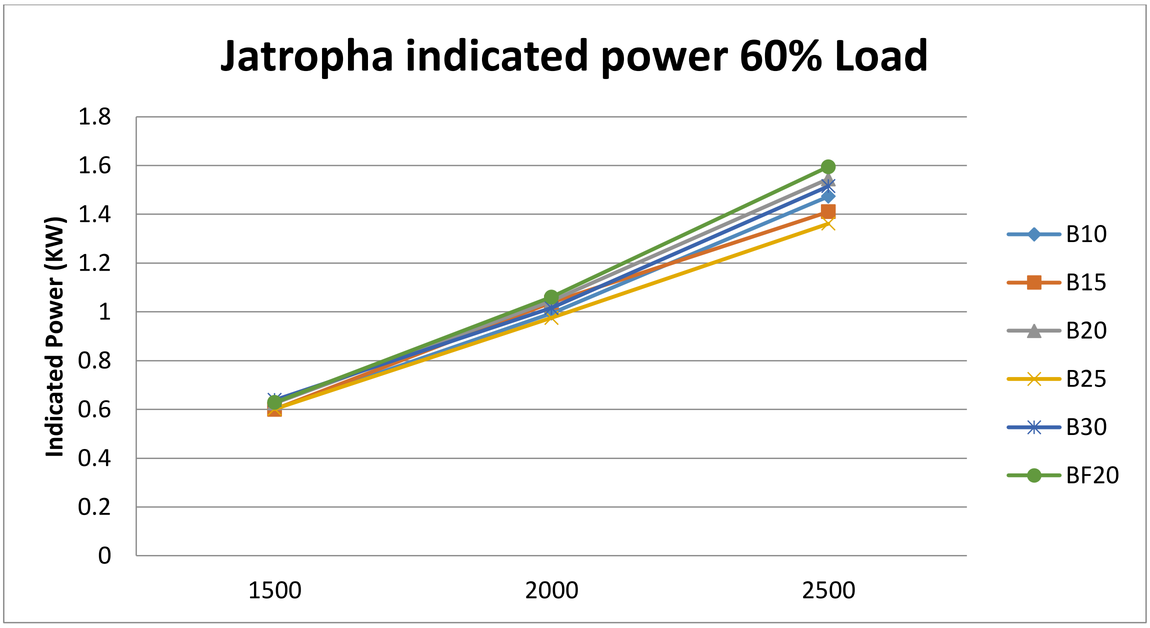


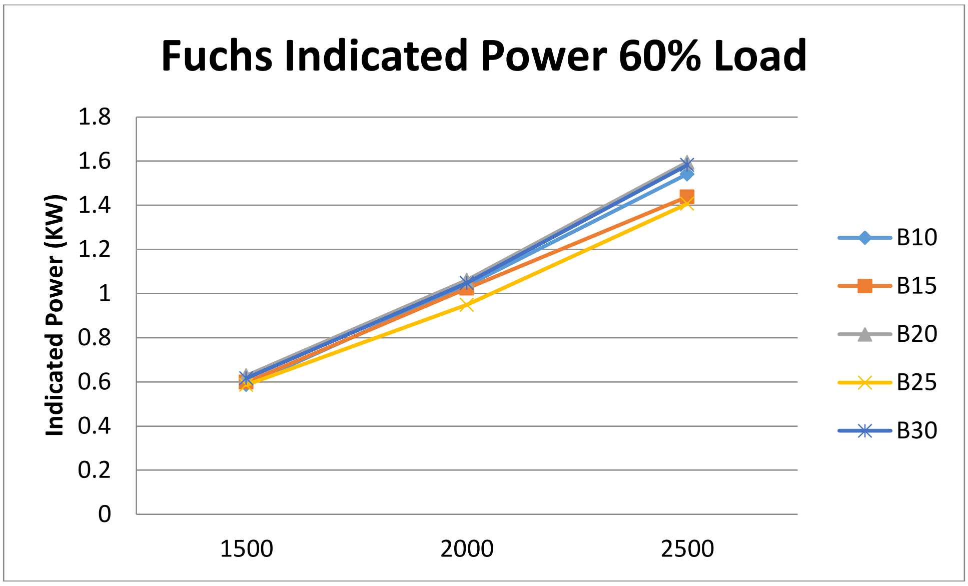
Figure 4.12 IP gasoline\Fuchs blend

Figures (4.11) and (4.12) shows value of the Indicated Power for no load, through the gasoline\jatropha blend and gasoline\Fuchs blend increase the brake power with continuous pattern with increasing speed due to increased torque with increase speed.



Speed (RPM)

Figure 4.13 IP of gasoline\jatropha blend



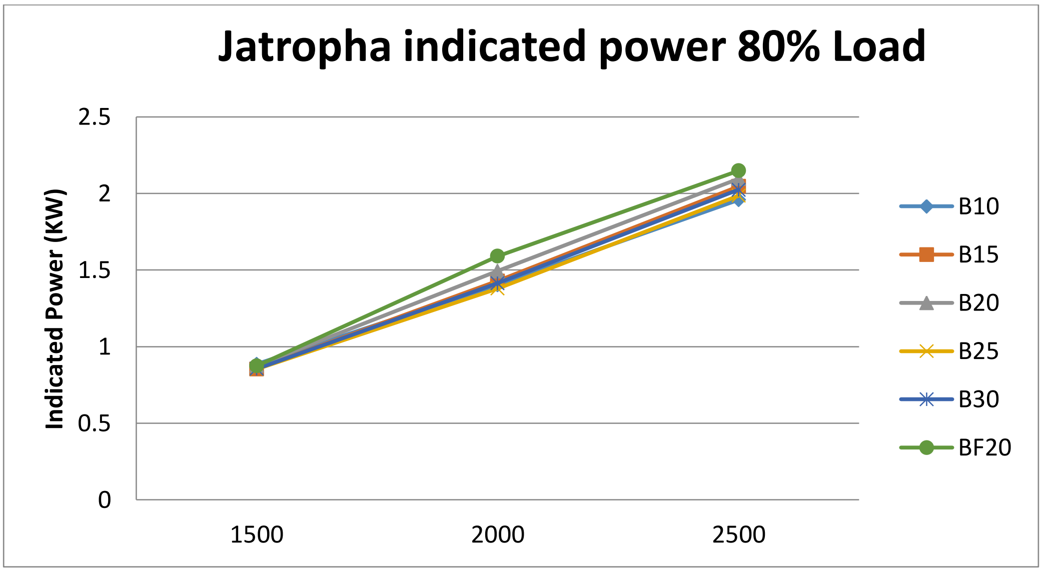
Speed (RPM)

Figure 4.14 IP of gasoline\Fuchs blend

Figures (4.13) and (4.14) shows value of the Indicated Powerfor60% load, through the gasoline\jatropha blend and gasoline\Fuchs blend increase the Indicated Power for the blend B20 for gasoline\jatropha blend that match for gasoline\Fuchs blend more than the blend B10 which is more than blends B15 and B25

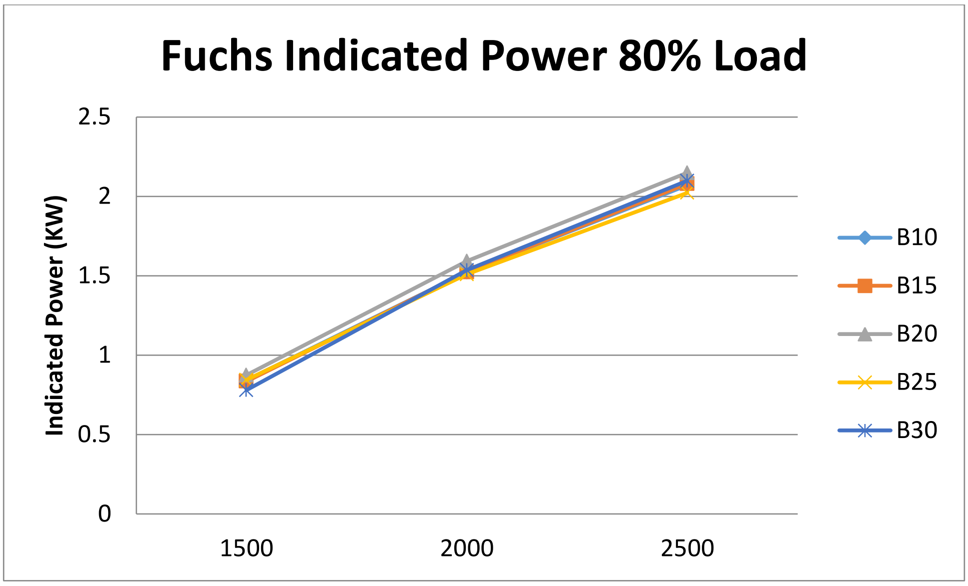
The value of the blend B30 at gasoline\jatropha blend and gasoline\Fuchs blend at the same about 1.6 kW

We note reduction in the indicated power in the gasoline\jatropha blend for the gasoline\Fuchs blend when the load is increase.



Speed (RPM)

Figure 4.15 IP of gasoline\jatropha blend



Speed (RPM)

Figure 4.16 IP of gasoline\Fuchs blend

Figures (4.15) and (4.16) shows value of the Indicated Powerfor80% load, through the gasoline\jatropha blend and gasoline\Fuchs blend increase the Indicated Power for the blend B20 for gasoline\jatropha blend that match for gasoline\Fuchs blend more than the blend B10 which is more than blends B15 and B25

The value of the blend B30 at gasoline\jatropha blend and gasoline\Fuchs blend at the same about 2.2 kW

We note reduction in the indicated power in the gasoline\jatropha blend for the gasoline\Fuchs blend when the 80%load is increase more than 60%load.

4.2.3 Brake mean effective pressure (B.M.E.P.)

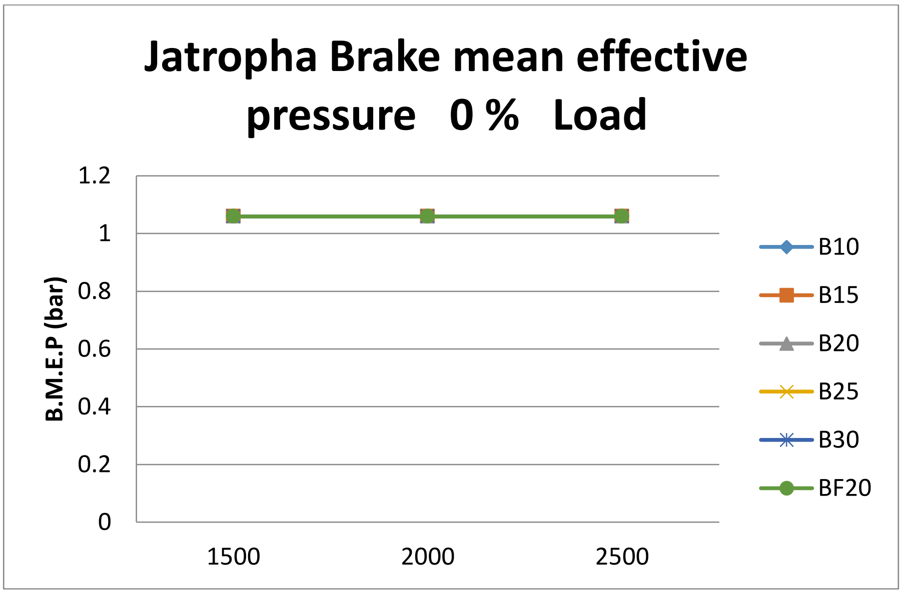
The brake means effective pressure as seen in table (4.9)using gasoline\jatropha blends and table (4.10)using gasoline\foucs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.17) to (4. 22).

Table (4.9) B.M.E.P (bar) - gasoline\jatropha

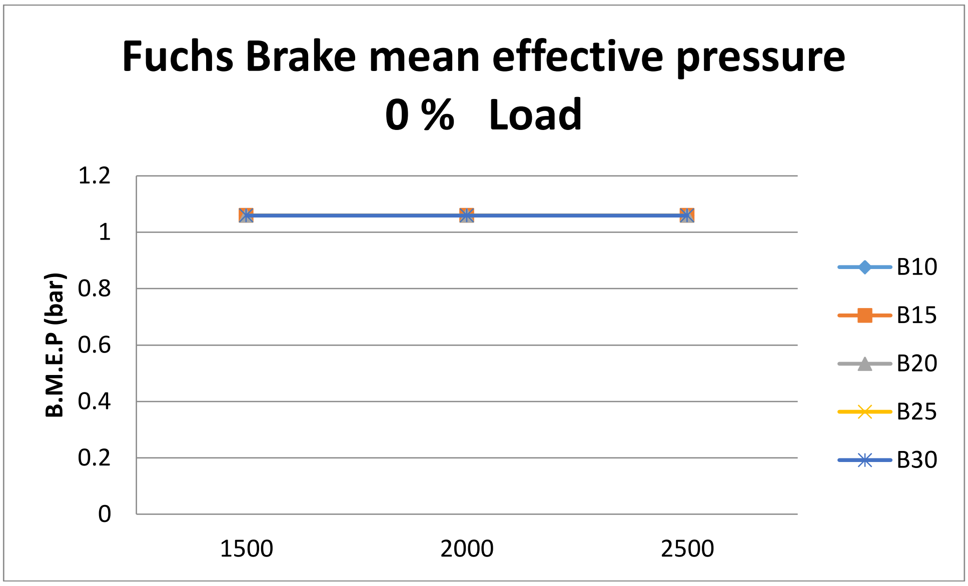
load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	1.0592641	1.0592641	1.0592641
	B15	1.0592641	1.0592641	1.0592641
	B20	1.0592641	1.0592641	1.0592641
	B25	1.0592641	1.0592641	1.0592641
	B30	1.0592641	1.0592641	1.0592641
60% load , 1.5 kw	B10	1.3770433	1.6948226	2.0126018
	B15	1.4300065	1.7477858	1.9066754
	B20	1.4829697	1.800749	2.1185282
	B25	1.377043	1.5888961	1.800749
	B30	1.4829697	1.6948226	2.0126018
80% load , 2 kw	B10	1.9066754	2.2244546	2.4363074
	B15	1.8537122	2.2774178	2.5422338
	B20	1.9066754	2.330381	2.6481602
	B25	1.800749	2.1185282	2.4363074
	B30	1.800749	2.1185282	2.4363074

Table (4.10) B.M.E.P (bar) - gasoline\Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	1.0592641	1.0592641	1.0592641
	B15	1.0592641	1.0592641	1.0592641
	BF20	1.0592641	1.0592641	1.0592641
	B25	1.0592641	1.0592641	1.0592641
	B30	1.0592641	1.0592641	1.0592641
60% load , 1.5 kw	B10	1.3770433	1.6948226	2.0126018
	B15	1.4300065	1.7477858	1.9066754
	BF20	1.4829697	1.800749	2.1185282
	B25	1.3770433	1.5888961	1.800749
	B30	1.4829697	1.6948226	2.0126018
80% load , 2 kw	B10	1.9066754	2.2244546	2.4363074
	B15	1.8537122	2.2774178	2.5422338
	BF20	1.9066754	2.330381	2.6481602
	B25	1.800749	2.1185282	2.4363074
	B30	1.800749	2.1185282	2.4363074



