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PERFORMANCE ANALYSIS OF SESAME OIL BIO-DIESEL

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Abstract: Rising energy demands in the developing countries and increased consumption of fossil fuels are leading to depletion of fossil fuels at a rapid rate. Various alternatives such as vegetable oils, bio-gas and methanol, and ethanol are therefore investigated by researchers to come up with alternative fuel solutions. Sesame oil is one of the capable alternative fuels for Diesel engines. Sesame oil is a non-traditional, non-toxic, low-cost, low-grade vegetable oil that can be produced locally using agricultural and plant resources. Bio-diesel is made from oils or fats by the trans-esterification process. In this paper we have discussed how sesame oil can be used as a bio-diesel as an alternative for diesel. In the present work two blends of sesame oil bio-diesel have been prepared and performance analysis of these two blends are studied experimentally by using CRDI VCR Engine set up. Finally these performance parameters are compared with that of the regular diesel. The results showed that maximum brake thermal efficiency is obtained for the blend B10 for the load of 12kg and the value is 30.55%. Maximum indicated thermal efficiency is obtained for the blend B10 for the load of 12kg and the value is 39.04%. Maximum CO emissions are obtained for the diesel for no load and the value is 0.026%. Maximum carbon dioxide emissions is obtained for the blend B20 for the load of 12kg and the value is 3.62%.

***Index Terms* - Sesame oil, Bio-Diesel, CRDI VCR Engine Set up, Bio-fuel**

I. INTRODUCTION

Bio-fuels are an important alternative energy source since they are renewable, organic, and ecologically beneficial. They can be extracted from a variety of organic plants such as mahua, jatropha, coconut, and vegetables. Bio-fuels are safe, non-combustible, innocuous, environmentally benign, and biodegradable. In addition, compared to diesel, bio-fuels produce cleaner and lower emissions. Plants help in removing carbon from the environment thereby helping to reduce the earth's environmental temperature[1]. Bio-fuels are mostly used as transportation fuel. Global bio-fuel output has significantly increased over the last decade, from 16 billion liters in the year 2000 to over 110 billion liters at present. In regular diesel cars, bio-diesel can be used without any engine modifications. Bio-diesel is an environmentally sustainable source of renewable energy[2], with better lubricating qualities and much lower emissions than today's low-sulfur diesel fuels. Bio-diesel also extends the life of fuel injection equipment that relies on low-pressure lubricating fuel in high-pressure systems by reducing fuel system wear. Bio-diesel undergoes complete combustion, improving engine performance and somewhat compensating for the higher energy density of diesel.

The increasing industrialization of petroleum products around the world is leading to a significant increase in demand. Fossil fuels are those that come from the fossils. There is a finite amount of fuel available in the fossils, and it is irreplaceable. With our existing known reserves and escalating consumption rates, they are expected to run out soon[2]. Rising oil costs have created a demand for bio-diesels. Because of rising energy demand in the emerging countries and increased consumption of fossil fuels, the supply of fossil fuels is depleting rapidly. Various alternatives such as vegetable oils, bio-gas and methanol, and ethanol are all examples of alternative diesel fuel choices. Sesame oil is one of the capable alternative fuels for Diesel engines[3]. Sesame oil is a non-traditional, non-toxic, low-cost, low-grade vegetable oil that can be produced locally using agricultural and plant resources. Because they produce fewer hazardous pollutants and greenhouse gases, their usage has no negative environmental consequences. Sesame oil is an edible vegetable oil produced from sesame seeds. In addition to being used as cooking oil, it is frequently utilized as a flavor enhancer in a variety of cuisines[4]. Sesame oil's stability and consistency are improved by the bio-active components contained in it, which also have a number of health benefits. In addition to these fundamental nutrients, sesame and sesamoline are two unique compounds found in sesame seeds. Both of these compounds belong to a class of beneficial fibers known as lingams, which reduce cholesterol in humans while also reducing high blood pressure and increasing vitamin E levels in animals. But due to the inefficient human harvesting procedure required to extract the oil, mass production of sesame oil is limited over the world [5]. Bio-diesel is made from oils or fats by the trans-esterification process, and it is widely used as a bio-fuel in many nations. It can be delivered to vehicles in its pure form, or blended with other bio-fuels or diesel at the appropriate quantities. In most circumstances, it works as a diesel addition to help vehicles emit less carbon monoxide and hydrocarbons. Long-chain fatty acid esters can be found in bio-diesel, which is generated from plants or animals. It is made by reacting lipids like animal fat, soybean oil, or other vegetable oils with alcohol to form methyl, ethyl, or propyl ester. Bio-diesel is a drop-in bio-fuel that is more compatible with current diesel engines and comes with a distribution infrastructure, unlike vegetable and waste oils, which are used as fuel converting diesel engines. Bio-diesel can be used in its pure form or mixed with petroleum diesel in any proportion. Bio-diesel blends can also be utilized in heating oils. Bio-fuels are generally classified into two classes based on their viscosity: low viscous fuels and high viscous fuels. Bio-diesel and vegetable oil are examples of high viscous fuels, whereas alcohols and ethers are examples of low viscous fuels.

