American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-8, Issue-9, pp-31-37
www.ajer.org
Research Paper Open Access

Assessments of Loads on Break Specific Fuel Consumptions and Thermal Efficiencies

[1]Festus L. Tor, [2]Obakoma, J., [3]Nwankwo A. M. and [4]Ayogu V. U.
[1&2]Department of Mechanical Engineering, Kenule Beeson Saro-Wiwa Polytechnic,Bori. Rivers State.
[3]Department of Mechanical Engineering Caritas University Amorji Nike, Enugu Nigeria
[4]Department of Mechanical Engineering Institute of Management and Technology, Enugu, Nigeria
Corresponding Author: Festus L. Tor

ABSTRACT: *The assessments of engine performance wereassessed in terms of the Brake Specific Fuel Consumption (BSFC) and Brake Thermal Efficiency based on loads. The engine was initially run on diesel to establish basic performance characteristics. Engine tests were then carried out using biodiesel from used vegetable oils, biodiesel-diesel blends, biodiesel preheated to 45 and 57ºC, and a subsequent comparative analysis done of their performance. From the tests, the average Brake Specific Fuel Consumption (BSFC) of biodiesel was found to be higher than that of diesel by approximately 12%. The fuels were then blended volumetrically to 10 (BD10), 30 (BD30), 50 (BD50) and 70(BD70) and 90% (BD90) biodiesel levels. Because of the greater energy density and better viscous properties of diesel, the engine was capable of generating the lowest BSFC while running on the reference diesel fuel. A small difference in BSFC was observed with BD30 and BD50 blends. As for B760 and BD90, due to the energy differences previously noted, they produced a much higher BSFC than diesel fuels. But in general, all blends showed a lower BSFC as compared to neat biodiesel. Neat biodiesel was then preheated to 35 and 47ºC. It was observed that preheating biodiesel from ambient conditions to 45ºC reduced the BSFC from 14 to 6.8 % above that of diesel. Based on the investigations, it was inferred that used vegetable oils can be processed to biodiesel of acceptable quality and used as fuel or additive to diesel fuel for use in diesel engines.*

Keywords: *Used-edible-oil, Load, assessment, break specific fuel consumptions and thermal efficiencies.*

Date of Submission: 26-08-2019 Date of acceptance: 09-09-2019

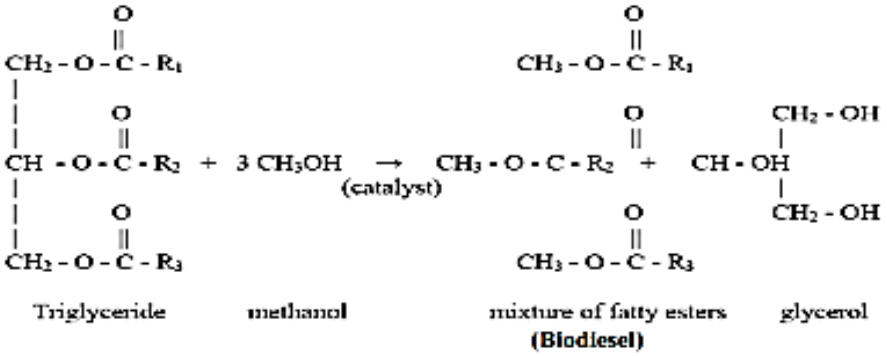
I. INTRODUCTION

According to Scholl and Sorenson, (1993), single means of exhausting alcohol is to combine it with vegetable oils via transesterificationmethod to form theequivalent ester of vegetable oil (biodiesel)

The mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats termed biodiesel is used for compression ignition engines. As noted by (Gerpen J.V. et al., 2004) biodiesel is made by reacting vegetable oils or animal fats with an alcohol in the in the presence of a catalyst to form an equivalent ester in a technique known as transesterification. The procedureyields a fuel withproperties near to those of predictable diesel. The also observed that present diesel engines have straight injection fuelsystems that are further sensitive to fuel spray quality than indirect injection engines.Meanwhile the diesel engine is improved for diesel fuel, a fuel with possessions closerto those of diesel is preferred to elude engine alterations. Consequently, examinationdeterminations havemotivated on transesterification of vegetable oils before they are used in diesel engines. Methanol remains the greatestfrequently used alcohol for transesterification processes.Nevertheless, other alcohols like butyl alcohol, isopropanol and ethanol, can also be secondhand, but methanol remained the most preferred alcoholsince it is more relatively cheaper and more freely available when compared to other alcohols.