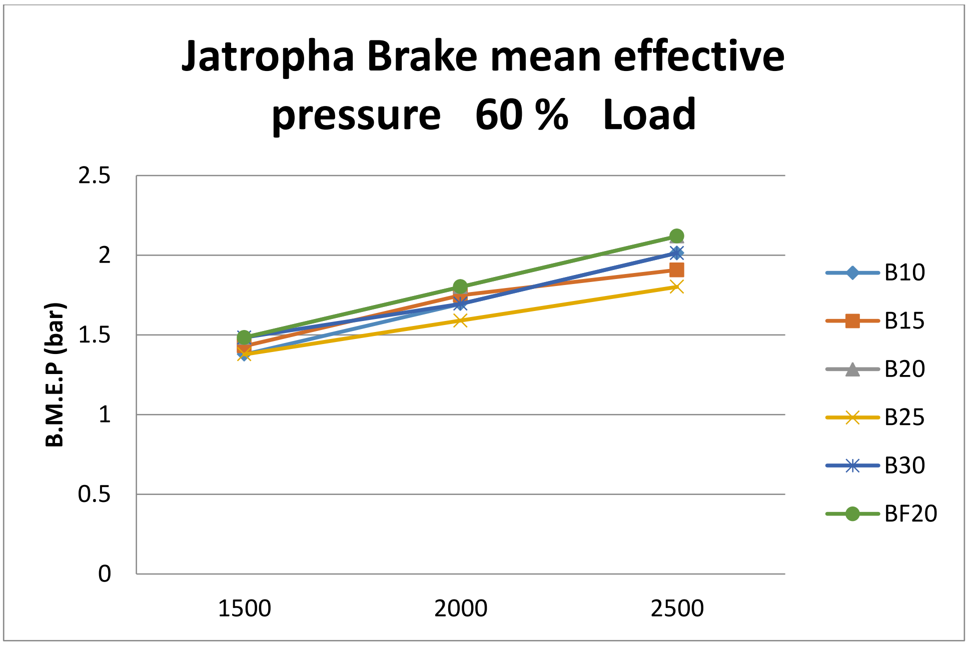
Speed (RPM)
Figure 4.17 B.M.E.P of gasoline\jatropha blend



Speed (RPM)

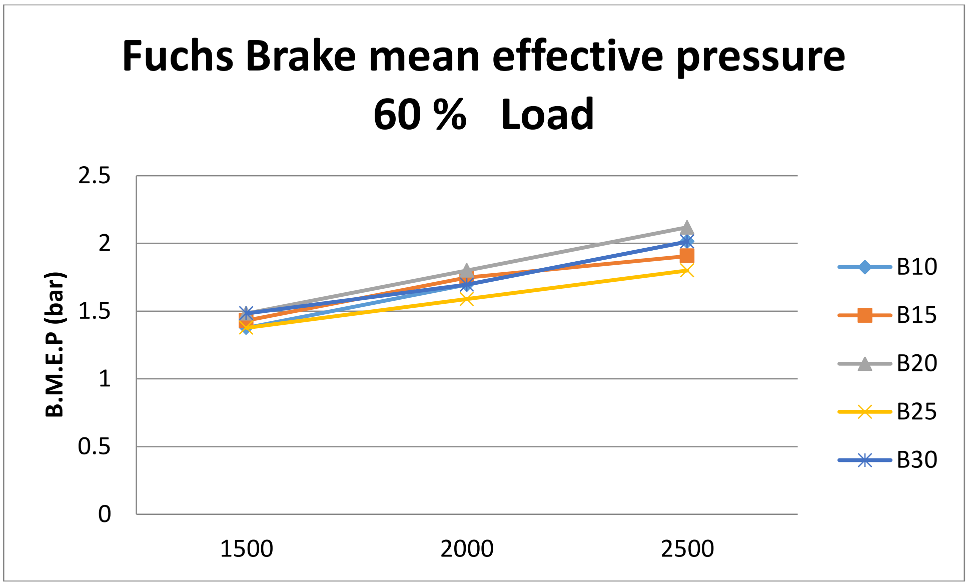
Figure 4.18 B.M.E.P of gasoline\Fuchs blend

Figures (4.17) and (4.18) shows value of the Brake mean effective pressure for no load, through the gasoline\jatropha blend and gasoline\Fuchs blend increase the Brake mean effective pressure with continuous pattern with increasing speed due to increased torque with increase speed. Because the small different to value the brake power at all the blends.



Speed (RPM)

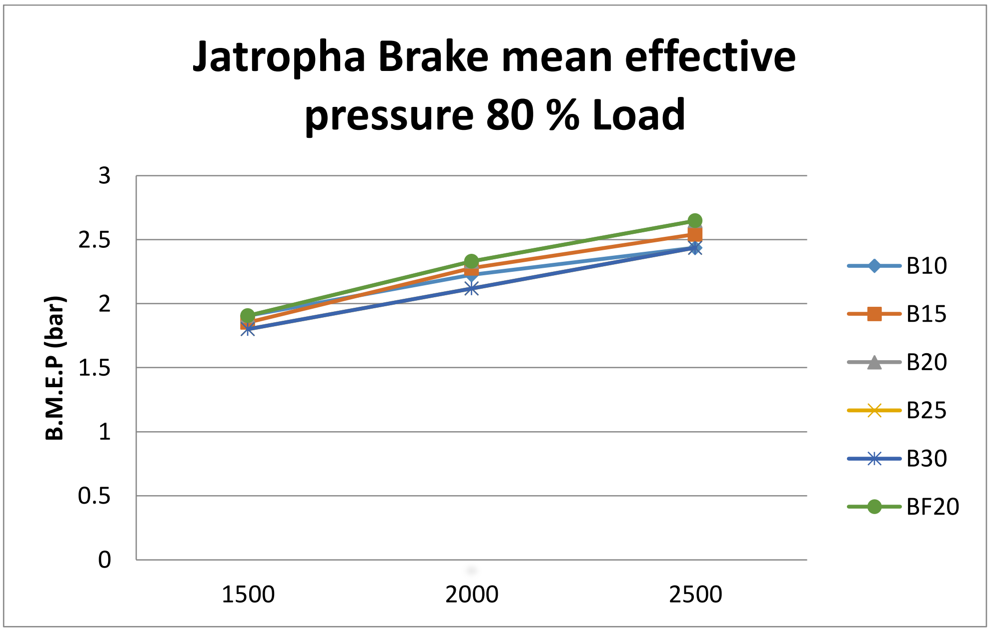
Figure 4.19 B.M.E.P of gasoline\jatropha blend



Speed (RPM)

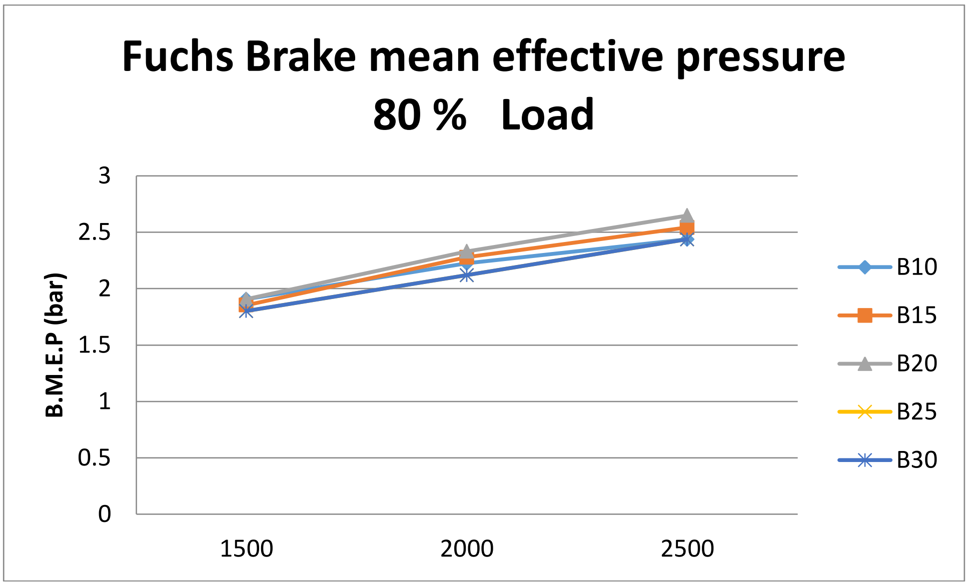
Figure 4.20 B.M.E.P of gasoline\Fuchs blend

Figures (4.19) and (4.20) shows value of the Brake mean effective pressure for60% load , through the gasoline\jatropha blend and gasoline\Fuchs blend increase the Brake mean effective pressure for the blend B20 for gasoline\jatropha blend that match for gasoline\Fuchs blend more than the blend B10 which is more than blends B15 and B25 The value of the blend B30 at gasoline\jatropha blend and gasoline\Fuchs blend at the same about 2.1 bar



Speed (RPM)

Figure 4.21 B.M.E.P of gasoline\jatropha blend



Speed (RPM)

Figure 4.22 B.M.E.P of gasoline\Fuchs blend

Figures (4.21) and (4.22) shows value of the Brake mean effective pressure for80% load , through the gasoline\jatropha blend and gasoline\Fuchs blend increase the Brake mean effective pressure for the blend B20 for gasoline\jatropha blend that match for gasoline\Fuchs blend more than the blend B10 which is more than blends B15 and B25 The value of the blend B30 at gasoline\jatropha blend and gasoline\ Fuchs blend at the same about 2.6 bar

We note reduction in the Brake mean effective pressure in the gasoline\jatropha blend for the gasoline\ Fuchs blend when the 80%load is increase more than 60%load.

4.2.4 Engine mechanical efficiency ($\dot{\eta}$)$_{mech}$) (%)

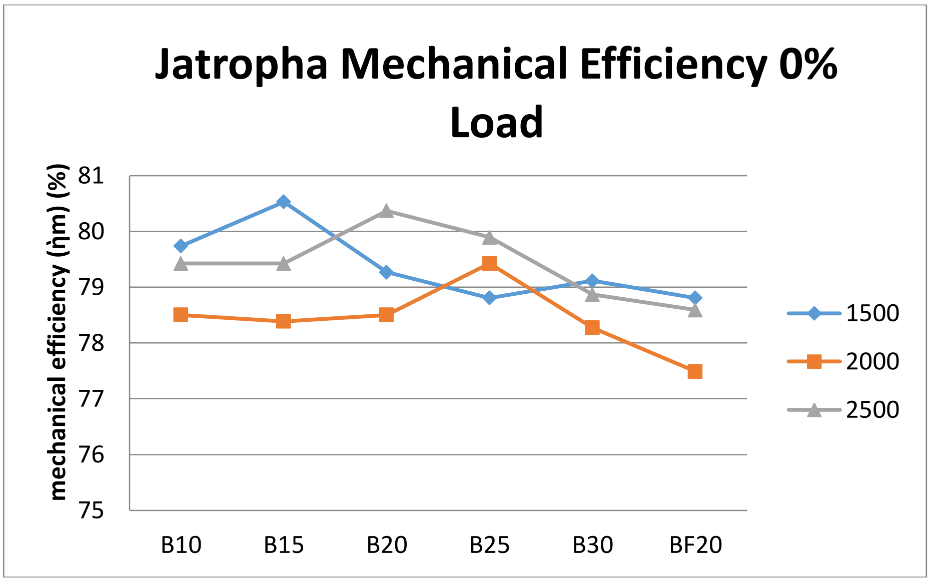
The mechanical efficiency as seen in table (4.11) using gasoline\jatropha blends and table (4.12) using gasoline\foucs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.23) to (4.28):

Table (4.11) mechanical efficiency (ῃm) (%) - gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	79.73669	78.5012	79.424187
	B15	80.528817	78387333	79.424187
	B20	79.268851	78.5012	80.369135
	B25	78.80647	79.424187	79.893867
	B30	79.114122	78.273796	78.867809
60% load , 1.5 kw	B10	83.251705	82.611302	82.768794
	B15	86.608959	81560032	81.895621
	B20	86.192357	83.465036	83.077386
	B25	83.120373	78.990773	80.128001
	B30	84.385016	80.880343	80.490099
80% load , 2 kw	B10	78.20667	76.816787	75.345286
	B15	78.872194	77.233186	75.251013
	B20	79.011305	75.61539	76.537321
	B25	76.64132	74.404887	74.339471
	B30	76.4712	72.556779	72.902339

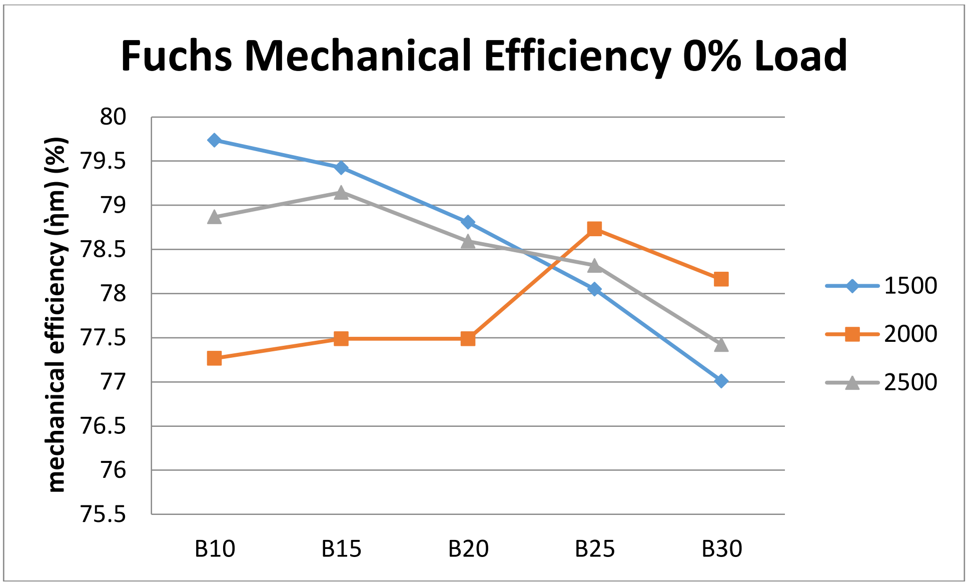
Table (4.12) mechanical efficiency (ή$_m$) (%) - gasoline\ Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	79.736691	77.26657	78.867809
	B15	79.424187	77.488152	79.14502
	BF20	78.80647	77.488152	78.592532
	B25	78.047705	78.72993	78.319171
	B30	77.009655	78.160587	77.421544
60% load , 1.5 kw	B10	85.272704	79.242214	79.14502
	B15	86.856426	82.748339	80.342583
	BF20	85.78839	82.313379	80.484042
	B25	85.410932	81.133318	77.547018
	B30	87.427412	78.387333	77.054347
80% load , 2 kw	B10	82.226063	70.775736	71.30309
	B15	80.666193	72.459945	74.068357
	BF20	79.217208	70.962213	74.672606
	B25	77.494688	68.043738	73.001676
	B30	83.963412	66.856797	70.347467



Speed (RPM)

Figure 4.23 mechanical efficiency (ή$_m$) (%) of gasoline\jatropha blend

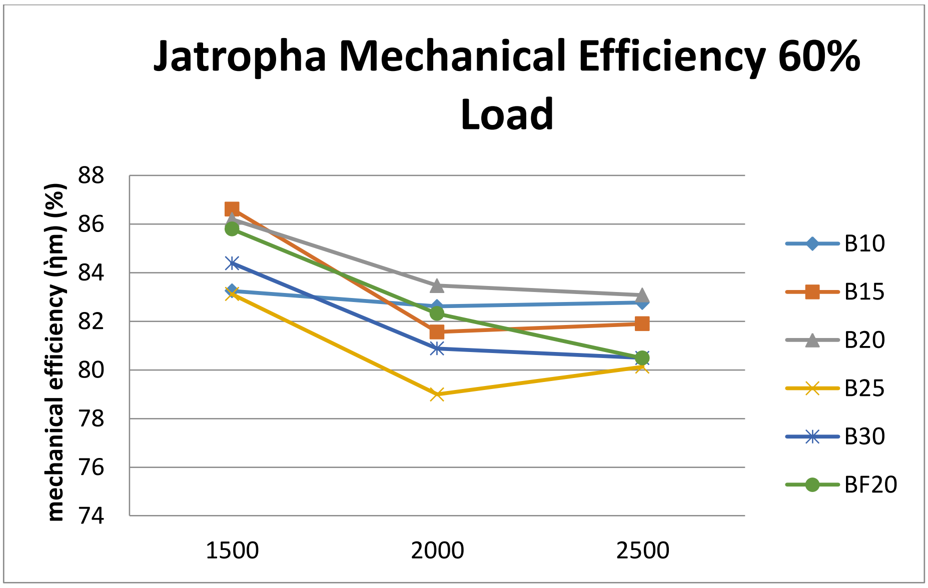


Speed (RPM)

Figure 4.24 mechanical efficiency (ῂm) (%) of gasoline\ Fuchs blend

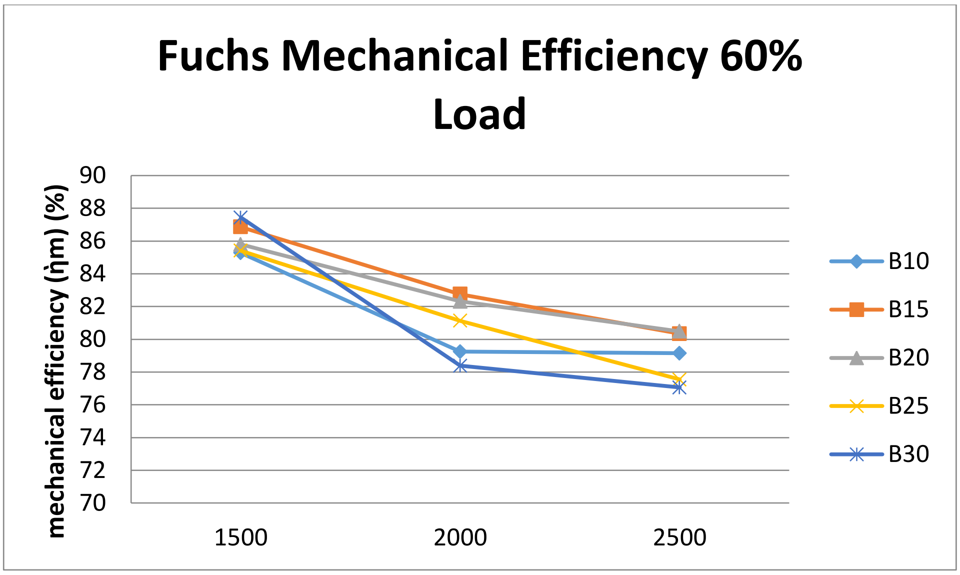
Figures (4.23) and (4.24) shows value of the mechanical efficiency for no load, through the gasoline\jatropha blend and gasoline\ Fuchs blend increase the mechanical efficiency with continuous pattern with decreasing speed and load.

The values of the B10at gasoline\ Fuchs blend great than the B10 at the gasoline\jatropha blend.



Speed (RPM)

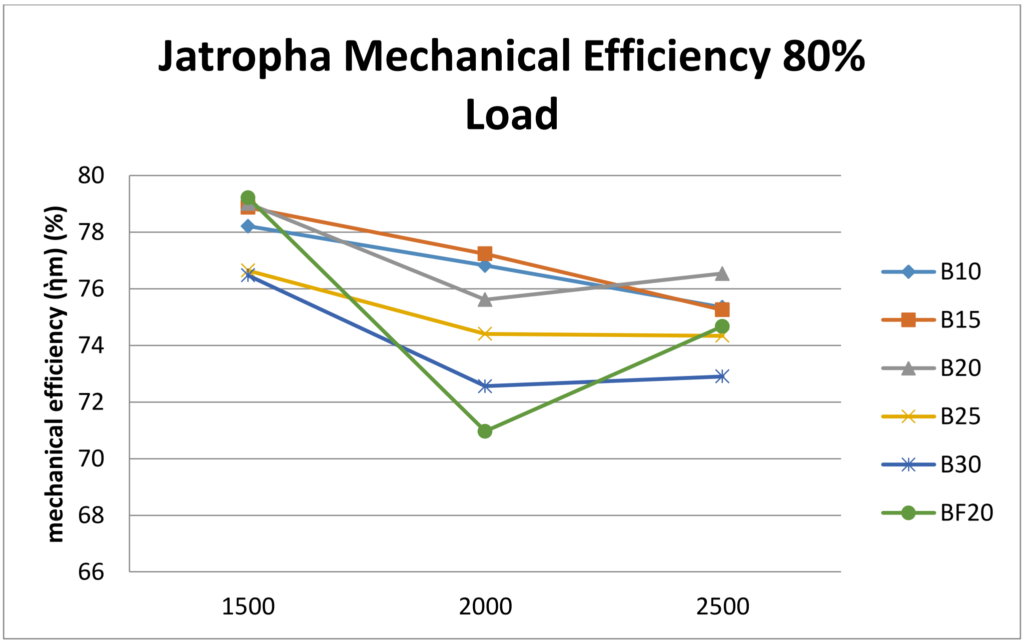
Figure 4.25 mechanical efficiency (ῂm) (%) of gasoline\jatropha blend



Speed (RPM)

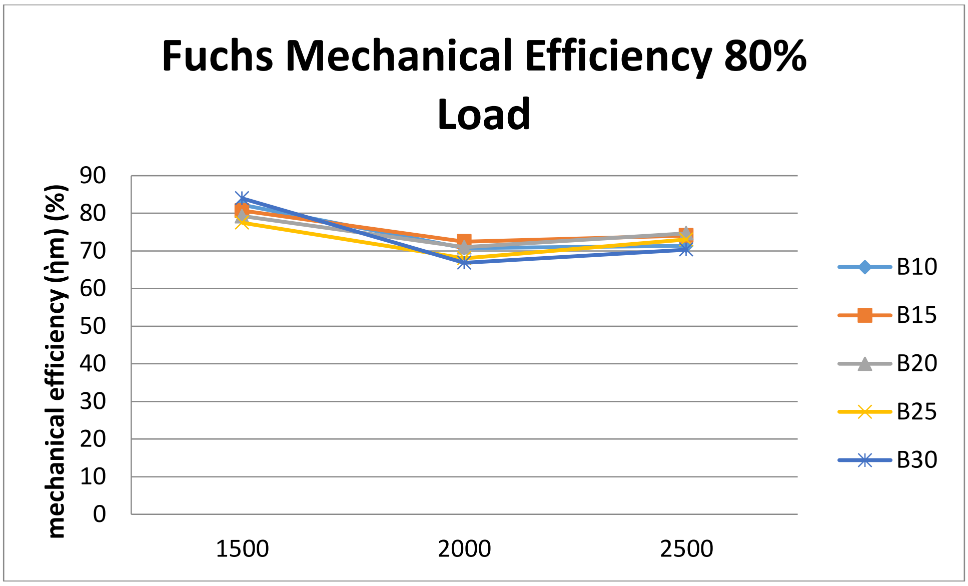
Figure 4.26 mechanical efficiency (ἡm) (%) of gasoline\ Fuchs blend

Figures (4.25) and (4.26) shows value of the mechanical efficiency for 60% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend decrease the mechanical efficiency with continuous pattern with increasing speed and load.



Speed (RPM)

Figure 4.28 mechanical efficiency (ἡm) (%) of gasoline\jatropha blend



Speed (RPM)

Figure 4.27 mechanical efficiency (ἡm) (%) of gasoline\ Fuchs blend

Figures (4.27) and (4.28) shows value of the mechanical efficiency for 80% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend increase the mechanical efficiency with continuous pattern with increasing speed and load

The values of the blends at gasoline\ Fuchs blend fast decreases than the blends at the gasoline\jatropha blend.

4.2.5 Brake specific fuel consumption (B.S.F.C):

The brake specific fuel consumption as table (4.13) using gasoline\jatropha blends and table (4.14) using gasoline\ Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.29) to (4.34):

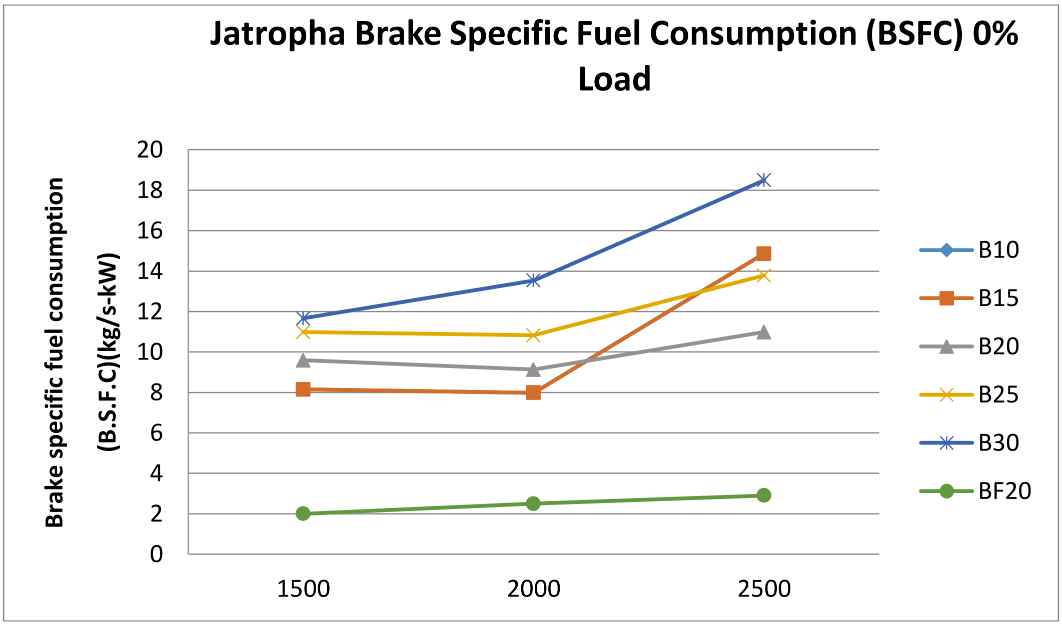
Which shows the variation of B.S.F.C of 2-stroke petrol and various blends of jatropha oil at different loads. It is found that the specific consumption for the blend is closed to petrol engine. However if the jatropha oil in the blend is increase the specific fuel consumption was found to be higher that effects the lower heating value and high fuel flow rate due to high viscosity and density of the blends i.e higher properties of jatropha oil which in turn increase the specific fuel consumption due to poor optimize of the fuel.

Table (4.13) Brake specific fuel consumption (B.S.F.C)(kg/s-kW)- gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	8.15	7.98	14.86
	B15	8.15	7.98	14.86
	B20	9.59	9.13	10.98
	B25	10.98	10.82	13.78
	B30	11.66	13.54	18.49
60% load , 1.5 kw	B10	9.02	10.53	18.05
	B15	9.02	10.68	18.05
	B20	9.47	11.31	16.48
	B25	11.66	14.3	19.95
	B30	13.07	15.16	22.29
80% load , 2 kw	B10	9.97	12.43	21.66
	B15	9.97	12.43	21.66
	B20	9.72	13.07	24.45
	B25	12.03	14.30	25.27
	B30	13.29	16.48	24.45

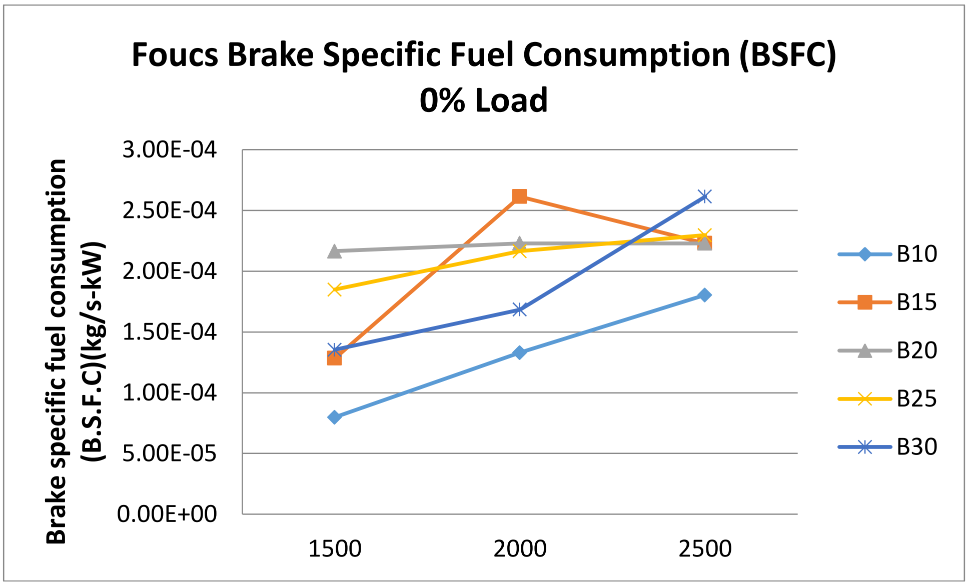
Table (4.14) Brake specific fuel consumption (B.S.F.C)(kg/s-kW)- gasoline\ Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	7.97884E-05	0.000132981	0.000180474
	B15	0.000128473	0.000261376	0.000222938
	BF20	0.000216569	0.000222938	0.000222938
	B25	0.000184876	0.000216569	0.000229694
	B30	0.000135355	0.000168442	0.000261376
60% load , 1.5 kw	B10	0.000120316	0.000143017	0.000216569
	B15	0.000145767	0.000291535	0.000291535
	BF20	0.000270711	0.000252663	0.000329561
	B25	0.000189498	0.000229694	0.000329561
	B30	0.000145767	0.000204862	0.000280737
80% load , 2 kw	B10	0.000130688	0.000148625	0.000236872
	B15	0.000216569	0.000344541	0.000315829
	BF20	0.000344541	0.000280737	0.000398942
	B25	0.000204862	0.000261376	0.000270711
	B30	0.000161274	0.000189498	0.000291535