It is alsosubstantially easier to improve and recycle by minimizing operation costs andenvironmental impactshazard. Catalyst is employed to improve the reaction to take place short time. Together acids and bases can be used as catalysts. Conversely, base-catalyzed reactions aredesiredas a result of easier reaction to be carried out with higher rate of reaction.Fats and oils are poised of molecules called triglycerides. Individually triglyceride is self-possessed of three long chain fatty acids of 8-22 carbons linked to a glycerol backbone.Kinast, (2003) says that biodiesel is composed of fatty acid chains that are chemically joined to one

methanol molecule. He observed that these molecules of glycerol are permanently removed from the final biodiesel. The general chemical organic reactions of transesterification with methanol is denoted by (Gerpen J. V. et al., 2004) is shown equation (1) as;



1)

Figure 1.1 Transesterification reaction of triglycerides with methanol to form Biodiesel

Spotless biodiesel is referred to as B 90. The principal advantages of biodiesel are that: it is biodegradable, non-toxic, renewable and used in most diesel engines without demandingwide engine modifications (GerpenJ. V. et al., 2004). As seen in most developing countries, oil producing plants have been projected as a resources of generating income as well as reducing dependence on imported oil (Guibert, 1997). Generally, in all the known oil-bearing crops, those with the greatest production possible are peanut oil, safflower, cottonseed, canola, soybean, corn, sunflower as well as rapeseed as noted by (Peterson, 2005). Because of high demand of edible oils in our everyday lives, it becomes expensive for use as fuel for diesel engines due to their great demand as food. Nevertheless, their remaining product (that is waste edible oils that are habitually discarded) can have a residual value as a source of energy if harnessed to biodiesel.

Fried food that are profound are standard on account of the fast and suitable preparation methods. Color, flavor, texture and palatability are the main characteristics of these foods that make them be appreciated by consumersDuring deep-frying, the food is cooked by immersion in hot oil. According to (Yunsheng, 2005), oxidative and hydrolytic reactions occur subsequent to physical and chemical changes in the oil and the formation of new compounds that leads to deterioration of the frying oil as a result heat and exposure to air.Chang and Peterson, (1978) noted that oxidized and heated fats may have carcinogenic properties because they contain potentially toxic substances, and as a result used frying oil should be discarded and no longer be used as human food. More use of cooking oil possibly retards food quality, for instance; increase in freshness since the crusts cooks faster than the interior, darkening in colour, bad odour and flavour and increased in final oil contented in the food as prescribed by (Yunsheng, 2005).

Hence because of this, used oil is usually drained as waste oil and changed with fresh oil after specific time duration of cooking usage. Used vegetable oils and fats derived from cooking activities in hotels, restaurants, schools etc, pose a major disposal problem in many parts of the world, more so in the context of stringent environmental audits and Rivers State of Nigeria. This poses environmental pollution and needs to be recycled

In the past, much of these waste products have been used in the production of animal feeds. Disposal in this manner has since diminished. It is currently acknowledged that one of the most attractive disposal method is use it as alternate bio-fuel in diesel engines. Nigerian's domestic production of edible oils is estimated at 760,000 tonnes, which The used vegetable oils are known as yellowish grease while biodiesel which is processed from this oil is known as yellowish greased methyl ester.). Investments in biodiesel production could save the country huge amounts in foreign exchange in addition to generation of income to farmers as well as in conservation of the environment. Therefor this work investigates theeffectsofpreheated fuel comparing with break specific fuel consumption (BSFC) and thermal efficiency onperformanceofengine operated onbiodieselfromwasted vegetableoil.

II. MATERIALS AND METHODS

2.1 Method for processing oil

The wasted vegetableoils were locally sourcedfrom Mama Onyinye restaurant Pollo Park Enugu, Enugu State and KenuleBeeson Saro-GiwaPolytechnics restaurantsBori Rivers State. Themethods adopted were as stated;

2.1.1 Materials

The materials used include**:** Thermometer, 50 ml flask, Dropper Mixer / blender,weighing scale (accurate to 0.01 grams), Methanol 99% purity, Funnel, Phenolphthalein indicator, Graduated pipette, Potassium Hydroxide (KOH) 85 % purity, Sodium Hydroxide (NaOH), one litre high density polythene container, two 20 litre capacity settling and separation containers with tap at the bottom and wasted vegetable oil (yellow grease)

2.1.2 Method

The methods involved includes;

Purification method, which involved the collection of wasted cooking oil were heated to about 100^{o}C for about 45 minutes, it was stirred to reduce water content in the oil and then passed through a sieve still hot to filter off solid particles and debris. After that purifications were made

Determination of the amount of KOH required for titration of free fatty acids. These were done by using; 1 gram of NaOH dissolved in one litre of distilled water in the high density container to make a 0.1 % lye solution, by applying 1 ml of dewatered waste vegetable oil mixed with 10 ml of isopropyl alcohol in a 50 ml flask, followed by the mixture of warmed by hot water while stirring until the oil completely dissolved in alcohol. Again, two drops of phenolphthalein indicator were added to the oil using a dropper the lye solution was added drop wise resulting to mixture while stirring action until the solution turned and stayed pink for about 25 seconds.

Afterwards, number of millilitres of lye solution used for titration plus 3.5 (amount required for fresh oil) now two numbers of grams of NaOHwere then required per litre of oil.

Later KOH was added for transesterification, the basic lye quantity was adjusted to corresponding strength of KOH.

Titration method, which involved the analysis for the running of test were as;2.5 ml of 0.1% NaOH solution to be used to titrate the Free fatty acids (FAAs). 4.5 grams of NaoH amount was required for one litre of fresh oil Titration result 2.5 ml Therefore, $4.5 + 2.5 = 7$ grams) of NaOH for every litre of used waste oil Amount of 85 % KOH that will give the equivalent strength of 7 g of NaOH 7 x 2.65 = 11.25 grams of KOH per litre of used waste vegetable oil.

(1.65 - convert quantity for 85% KOH)

Transesterification method, which involvedPotassium-methanoxide was preparation by dissolving the predetermined amount of KOH, (11.25 grams) in 200 ml of methanol (in a high density polythene container) for every litre of cleaned used waste vegetable oil to be processed.

Then the oil was heated to 65^{o}C then mixed with potassium-methanoxide at a ratio of 5:1 respectively. The mixture was vigorously stirred in a 10 litre capacity blender for about 55 minutes and then transferred to a settling container to allow glycerol to separate from biodiesel.

Separation method, which involved settling of glycerol that is higher density than biodiesel, it settled at the bottom of the container. After 24-hours of separation, the tap beneath the container was opened and glycerol was drained off.

Step four: Washing and drying.

Crude biodiesel was washed three times by agitation with clean water to remove traces of methanol and KOH from the oil. After each wash, the oil was transferred to the settling container for about four hourswhere it was allowed to separate. The amount of water used in each wash was equal to the amount of oil being cleaned. Water was then drained off after separation. It was noted that using warm water hastened the separation processes.

Finally, the oil (biodiesel) was heated to about 110^{o}C for about thirty minutes while stirring to evaporate off residual water from the washing process. The flow chart of the waste oil purification and biodiesel generation is shown in figure 3.1.