Speed (RPM)

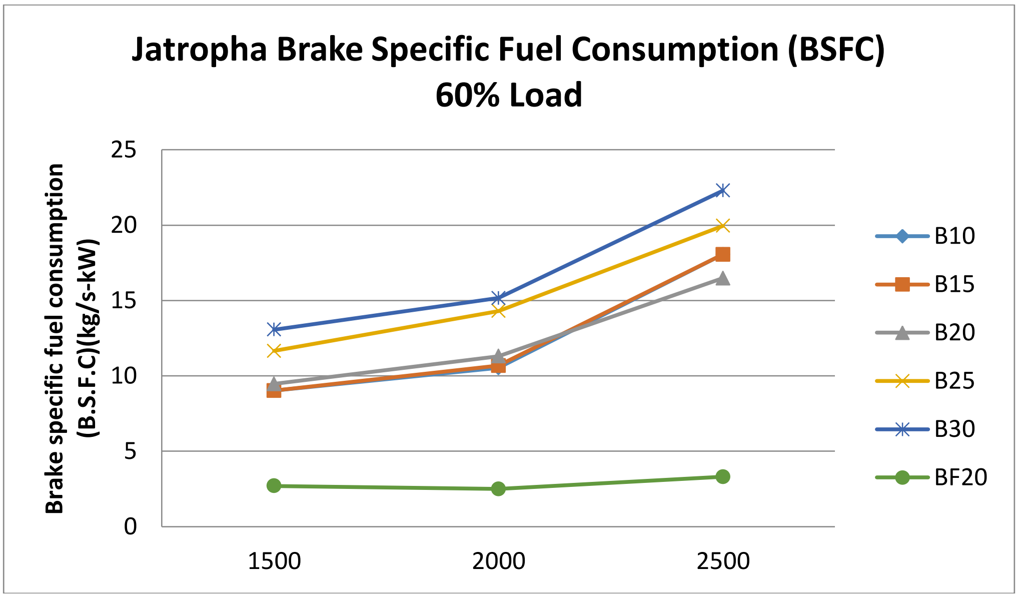
Figure 4.29 B.S.F.C of gasoline\jatropha blend



Speed (RPM)

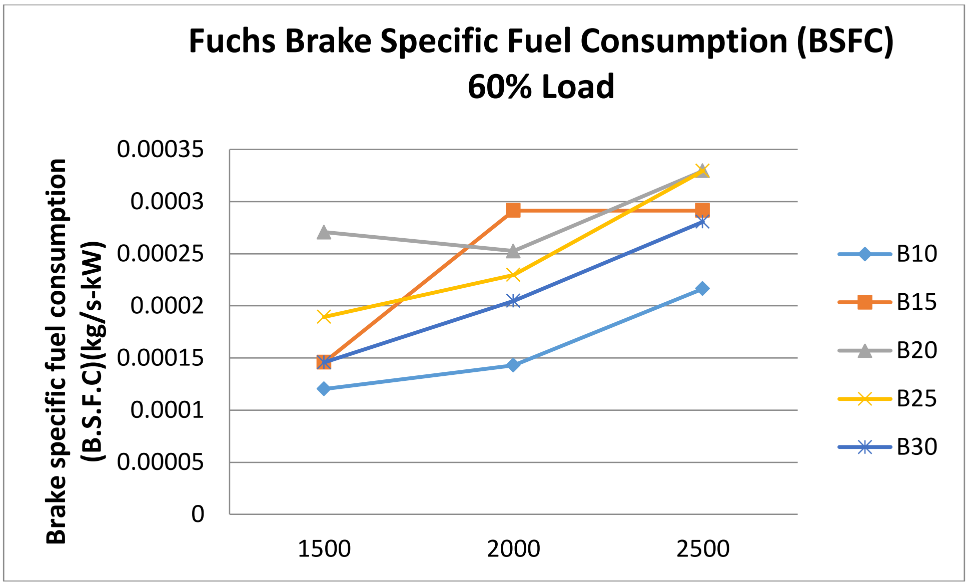
Figure 4.30 B.S.F.C of gasoline\ Fuchs blend

Figures (4.29) and (4.30) shows value of the Brake Specific Fuel Consumption for no load, through the gasoline\jatropha blend and gasoline\ Fuchs blend increase the Brake Specific Fuel Consumption with continuous pattern with increasing speed and load



Speed (RPM)

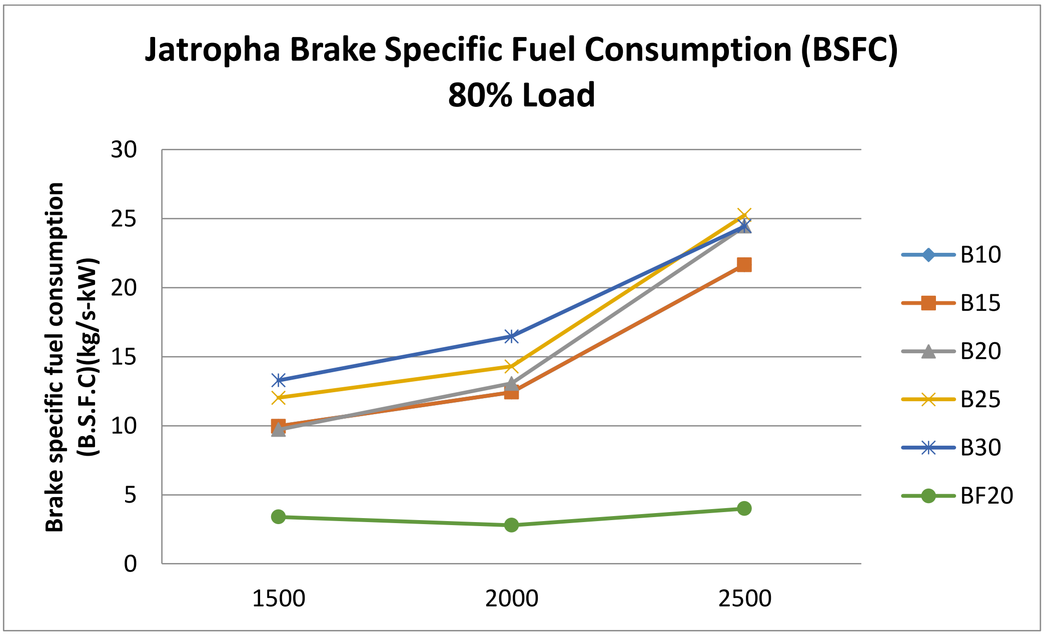
Figure 4.31 B.S.F.C of gasoline\jatropha blend



Speed (RPM)

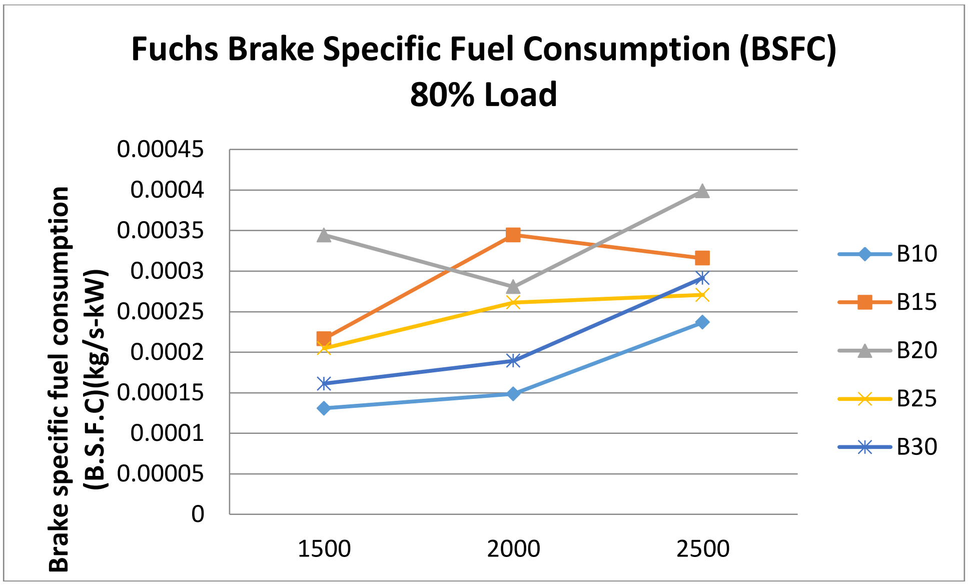
Figure 4.32 B.S.F.C of gasoline\ Fuchs blend

Figures (4.31) and (4.32) shows value of the Brake Specific Fuel Consumption for 60% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend increase the Brake Specific Fuel Consumption with continuous pattern with increasing speed and load



Speed (RPM)

Figure 4.33 B.S.F.C of gasoline\jatropha blend



Speed (RPM)

Figure 4.34 B.S.F.C of gasoline\ Fuchs blend

Figures (4.33) and (4.34) shows value of the Brake Specific Fuel Consumption for 80% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend increase the Brake Specific Fuel Consumption with continuous pattern with increasing speed and load.

4.2.6 Brake thermal efficiency (ήB.T) (%)

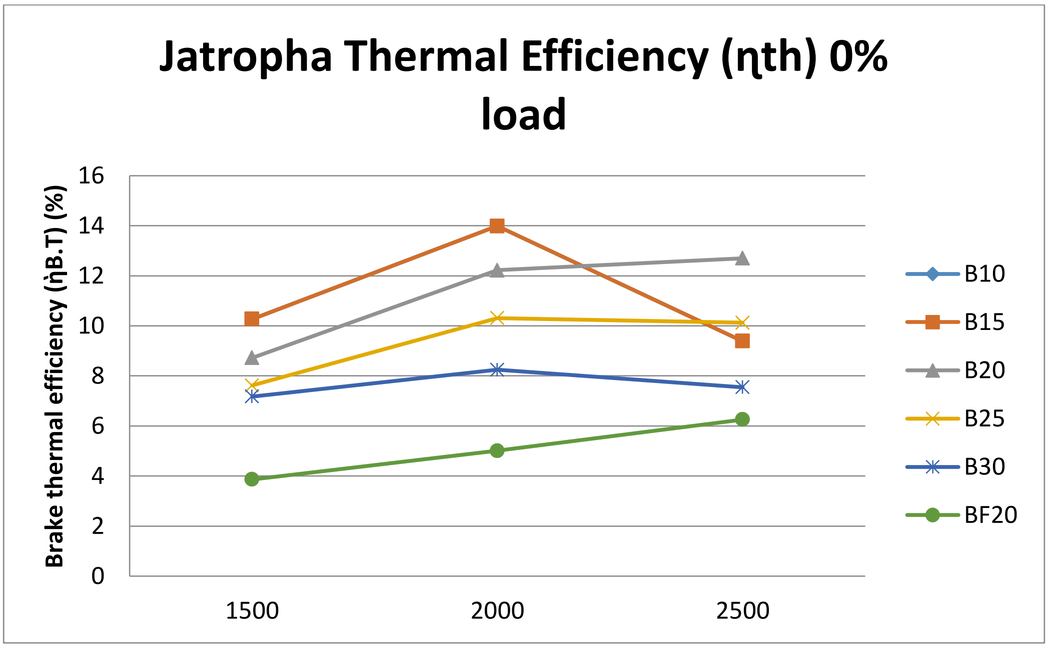
The brake thermal efficiency as in table (4.15) using gasoline\jatropha blends and table (4.16) using gasoline\foucs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.35) to (4. 40).

Table (4.15) Brake thermal efficiency (ῄB.T) (%)-gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	10.2699968	13.9878093	9.38655624
	B15	10.2699968	13.9878093	9.38655624
	B20	8.7239758	12.2209281	12.6994584
	B25	7.619675	10.3068068	10.1227567
	B30	7.17795477	8.24544548	7.54605501
60% load , 1.5 kw	B10	12.058964	16.9620593	14.6871998
	B15	12.5227703	17.2491775	13.9141892
	B20	12.3681682	16.7706471	16.9326112
	B25	9.3313412	11.7055878	11.8896379
	B30	8.96692196	11.7792078	11.8896379
80% load , 2 kw	B10	15.106834	18.8614565	14.8160348
	B15	14.6871998	19.3105388	15.4602103
	B20	15.5043823	18.7878365	142638845
	B25	11.8270609	15.6074504	12.6994584
	B30	10.7006741	13.546089	13.1227737

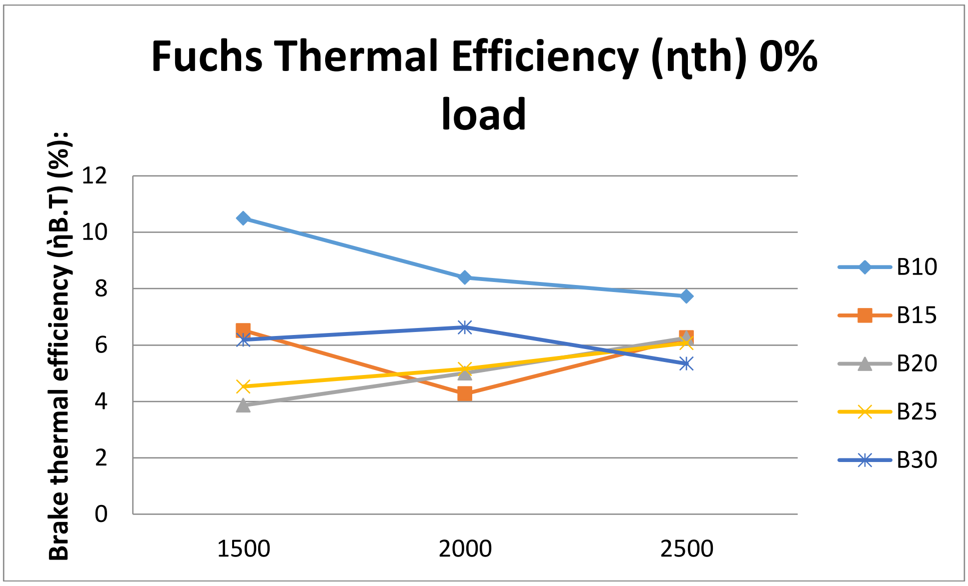
Table (4.16) Brake thermal efficiency (ὴ$_{B.T}$) (%)-gasoline\ Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	10.490857	8.39268558	7.73010514
	B15	6.51537433	4.26996284	6.25770416
	BF20	3.86505257	5.00616333	6.25770416
	B25	4.52763301	5.15340342	6.07365403
	B30	6.18408411	6.6258044	5.33745355
60% load , 1.5 kw	B10	9.04422301	12.4859603	12.2393331
	B15	7.75219115	6.3166002	8.61354572
	BF20	4.32885888	7.50924499	8.46630562
	B25	5.74236381	7.28838484	7.19635978
	B30	8.03930934	8.71661379	9.44177127
80% load , 2 kw	B10	11.5288997	15.7694145	13.546089
	B15	6.76384199	6.96445663	10.601287
	BF20	4.3730309	8.74606181	8.74238081
	B25	6.94605161	8.53992567	11.8528279
	B30	8.82336286	11.7792078	11.0061973