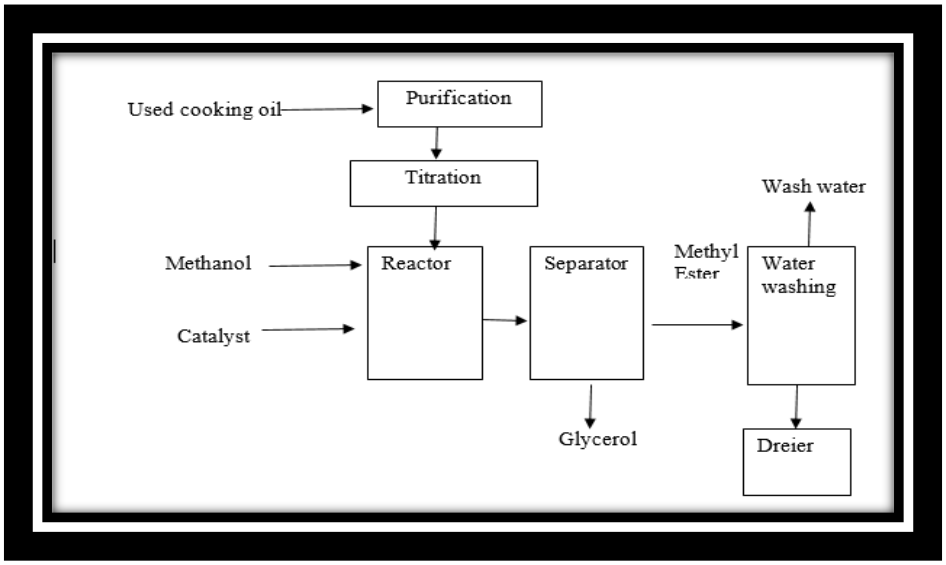


Figure 3.1: Process flow chart for biodiesel production from used edible oils.

2.2: Engine set and performance tests

The engine performance tests were conducted in the Thermodynamics laboratory at The Department of Mechanical and Manufacturing Engineering. The engine used in this study was a commercial plant that had been retrofitted for laboratory use. It is a 6-cylinder, direct injection and turbo charged diesel engine rated at 85 BHP. The parameters of interest were the Brake thermal efficiency and Brake specific fuel consumption of Table 2.1

Table 2.1: Parameters of the engine used in performance tests

Make	Ford
Type	Six cylinder open combustion chamber
Bore	100mm
Stroke	115mm
Displacement	541
Compression	16.1

The power developed by the engine was controlled by varying the volume of the fuel injected into the cylinder. The engine manufacturers test data is shown in figure 3.3. The engine was coupled to a G-type Froude Hydraulic dynamometer for measuring the engine output over the entire range of operation. The engine was loaded by regulating the amount of water going into the dynamometer. This was done by adjusting knobs provided on the dynamometer in steps of one Pound. The load and the engine speed were displayed on dials on the dynamometer. The Dynamometer cross-section diagram is shown below.

2.3.1: Cooling water system

The cooling water to the engine was circulated by a pump. The external circuit was via a header tank, fitted with a thermometer. The water temperature in the header tank was kept constant at (49^{o}C) by supplying water from the mains while allowing the same amount of hot water to drain off. Thermometers were provided to measure the inlet and outlet water temperatures to and from the engine.

2.3.2: Fuel flow rate

The fuel consumption was measured using a calibrated pipette. The supply from the fuel tank was allowed to fill the pipette to the 150ml level. The fuel tank supply was then cut off and the time taken to consume the 150ml of fuel in the pipette was recorded.

3.3.3: Fuel heating system

A heat exchanger was designed and installed between the fuel filter and fuel pump for preheating of fuel. It consisted of a ¼ inch diameter copper tube coil immersed in a 20-liter water bath. The water bath was heated using an electrical hot plate. The temperature of the water was held to the desired level using a calibrated thermostat.

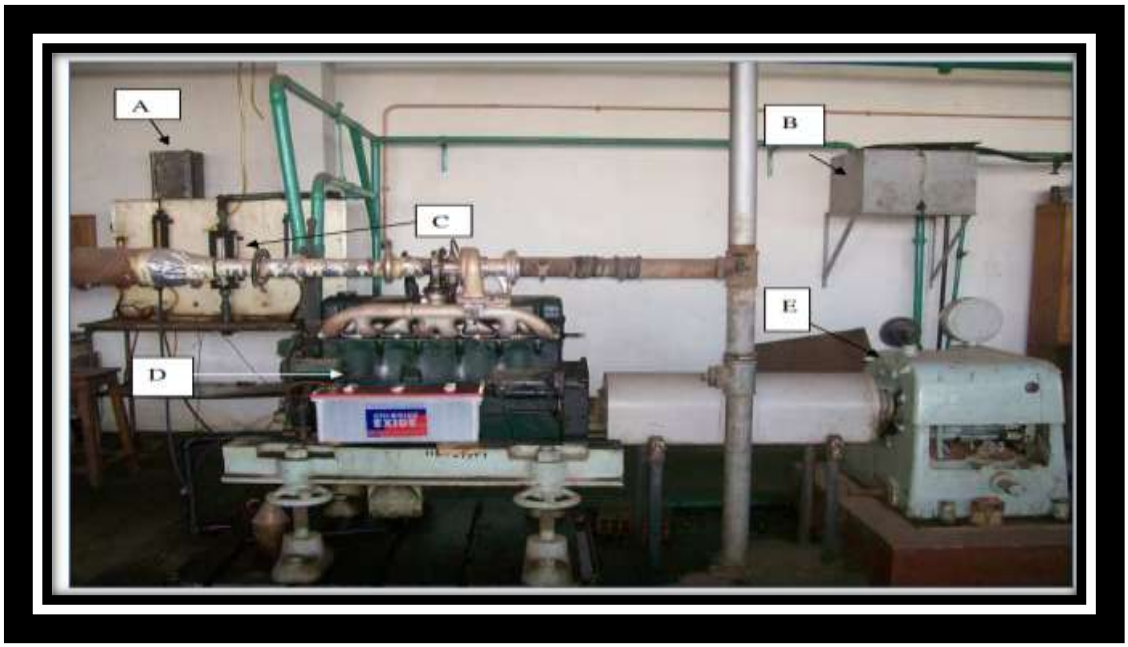


Plate 2.1: Engine test setup used in performance tests

A is the Fuel tank, B isthe Cooling water tank, C is the Fuel flow pipette, D is the Engine and E is Dynamometer

2.3.4 Engine test procedure

The throttle was set to give a speed of 183.25 m/sat a light load. The load was adjusted to give a reading of 0.91kg on the dynamometer dial. When conditions were steady, the following data was recorded: Speed, Load, the time taken to consume 150ml of fuel, cooling water outlet temperature, cooling water inlet temperature, exhaust air temperature and the ambient temperature. The above procedure was repeated for loads of 1.36,1.81,2.27,2.72, 3.18 and 3.63kg respectively at the same speed for all fuel samples tested. Before the tests began the engine was warmed up using diesel fuel. The fuel lines were then drained of at each change of fuel. One cm^3 of the test fuel was run through the system to purge of any remaining fuel from previous tests.

2.3.5: Analysis

The following equations were used to calculate the thermal efficiency and the Brake specific fuel consumption. Sample calculations are shown below as;

$$\text{Power input} = \frac{\text{density xvolume xheating}}{\text{t}} (\text{kw}) \quad (2)$$

$$\text{Brake power} = \frac{\text{W x N x 0.7457}}{200} (\text{kw}) \quad (3)$$

$$\text{Thermal efficiency} = \frac{\text{Brake power}}{\text{Power input}} (\%) \quad (4)$$

$$\text{Brake specific fuel consumption} = \frac{\text{Density x volume}}{\text{t x Brake power}} (\text{kg/kWh}) \quad (5)$$

2.5.6: Sample Analysis for BSFC and thermal efficiency for biodiesel.

Data sample: Time to consume 150ml of fuel (t) = 83.55 seconds
Density of biodiesel = 879 kg/m3
Engine speed (N) = 1750 rpm
Heating value = 38.52 MJ/kg
From equation (3.7)

Power input = $\frac{879 \times 150 \times 38.52 \times 10^{-3}}{83.55} = 60.79\text{KW}$

From equation (3.8)

Brake power = $\frac{2 \times 1750 \times 0.7457}{200} = 13.05$ kw

From equation (3.9)

Thermal efficiency = $\frac{13.07}{60.79} = 21.46\ \%$

From equation (3.10)

Brake specific fuel consumption (BSFC) = $\frac{870 \times 150 \times 10^{-6} \times 3600}{83.55 \times 13.05} = 0.435$ kg/KWh

III. RESULTS AND DISCUSSION

3.1 Engine test results

3.1.1 Effects of biodiesel on engine performance

As shown on Figure 4.1 the BSFC of the engine when operating on biodiesel was higher than when operating on diesel. From the tests, the average BSFC of biodiesel was approximately 12 % higher (282 g/kWh for diesel and 318 g/kWh for biodiesel). When an engine is tested on fuels with different properties, it will yield consumptions that vary by less than the percentage difference in the calorific value since the diesel engine is optimized for diesel fuel. Therefore, both the low energy density and the high viscosity of biodiesel were perceived to be the cause of the increased BSFC. At this point effects of two processes were incorporated in the study, namely preheating of the fuel and blending it with diesel. Preheating the oil was expected to reduce the viscosity and as a result improve its spray and atomization characteristics. Blending with diesel was expected to reduce the viscosity and increase the calorific value of the oil.