Speed (RPM)

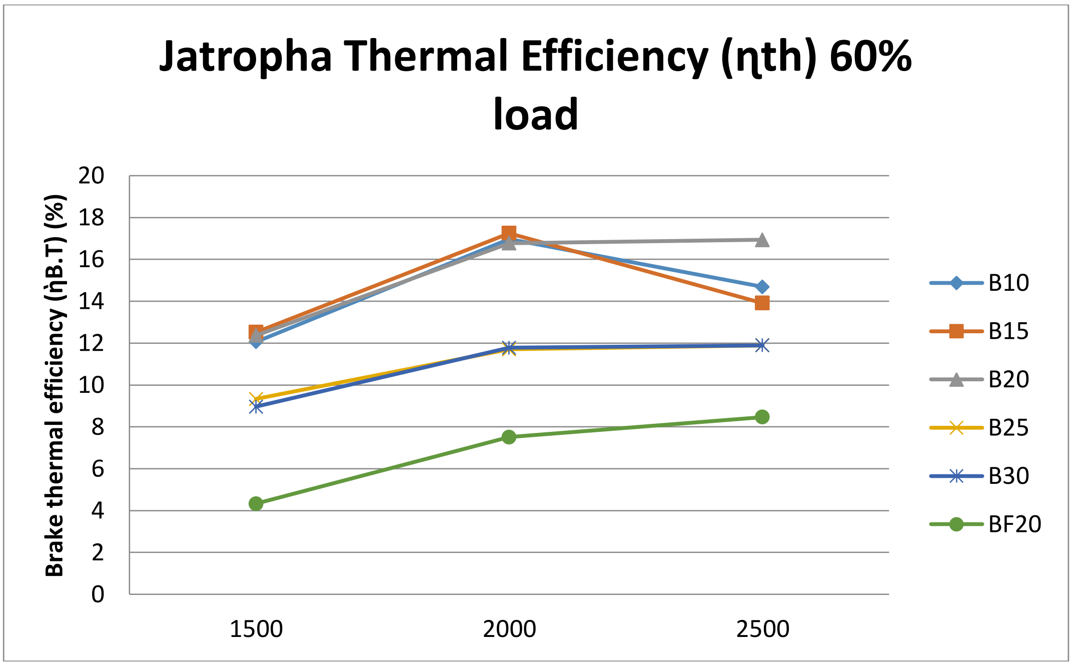
Figure 4.35 Brake thermal efficiency (ὴB.T) (%): of gasoline\jatropha blend



Speed (RPM)

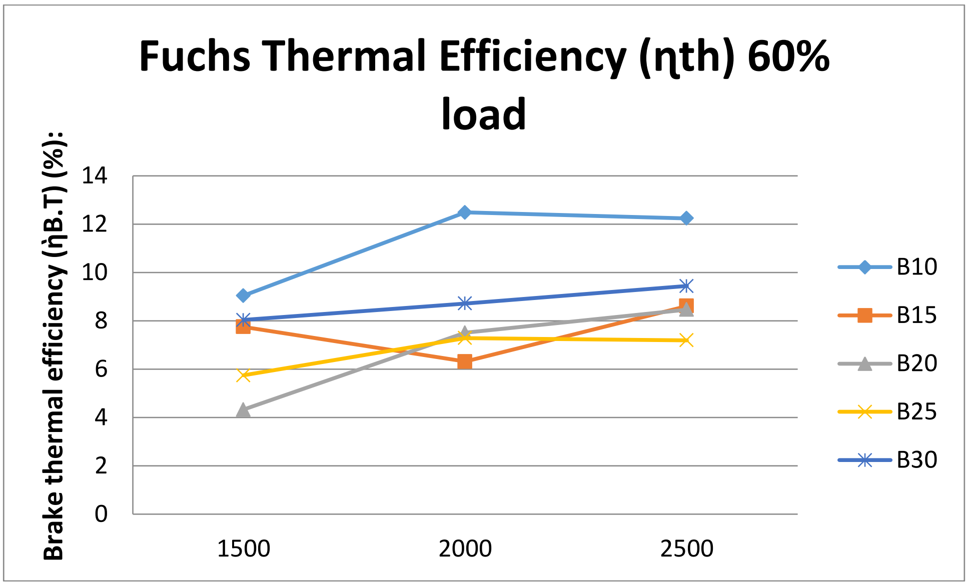
Figure 4.36 Brake thermal efficiency (ṅB.T) (%): of gasoline Fuchs **blend**

Figures (4.35) and (4.36) shows value of the Brake thermal efficiency for no load, through the gasoline\jatropha blend and gasoline\ Fuchs blend decrease the Brake thermal efficiency with continuous pattern with decreasing speed and load. The values of the B10at gasoline\ Fuchs blend great than the B10 at the gasoline\jatropha blend.



Speed (RPM)

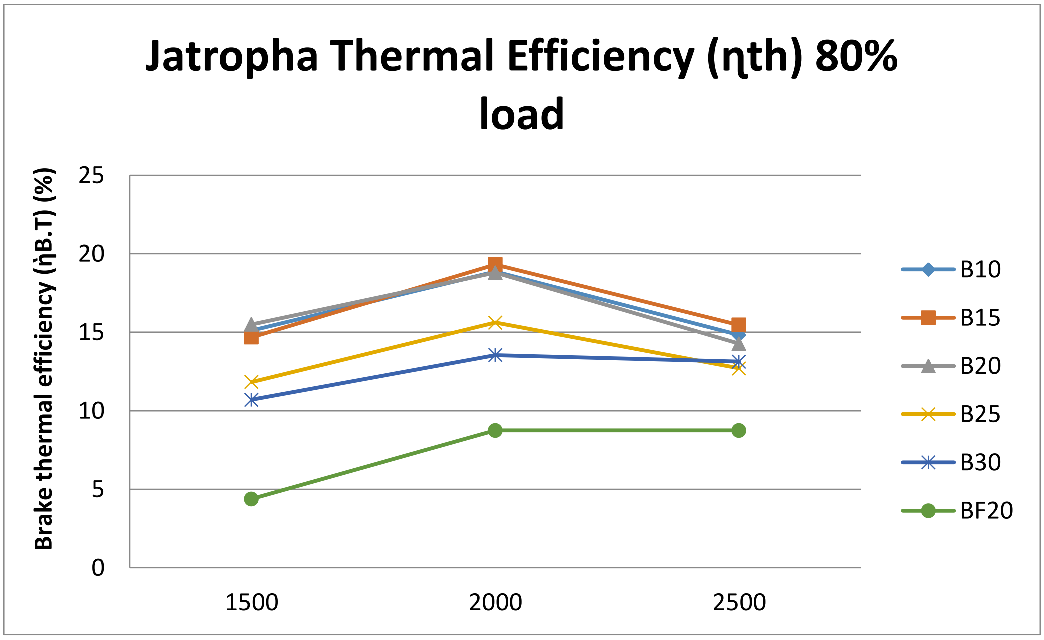
Figure 4.37 Brake thermal efficiency (ṅB.T) (%): of gasoline\jatropha blend



Speed (RPM)

Figure 4.38 Brake thermal efficiency (ṅB.T) (%): of gasoline\foucs blend

Figures (4.37) and (4.38) shows value of the Brake thermal efficiency for 60% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend decrease the Brake thermal efficiency with continuous pattern with increasing speed and load



Speed (RPM)

Figure 4.39 Brake thermal efficiency (ṅB.T) (%): of gasoline\jatropha blend

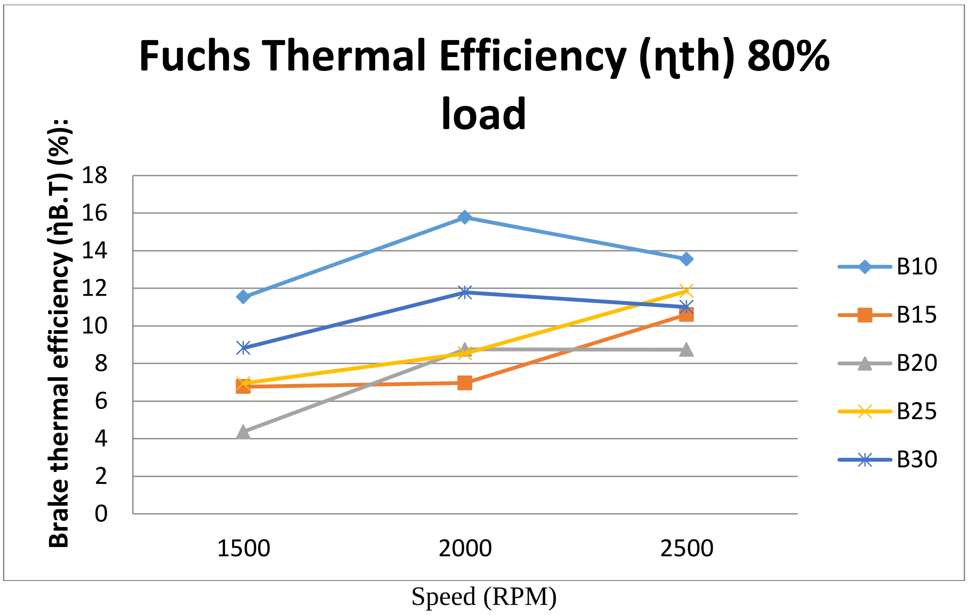


Figure 4.40 Brake thermal efficiency (ṅB.T) (%) of gasoline\foucs blend

Figures (4.39) and (4.40) shows value of the Brake thermal efficiency for 80% load, through the gasoline\jatropha blend and gasoline\ Fuchs blend decrease the Brake thermal efficiency with continuous pattern with decreasing speed and load.

The values of the B10at gasoline\ Fuchs blend great than the B10 at the gasoline\jatropha blend.

4.3 Engine emissions:

The engine emissions consists of carbon monoxide, carbon dioxide, hydrocarbons, nitrogen monoxide and oxygen, which were measured.

4.3.1 Carbon monoxide CO (% volume)

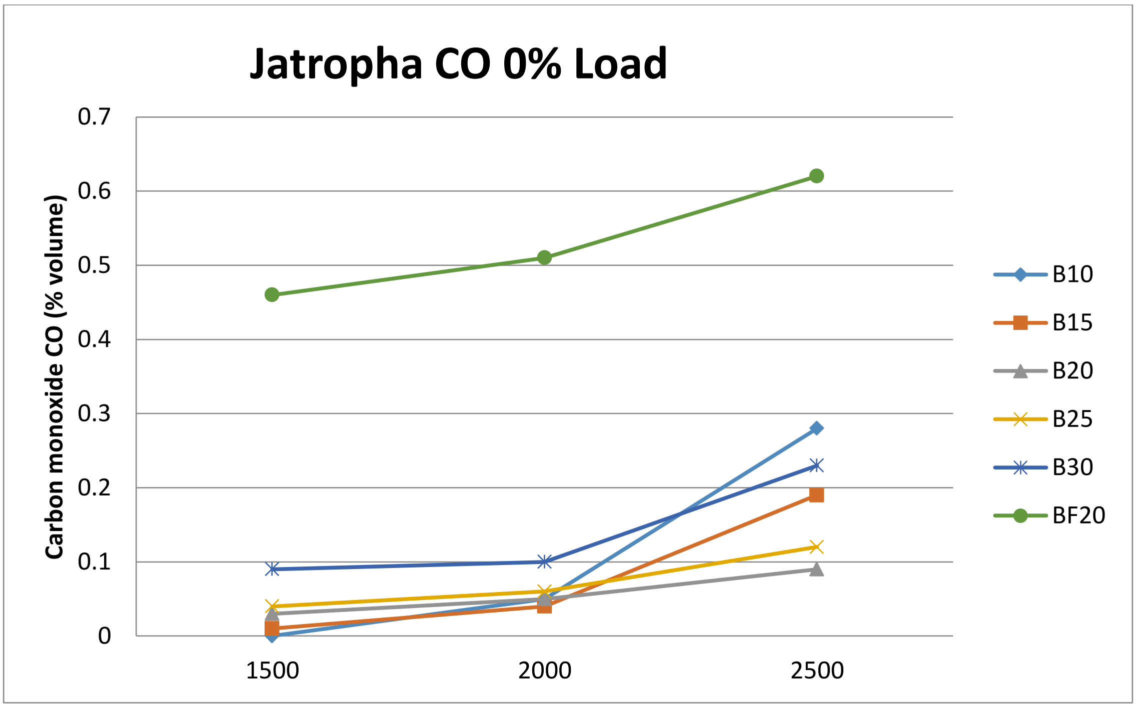
As in table (4.17) using gasoline\jatropha blends and table (4.18) using gasoline\ Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.41) to (4. 44):

Table (4.17) Carbon monoxide CO (% volume) - gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0	0.05	0.28
	B15	0.01	0.09	0.08
	B20	0.03	0.05	0.09
	B25	0.04	0.06	0.12
	B30	0.09	0.041	0.21
60% load , 1.5 kw	B10	0.03	0.05	0.09
	B15	0.02	0.031	0.05
	B20	0.03	0.04	0.09
	B25	0.04	0.05	0.11
	B30	0.06	0.09	0.2
80% load , 2 kw	B10	0.01	0.1	0.19
	B15	0.03	0.13	0.35
	B20	0.02	0.11	0.22
	B25	0.03	0.2	0.4
	B30	0.02	0.1	0.29