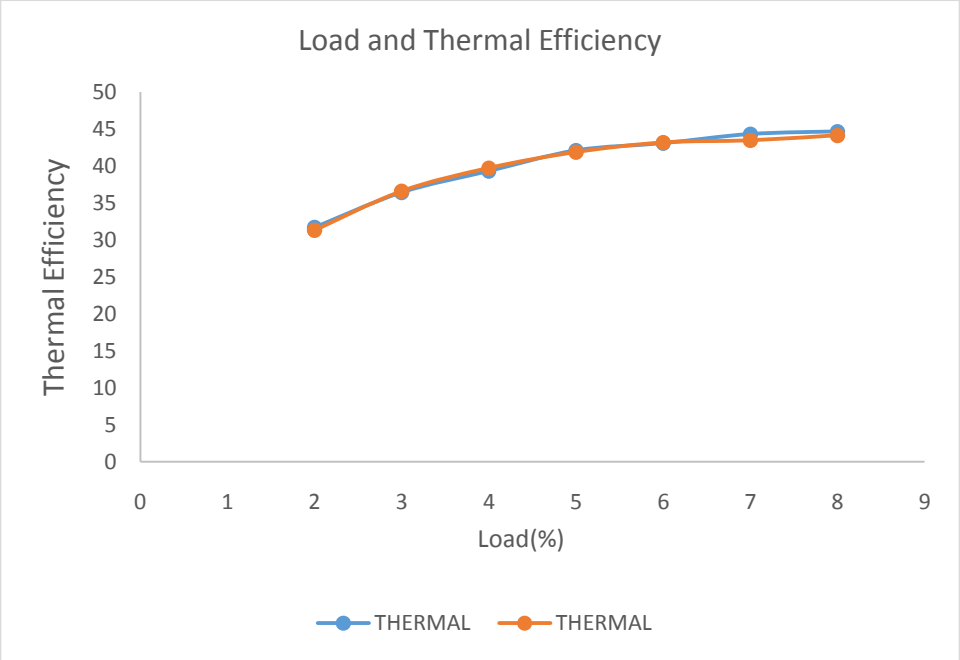


Figure 4.1 Variation of Thermal efficiencies of diesel and biodiesel with Load

3.1.2: Effects of blends on engine performance

The fuels were blended volumetrically to 10 (BD10), 30 (BD30), 50 (BD70) and 90% (BD90) biodiesel levels. Comparison of the BSFC of the engine when running on biodiesel, diesel and their blends is shown in Figure 4.2. It was observed that the BSFC of diesel, biodiesel and their blends maintained a similar trend, the BSFC reduced with increase in load for all the fuel samples. The BSFC of the fuel samples were also found to increase with increase in the proportion of biodiesel content in the blend. Because of the greater energy density and viscous properties of Diesel, the engine was capable of generating the lowest BSFC while running on the reference diesel fuel. However, a smaller difference in BSFC was observed with BD20 and BD40 blends compared to that of Diesel. The average values were found to be 0.285 kg/kWh for BD20 and 0.290kg/kWh for BD40, while the corresponding value for Diesel was 0.282 kg/kWh. BD60 had a BSFC of 0.307kg/kWh, much higher than that of diesel, while that of BD80 was 0.317kg/kWh, very close to that of biodiesel (0.318 kg/KWh).

In general, all blends showed improved BSFC compared to neat biodiesel. This was attributed to the combined effects of the improved viscous properties and heating values of the blends.