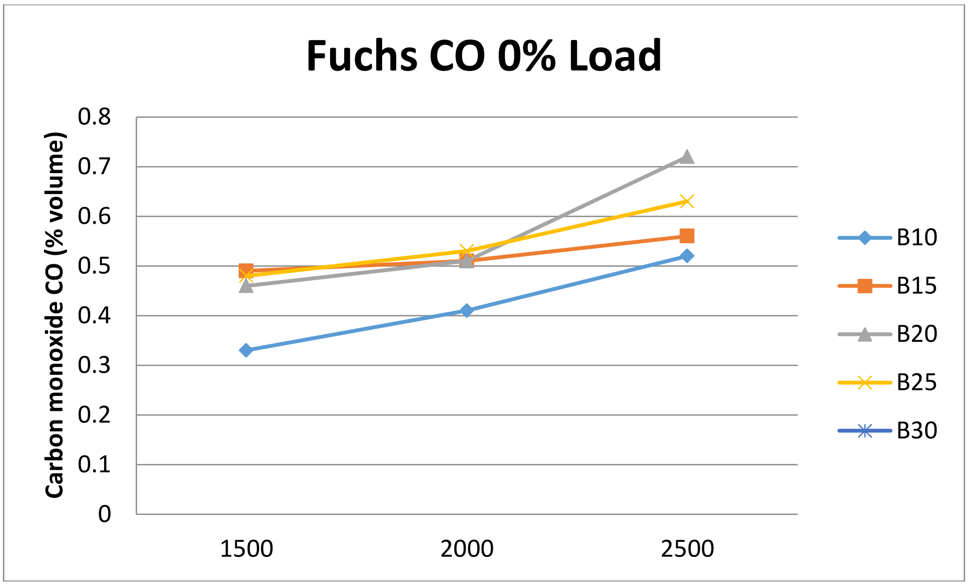
Table (4.17) Carbon monoxide CO (% volume) - gasoline\ Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.33	0.41	0.52
	B15	0.49	0.51	0.56
	BF20	0.46	0.51	0.72
	B25	0.48	0.53	0.63
	B30	0.16	0.19	0.55



Speed (RPM)

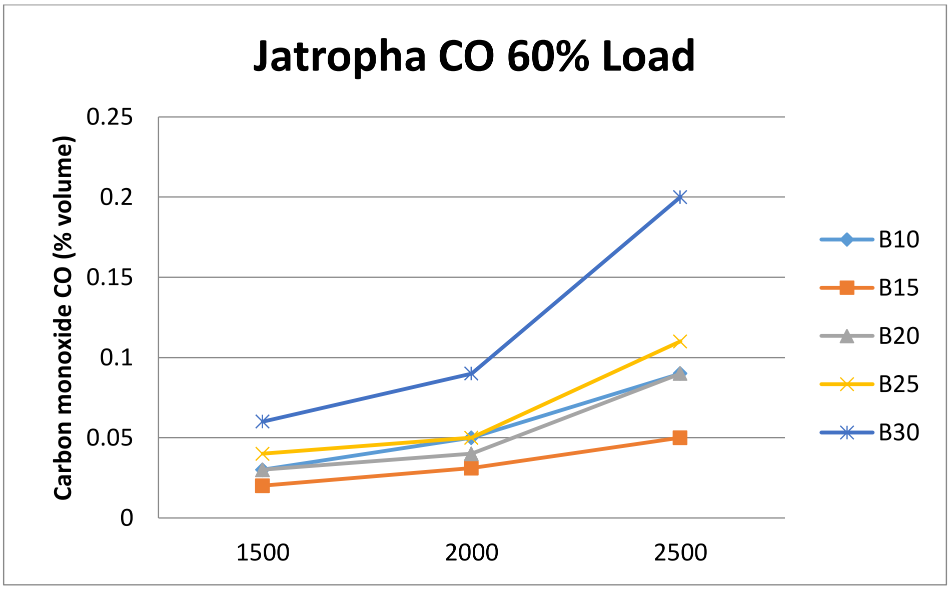
Figure 4.41 Carbon monoxide CO (% volume) of gasoline\jatropha blend



Speed (RPM)

Figure 4.42 Carbon monoxide CO (% volume)of gasoline\ Fuchs blend

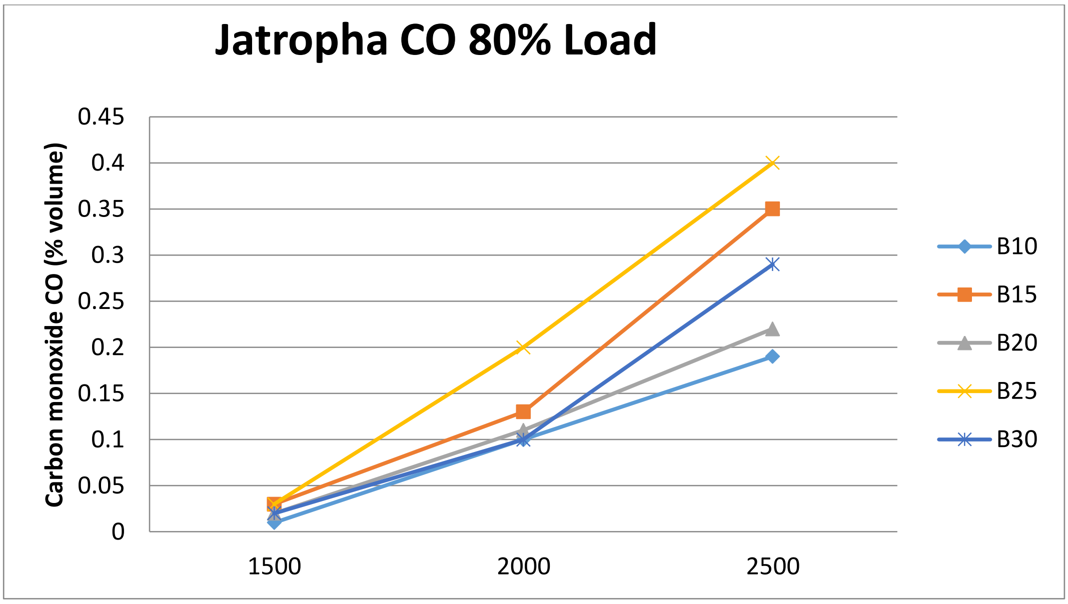
Figures (4.41) and (4.42) shows value of the Carbon monoxide for no load, through the gasoline\jatropha blend and gasoline\foucs blend at B20 increase the Carbon monoxide at all speed more than B10 andB30 respectively.



Speed (RPM)

Figure 4.43 Carbon monoxide CO (% volume) of gasoline\jatropha blend

Figure (4.41) show value of the Carbon monoxide for 60% load, through the gasoline\jatropha blend at B20 increase the Carbon monoxide at all speed more than B25 andB30 respectively.



Speed (RPM)

Figure 4.44 Carbon monoxide CO (% volume) of gasoline\jatropha blend

Figure (4.41) show value of the Carbon monoxide for 80% load, through the gasoline\jatropha blend at B25 increase the Carbon monoxide at all speed more than B20 andB15 respectively.

4.3.2 Carbon dioxide (Co2):

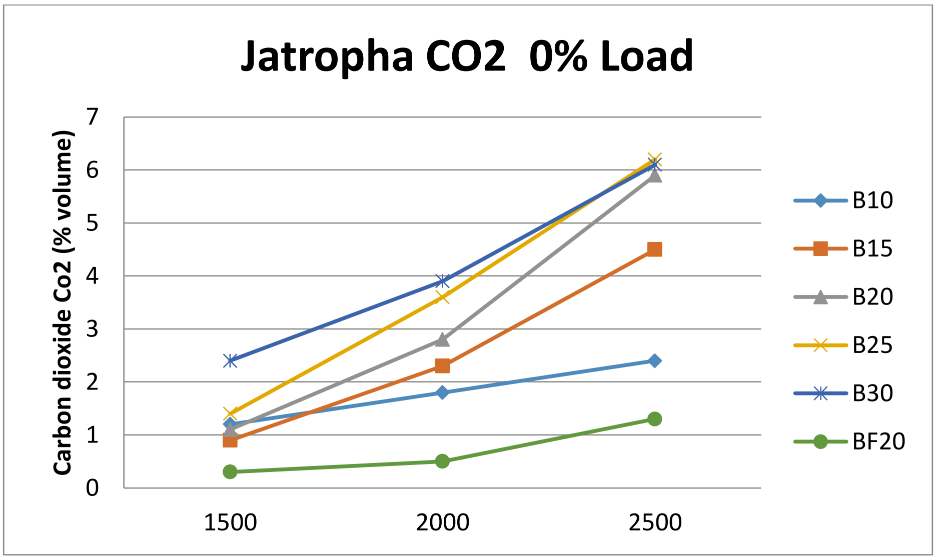
As seen in table (4.18) using gasoline\jatropha blends and table (4.19) using gasoline\ Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.45) to (4. 48):

Table (4.18) Carbon dioxide CO_2 (% volume) - gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	1.2	1.8	2.4
	B15	0.9	2.3	4.5
	B20	1.1	2.8	5.9
	B25	1.4	3.6	6.2
	B30	2.4	3.9	6.1
60% load , 1.5 kw	B10	1.6	3.6	2.6
	B15	0.9	4	2.7
	B20	1.2	2.2	1.9
	B25	1.6	4.3	4.2
	B30	3.2	5.2	4.9
80% load , 2 kw	B10	2.3	4.8	4.1
	B15	2.1	2.7	1.6
	B20	1.4	2.4	1.2
	B25	1.7	4.1	3.1
	B30	2.8	4.4	3.5

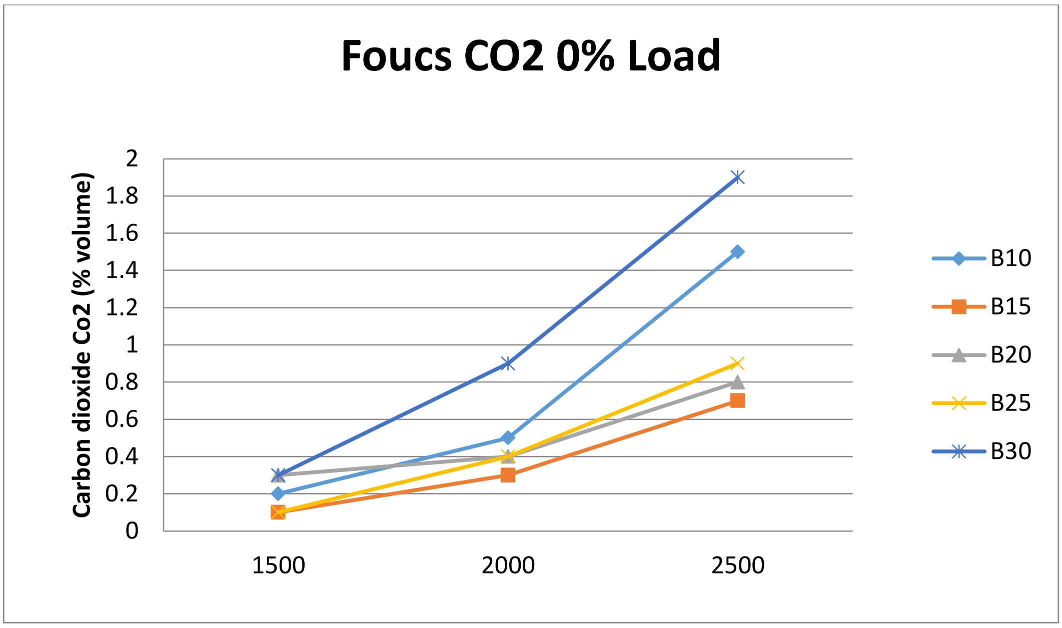
Table (4.19) Carbon dioxide CO_2 (% volume) - gasoline\ Fuchs blends

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0.2	0.5	1.5
	B15	0.1	0.3	0.7
	BF20	0.3	0.4	0.8
	B25	0.1	0.4	0.9
	B30	0.3	0.9	1.9



Speed (RPM)

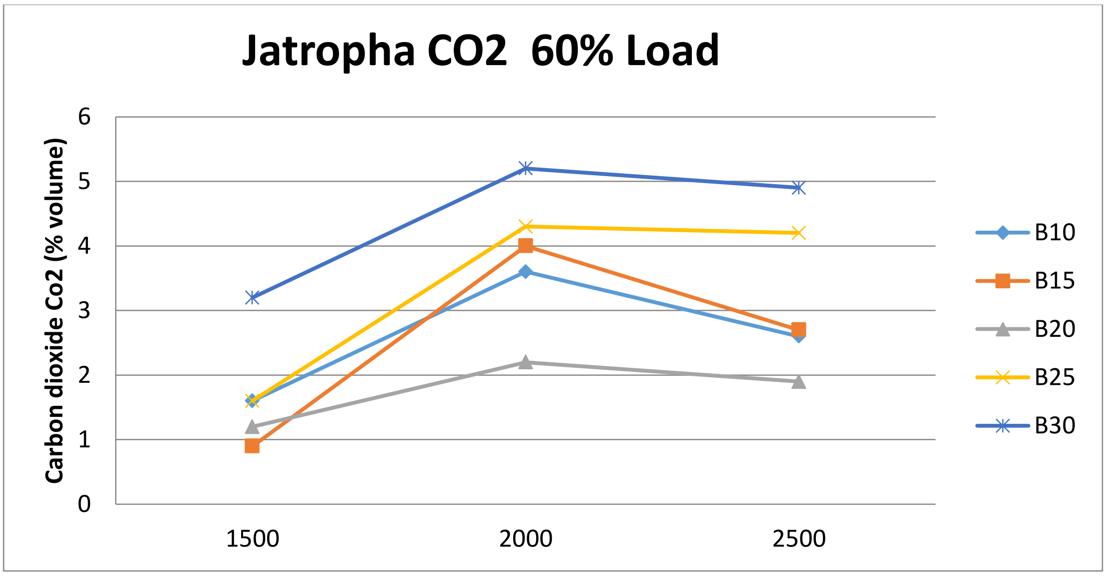
Figure 4.45 Carbon dioxide CO_2 (% volume) of gasoline\jatropha blend



Speed (RPM)

Figure 4.46 Carbon dioxide Co_2 (% volume) of gasoline\ Fuchs blend

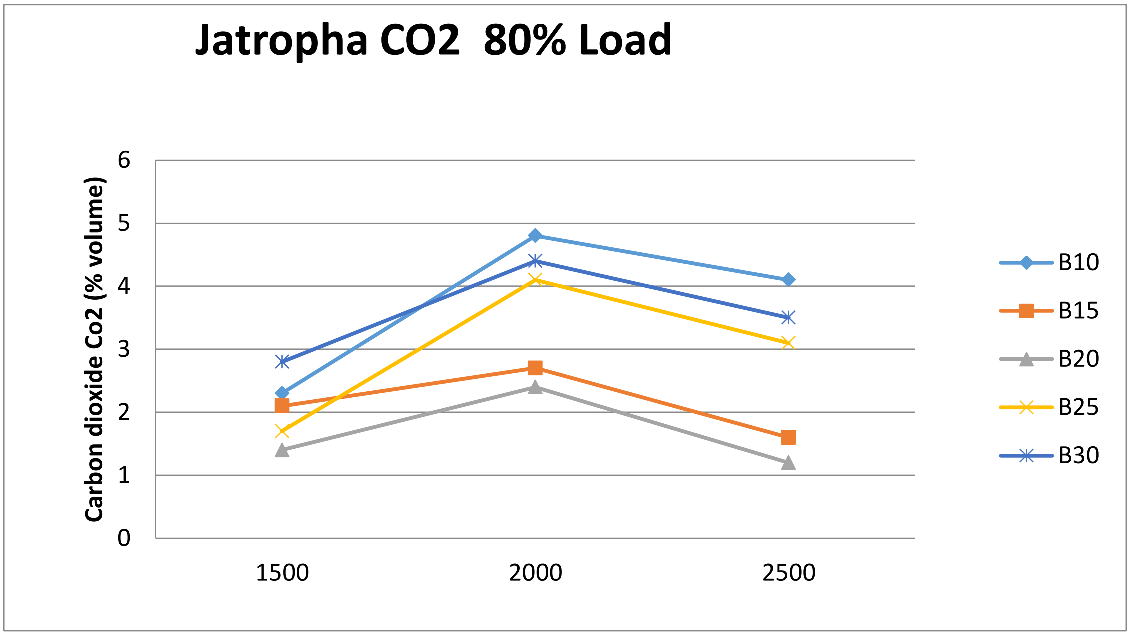
Figures (4.45) and (4.46) shows value of the Carbon dioxide for no load, through the gasoline\jatropha blend and gasoline\ Fuchs blend at B15 increase the Carbon dioxide at all speed more than B20 andB25 respectively.



Speed (RPM)

Figure 4.47 Carbon dioxide Co2 (% volume) of gasoline\jatropha blend

Figure (4.47) show value of the Carbon dioxide for 60% load, through the gasoline\jatropha blend at B20 decrease the Carbon dioxide at all speed more than B15 andB25 respectively.



Speed (RPM)

Figure 4.48 Carbon dioxide Co2 (% volume) of gasoline\jatropha blend

Figure (4.48) show value of the Carbon dioxide for 80% load, through the gasoline\jatropha blend at B20 decrease the Carbon dioxide at all speed more than B15 andB25 respectively.

4.3.3 Nitrogen monoxide (NO) (PPM):

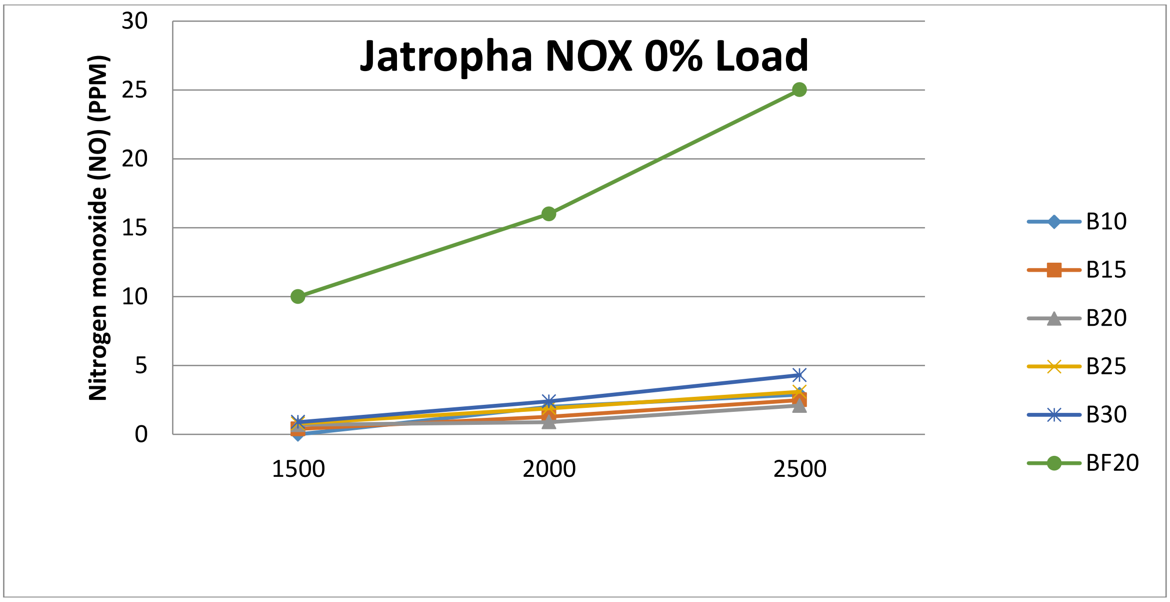
As in table (4.20) using gasoline\jatropha blends and table (4.21) using gasoline\ Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.49) to (4.52):

Table (4.20) Nitrogen monoxide NO (PPM) - gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	0	2	2.9
	B15	0.4	1.3	0.1
	B20	0.7	0.9	2.1
	B25	0.8	1.9	3.1
	B30	0.9	2.4	4.3
60% load , 1.5 kw	B10	0.4	2.2	3.1
	B15	0.5	0.6	0.9
	B20	0.3	0.8	1.6
	B25	0.6	2.2	3.1
	B30	0.7	2.1	2.9
80% load , 2 kw	B10	0.2	2.6	2
	B15	0.3	0.8	0.2
	B20	0.1	2.1	1.1
	B25	1.3	2.7	2.4
	B30	0.5	1.9	1.5

Table (4.21) Nitrogen monoxide NO (PPM) - gasoline\ Fuchs blends

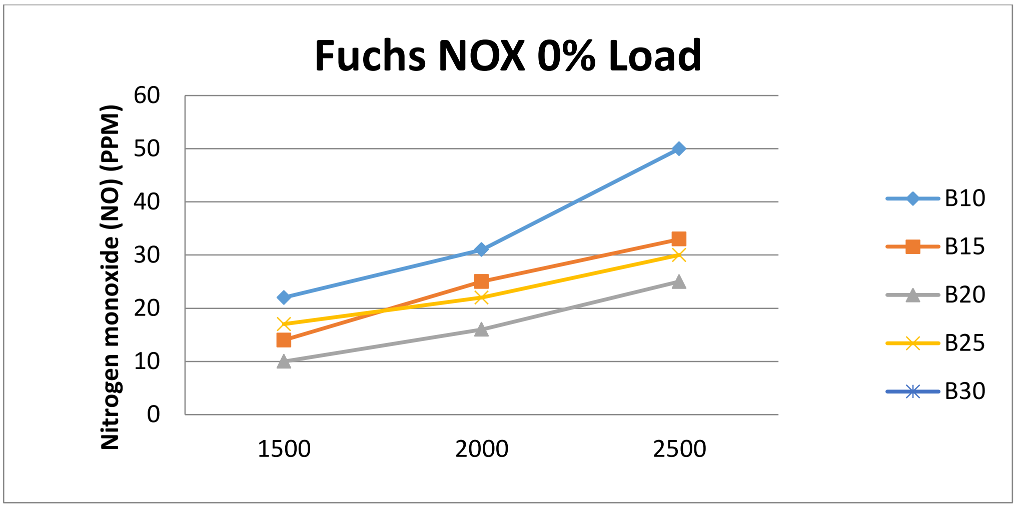
load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	22	31	50
	B15	14	25	33
	BF20	10	16	25
	B25	17	22	30
	B30	21	52	65



Speed (RPM)

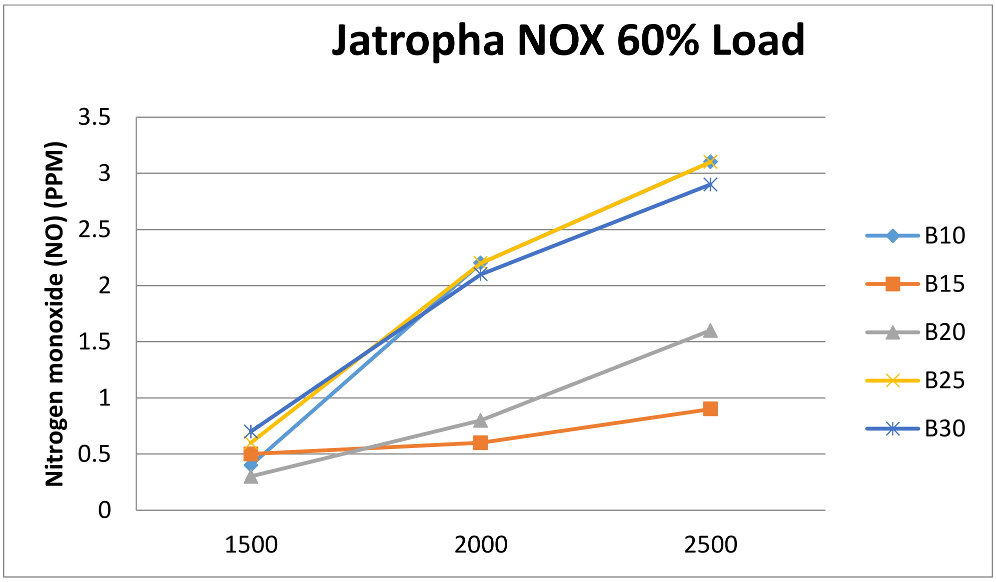
Figure 4.49 Nitrogen monoxide (NO) (PPM) of gasoline\jatropha blend

Figure (4.49) show value of the Nitrogen monoxide for no load, through the gasoline\jatropha blend at B20 increase the Nitrogen monoxide at all speed more than B10 andB25 respectively.



Speed (RPM)

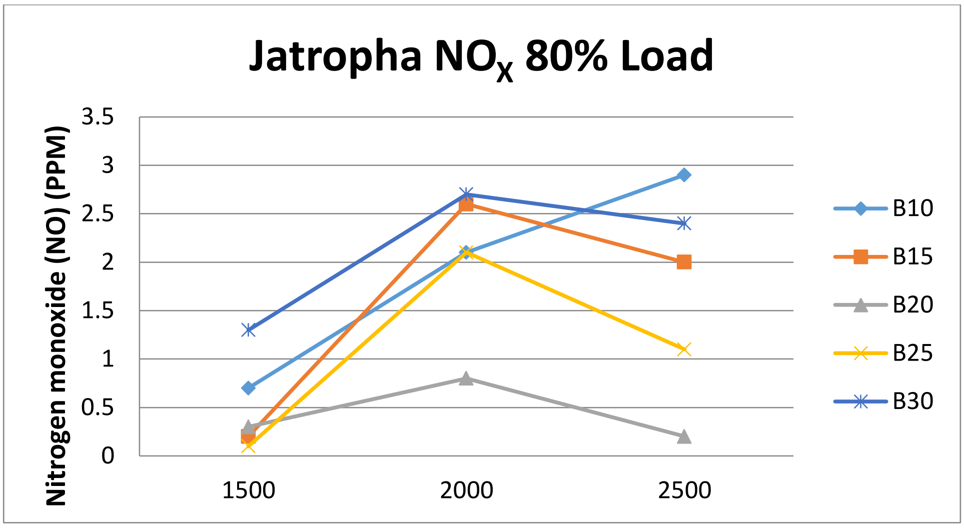
Figure 4.50 Nitrogen monoxide (NO) (PPM) of gasoline\ Fuchs blend



Speed (RPM)

Figure 4.51 Nitrogen monoxide (NO) (PPM) of gasoline\jatropha blend

Figure (4.51) show value of the Nitrogen monoxide for 60% load, through the gasoline\jatropha blend at B20 increase the Nitrogen monoxide at all speed more than B30 andB25 respectively.



Speed (RPM)

Figure 4.52 Nitrogen monoxide (NO) (PPM) of gasoline\jatropha blend

Figure (4.52) show value of the Nitrogen monoxide for 80% load, through the gasoline\jatropha blend at B15 decrease the Nitrogen monoxide at all speed more than B30 andB20 respectively.

4.3.4 Hydrocarbons (HC) (PPM):

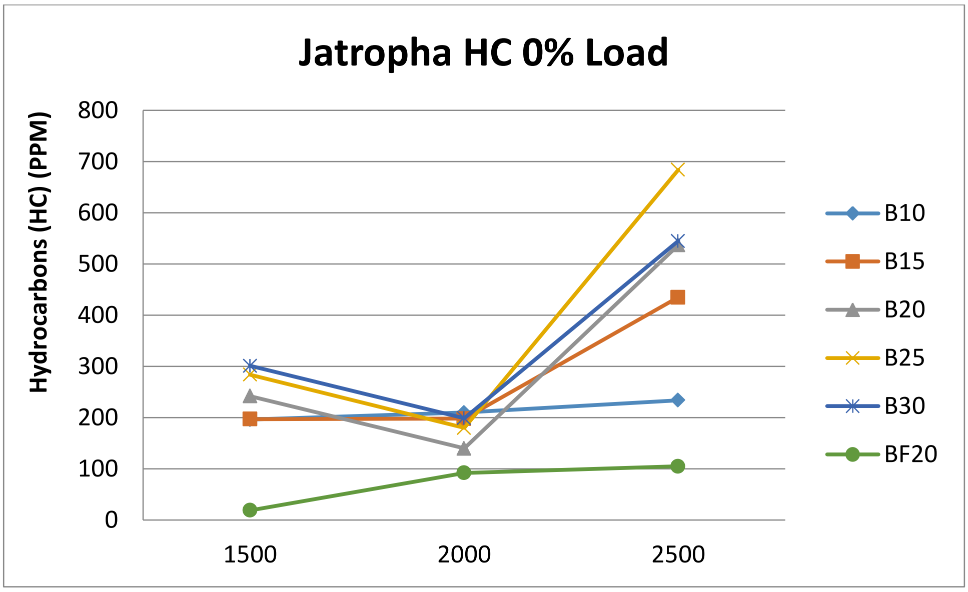
As in table (4.22) using gasoline\jatropha blends and table (4.23) using gasoline\ Fuchs blends, for the speeds (1500, 2000 and 2500 RPM) and loads (0, 60 and 80%), can be plot as in figures from (4.53) to (4.56):

Table (4.22) Hydrocarbons HC (PPM) - gasoline\jatropha

load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	196	338	234
	B15	197	198	435
	B20	242	140	537
	B25	284	180	684
	B30	301	199	545
60% load , 1.5 kw	B10	88	328	284
	B15	70	198	378
	B20	162	99	251
	B25	221	153	322
	B30	286	182	493
80% load , 2 kw	B10	91	378	156
	B15	104	160	195
	B20	101	181	203
	B25	198	172	241
	B30	250	180	341