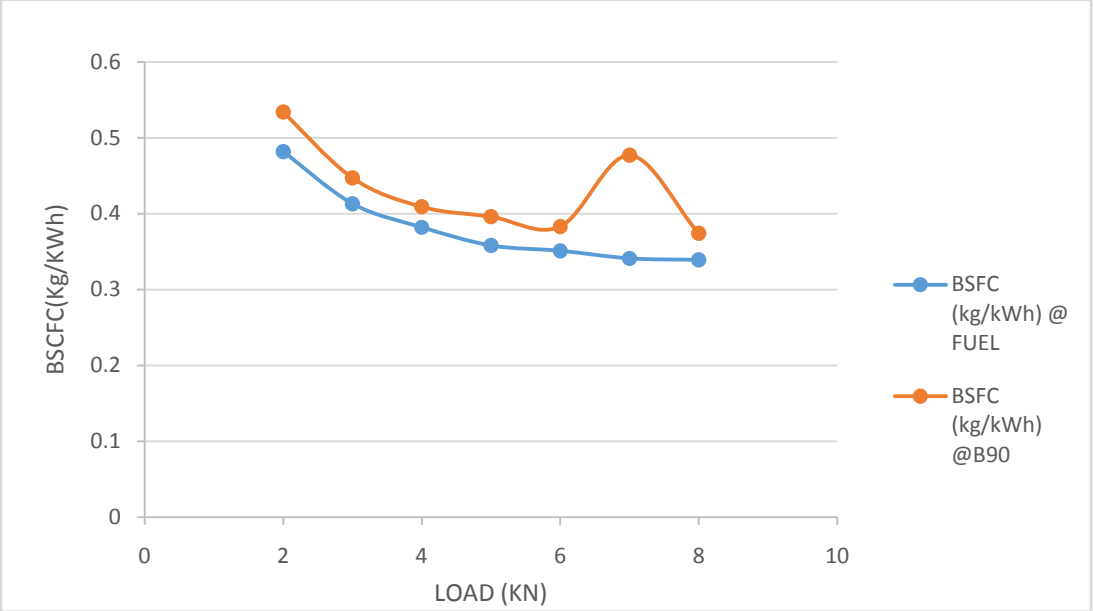


Figure 4.2 Comparison of BSFC of diesel, biodiesel and their blends with respect to increasein load

IV. CONCLUSION

BSFC of the engine when operating on biodiesel was 12% higher than when running on diesel. There was no significant difference in thermal efficiencies between biodiesel, diesel and the blends. BSFC for the blends was found to increase with increase in proportion of biodiesel content in the blend. The engine was capable of generating the lowest Brake Specific Fuel Consumption while running on the reference diesel fuel. A small difference in BSFC was observed with BD10 and BD40 blends. As for BD70 and BD90, due to the energy differences, they produced a higher BSFC than diesel fuel.

ACKNOWLEDGEMENTS

This immense acknowledgement goes to TETFUND Nigeria for sponsoring this research through my employer Kenule Beeson Saro-Wiwa Polytechnics, Bori. Rivers State, Nigeria.

REFERENCES

[1]. Chang, S. S. and Peterson, C. L., 1978. Chemical reaction involved in the deep–fat frying of foods. J. American Oil Chemist Society 55: 718–727.
[2]. Gerpen, J.V., Shanks, B., Pruszko, R., Clements, D. and Knothe, G., 2004. Biodiesel Production Technology. Report prepared for National Renewable Energy Laboratory. Colorado. Guibert, J. C., 1997. Fuels and Engines. Volume 1. Editions Technip. Revised 1997.
[3]. Kinast, J.A., 2003. Biodiesel Production from Multiple Feed Stocks and Properties of Biodiesel/Diesel Blends. Report prepared for the National Renewable Laboratory. Colorado. Peterson, C. L., Thompson, J. C. and Taberski, J. S. 1999. One-Thousand-Hour Engine
[4]. Durability Test with HySEE Using a 5x-Ema Test Cycle. American Society of Agricultural Engineers vol. 42(1): 23-30.
[5]. Scholl, K. W. and Sorenson, S. 1993. Combustion of Soy Bean Oil Methyl Ester in Direct Injection Diesel Engine. SAE Technical Paper Series 930934. pp 209-224
[6]. Yunsheng, L. I., 2005. Quality Changes in Chicken Nuggets Fried in Oils with Different Degrees of Hydrogenation. MSc Thesis. Department of Bio-resource Engineering. McGill University. Canada.

Festus L. Tor" Assessments of Loads on Break Specific Fuel Consumptions and Thermal Efficiencies" American Journal of Engineering Research (AJER), vol. 8, no. 9, 2019, pp. 31-37