Table (4.23) Hydrocarbons HC (PPM) - gasoline\ Fuchs blends

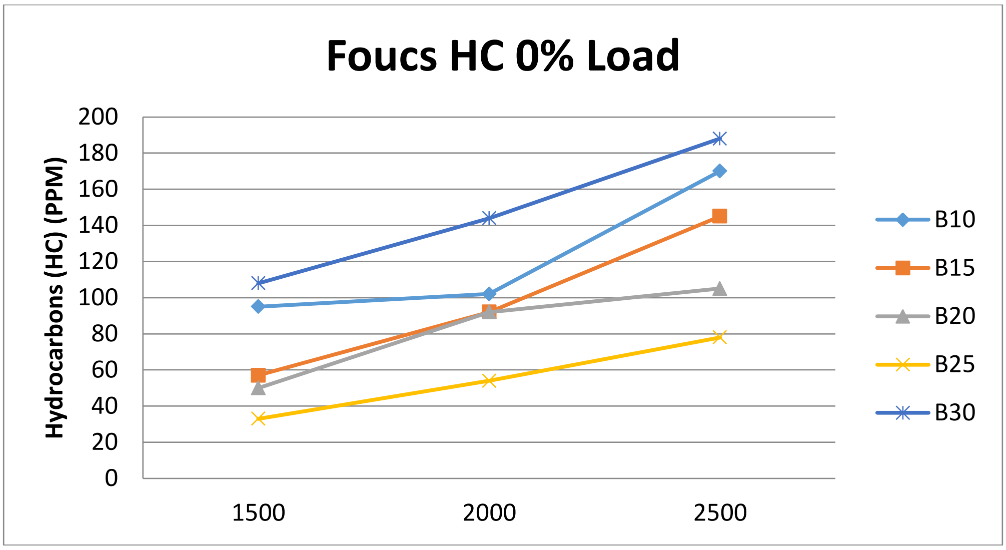
load	fuel	Speed(RPM)		
		1500	2000	2500
0% load , 0 kw	B10	195	40	486
	B15	57	35	0
	BF20	19	92	105
	B25	16	13	10
	B30	108	66	10



Speed (RPM)

Figure 4.53 Hydrocarbons (HC) (PPM) of gasoline\jatropha blend

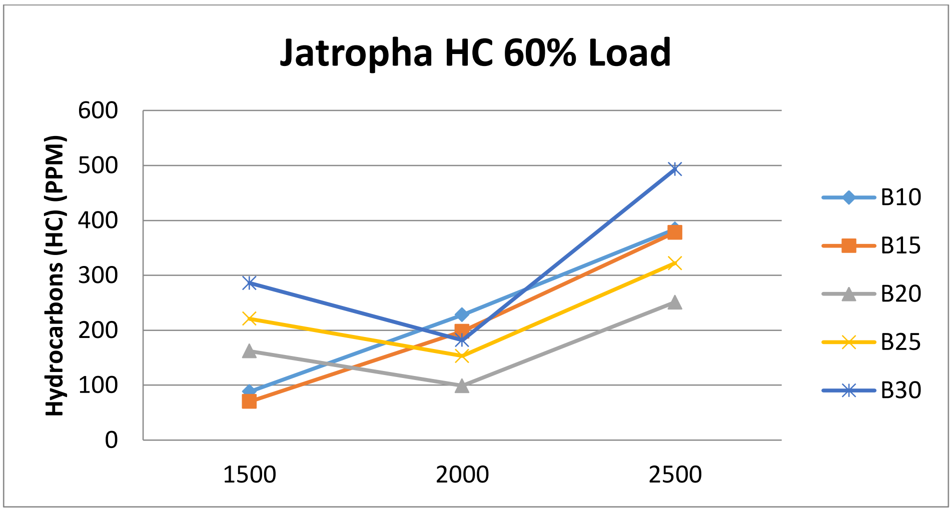
Figure (4.53) show value of the Hydrocarbons for no load, through the gasoline\jatropha blend at B20 increase the Hydrocarbons at all speed more than B15 andB25 respectively.



Speed (RPM)

Figure 4.54 Hydrocarbons (HC) (PPM) of gasoline\ Fuchs blend

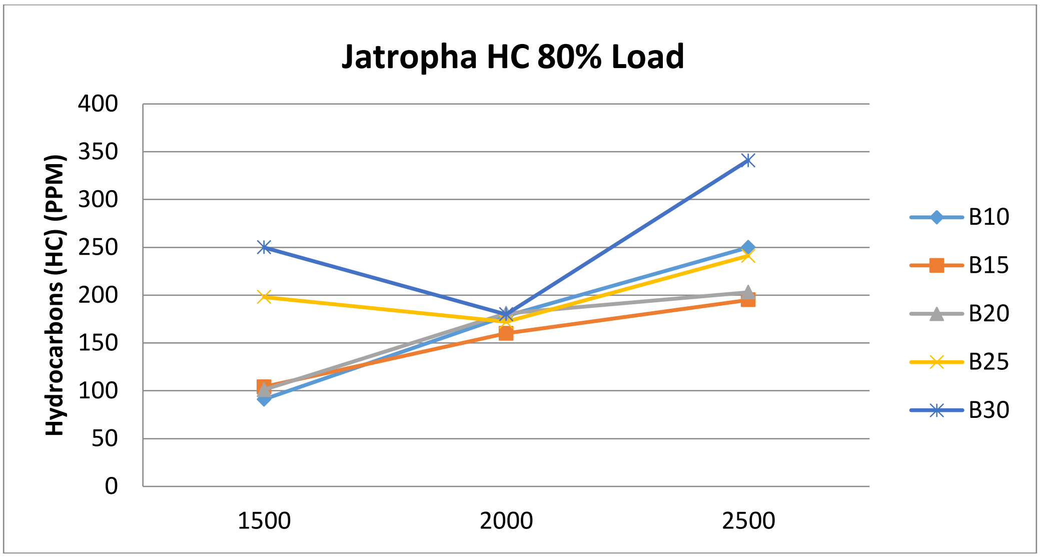
Figure (4.54) show value of the Hydrocarbons for no load, through the gasoline\ Fuchs blend at B20 increase the Hydrocarbons at all speed more than B15 andB25 respectively but the B15 and B25 is decrease.



Speed (RPM)

Figure 4.55 Hydrocarbons (HC) (PPM) of gasoline\jatropha blend

Figure (4.55) show value of the Hydrocarbons for 60%load, through the gasoline\jatropha blend at B20 increase the Hydrocarbons at all speed more than B25 andB30 respectively.



Speed (RPM)

Figure 4.56 Hydrocarbons (HC) (PPM) of gasoline\jatropha blend

Figure (4.56) show value of the Hydrocarbons for 80% load, through the gasoline\jatropha blend at B15 increase the Hydrocarbons at all speed more than B20 andB25 respectively.

4-4 Discussion:-

- The density is increased as a result of increasing the percentage of jatropha oil in gasoline, is due to the high density of jatropha.
- The viscosity is increased as a result of increasing the percentage of jatropha oil in gasoline, is due to the high viscosity of jatropha.
- The Octane number is decreased as a result of increasing the percentage of jatropha oil in gasoline, is due to addition of jatropha.
- The Calorific value is decreased as a result of increasing the percentage of jatropha oil in gasoline, is due to the law Calorific value of jatropha.
- The Brake power was increased when increase the engine speed.
- The Brake power was increased when increase the load to 60%, and 80% because increasing the load well lead to as increase the torque.
- At load60% the increase in The Brake power was in the range of (0.4-1.2) KW
- At load80% the increase in The Brake power was in the range of (0.7-1.6) KW
- The Indicated power was increased when increase the engine speed.
- The Indicated power was increased when increase the load to 60%, and 80% because increasing the load well lead to as increase the torque.
- At load60% the increase in The Indicated power was in the range of (0.6-1.6) KW
- At load80% the increase in The Indicated power was in the range of (0.8-2.1) KW
- The Brake mean effective pressure was increased when increase the engine speed.
- The Indicated power which depends on the friction power, in cases by increase the engine speed.
- The mechanical efficiency of blends at 60% and 80% load decrease by increasing the engine speed this is due to the fact the Indicated power.
- The brake specific consumption was increasing by increase of engine speed at 0%, 60% and 80% load.
- How weave B15 showed different beehive of increasing of brake specific consumption that increase up to 2000 rpm, and decrease after wands.
- The thermal efficiency was increase at 60% and 80% up to 2000 rpm and decrease after wands.

- Carbon monoxide emission at 0% load showed high value of Fuchs blend then that jatropha blend.
- Carbon monoxide emission increase by the increase of engine speed.
- At 60% load Carbon monoxide emission was very high at B10 compare the ether.
- Jatropha oil at carbon dioxide emission at 0%load by increase of speed with an exception of B10 which increase up to 2000 rpm and then decrease.
- Fuchs oil at carbon dioxide emission at 0%load showed increment increase with the increase of speed how over B10 rapid increase at 2500 rpm.
- At 60% and 80% load, Jatropha oil at carbon dioxide emission increase at the speed up to 2000 rpm and then decrease at 2500 rpm.
- Jatropha oil at Nitrogen monoxide at 0% load showed increase and the increase of the speed up to 2000 rpm, and anther increase up to 2500 rpm with an exception of B15 with showed decrease after 2000 rpm to zero ppm at 2500 rpm.
- At 60% load Jatropha oil at Nitrogen monoxide increase with increase the speed with exception of B10and B15 witch the value of zero ppm at 2500.
- At 80% load Jatropha oil at Nitrogen monoxide increase up to 2000 rpm and then decrease with B15 should zero ppm at 2500rpm.
- Jatropha oil at Hydrocarbons emission at 0% load showed decrease at speed up to 2000 rpm and then increase with an exception of B15 with showed increase at 2000 rpm and then decrease.
-

Chapter V

Conclusion and Recommendations

5.1Conclusion:

Engine performance and emission results of gasoline\jatropha blends and gasoline\fuchs engine oil blend were compared, the major conclusions are:

- The blend B20 is the most suitable for use for Two-stroke engine because it gives more stability in terms of good performance and less emission of harmful pollutants, which contributes to reducing the spread of pollutants.
- Adding jatropha oil to gasoline fuel lead to improvements in the thermal value of fuel, density, and octane number.
- Nitric Oxides (NO_x) are decreased while increasing in engine speed in the range of (1500-2500 rpm). And when the increase in oil/fuel mixing ratios, it found that there is an increase in small quantity of nitrogen oxides (NO_x)
- Nitrogen oxides were found to be minimal and diminishing in two-stroke engine.
- Carbon Monoxide (CO) is increasing while increasing in engine speed in the range of (1500-2500 rpm). And when the increase in oil/fuel mixing ratios, it was found that there is a decrease in the quantity of Carbon Monoxide (CO).
- Carbon Dioxide (CO_2) is decreasing relatively while increasing in engine speed in the range of (1500-2500 rpm). And when the increase in oil/fuel mixing ratios, it was found that there is an increase in the quantity of Carbon Dioxide (CO_2).
- Hydrocarbons (HC) are increasing while increasing in engine speed in the range of (1500-2500 rpm). And when the increase in oil/fuel mixing ratios, it was found that there is an increase in the quantity of Hydrocarbons (HC).
- How Evan one of the drawback of this mixture is the high toxicity of jatropha oil.

5.2 Recommendations:

The following suggestions are put forward for future investigations:

1- Investigation performance and emission of two-stroke gasoline engine when fueled by Jatropha biodiesel.

2- - Additional research can be done for four- stroke gasoline engine to study performance and emission when fueled by Jatropha biodiesel

3- Develop laws and regulations specify the minimum emission of single cylinder two-stroke engines.

4- Develop engine specifications standards, particularly the engine exhaust emission.

5- Strongly recommended to measure the emissions of SOx by using gas analyzer have ability to analyze sulphur oxides (SOx).

6- - We recommend the rehabilitation of the internal combustion engine laboratory and the addition of a two-stroke engine with a modern device to measure the emissions and a measuring device for engine performance.

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Appendix

Table Specifications of gasoline

Property specification		Unit	Test method	Specification	Result
Distillation	10%Recoverd	°c	ASTM D86	Max 70	Sudanese petroleum Corporation
	50%Recoverd	°c		Max 120	
	90%Recoverd	°c		Max 190	
	FBP	°c		Max 205	
	Residue	%Vol		Max 2.0	
Lead content		g/l	ASTM D3237	Max 0.013	
Reid vapor Pressure	1st Nov.- 31Mr.	Kpa	ASTM D323	45 - 80	
	1st Apr.- 31Oct.			40 - 67	
Existent gum		mg/100ml	ASTM D381	Max 5.0	
Induction period		minutes	ASTM D525	Min 240	
Sulphur content			ASTM D5453	Max 0.1	
Doctor test		% mass	ASTM D4952	Negative	
Copper Strip Corrosion Rating		-	ASTM D130	Max No. 1	
Octane number(RON)		-	ASTM D2699	Min 90	
		-			92.2

MINISTRY OF PETROLEUM & GAS (Mop)
SUDANESE PETROLEUM CORPORATION (SPC)
PETROLEUM LABORATORIES, RESEARCH & STUDIES PLRS
Khartoum Elamarat Street 61
Tel: +(249)-1-83571064 - +(249)-1-83429641
Fax:+(249)-1-83 429641
P.O.BOX:2986
E-mail:info.cpl@spc.sd

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المؤسسة السودانية للنفط
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تلفون+(249)-1-83571064 - +(249)-1-83429641
فاكس :+(249)-1-83 429641 -ص.ب 2986

TEST REPORT

Sample Type	Engine oil
Sample Code	Eng - 270
Sample ID	"0020251
Customer Name	Student
Customer Ref.	2 - Strock (Fuchs)
Date /Time Received	17/04/2017

Report Number
"0020251
Date /Time Report
27/04/2017

Test Name	Test Method	Unit	Result
Kinematic viscosity@40^{0}C	ASTM D445	cSt	172.2
Kinematic viscosity@100C	ASTM D446	cSt	21.74
Viscosity index	ASTM D2270		151
Pour Point	ASTM D97	°C	-24
Density @ 15°C	ASTM D4052	g/ml	0.89202
Density @ 35°C	ASTM D4052	g/ml	0.87942

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Khartoum Elamarat Street 61
Tel: +(249)-1-83571064 - +(249)-1-83429641
Fax:+(249)-1-83 429641
P.O.BOX:2986
E-mail:info.cpl@spc.sd

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TEST REPORT

Sample Type	**Jatropha**	
Sample Code	Sp-1366	**Report Number**
Sample ID	0020250	**0020250**
Customer Name	**Student**	Date/Time Report
Customer Ref.	—	24-Apr-17
Date /Time Received	17-Apr-17	

Test Name	Test Method	Unit	Result
Density @15 °C	ASTM D 4052	g/cm^3	0.9199
S.G	ASTM D4052		0.9208
Kin Viscosity @40 °C	ASTM D 445	cSt	41.43
Sulfur content	ASTM D 4294	%m	0.0053
Calorific value gross	Calc	Mj/kg	43.757
Water content by distillation	ASTM D4006	%V	0.00
TAN	ASTM D664	mgKOH/g	1.90

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Date: 24. 4. 2017

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