Bio-diesel is derived from oils or fats via trans-esterification and obtained as a liquid with a composition comparable to fossil/mineral diesel. Methyl (or ethyl) fatty acid esters are chemically made up of (FAMEs). Bio-diesel feed-stock include animal fats, vegetable oils, corn, rapeseed, jatropha, mahua, mustard, sesame, flax, sunflower, palm oil, farm pennycress, Pongamia pinnata, and algae. In fact, pure bio-diesel (B100), commonly known as "neat" bio-diesel, reduces emissions by up to 60% when compared to second-generation B100 diesel. When blended with mineral diesel, bio-diesel can be utilized in any diesel engine. It can be used in its pure form (B100) in diesel engines, however there may be some maintenance and performance issues during winter use, depending on which feed-stock is used, as the fuel turns viscous at lower temperatures.

Due to the increasing interest of research community in bio-fuels many researchers are inventing and studying different compositions of bio-fuel with an aim to come up with a better alternative for the fast-depleting fossil derivative fuels. In a direct injection diesel engine, Bhaskar et al.[1] tested 20 %, 40 %, 60 %, 80 %, and 100 % fish oil methyl ester and found that 20 % FOME was the best mix for NO_X reductions using exhaust gas re circulation. They found that increasing the FOME concentration in bio-diesel blends enhanced NO_X emissions. EGR of 10%, 20%, and 30% of the 20% fish oil methyl ester is employed to reduce NO_X emissions. It was proposed that a 20% EGR was the best rate for increasing NO_X in soot values without causing a significant increase.

Mithun Das et al.[4] employed special methanol and sodium hydroxide parameters with refined castor oil for bio-diesel manufacturing. Bio-diesel blends such as B5, B10, and B15 were chosen for study, and research was carried out on a porous sphere. They found that Diesel had a high rate of evaporation, and the data revealed that bio-diesel blends had a strong chemical reactivity. They came to the conclusion that using bio-diesel in small amounts in diesel bio-diesel blends could assist reduce reliance on fossil fuels.K. Kannan and Marappan [6] used Thevetia Peruviana Diesel and Di-ethyl Ether blends of 5%, 10%, 15%, and 20% to test the efficiency and emission characteristics of the diesel engine. According to the detailed analysis, a 20% DEE mix will result in a 5% increase in full-load bio-diesel blend, resulting in a 14.63 percent reduction in harmful smoke quality. It was determined that a 20% blend would produce better outcomes. J. P. Subrahmanyam et al. [7] investigated the combustion and emission characteristics of a diesel engine utilizing Karanja oil methyl ester (KOME) blend in a 5 percent, 10%, 15%, and 20% ratio with Di ethyl ester. They found that with a 15% KOME blend, brake thermal efficiency increased by 5.5 percent and with a 20% KOME-DEE blend, smoke opacity dropped to a minimum maximum load level. According to the numerous KOME-DEE blend tests, the best blend based on emission and efficiency characteristics was 15% KOME DEE.

Hossein Soukht Saraee et al,[8] demonstrated that a maximum yield of 35 to 40% of oil can be extracted from Pistacia Khinjuk utilizing the Soxhlet extractor. Fuel samples such as B5, B10, B20, B40, and B100 have been explored for DI Diesel engine research and testing. Bio-diesel samples found that it consumed more fuel than gasoline. Bio-diesel blends with lower CO and HC smoke contents have been discovered. Sayin et al. [9] investigated the effects of canola bio-diesel in CI engines with various FIPs and engine loads. Their findings showed that as bio-diesel blends in fuel types increased, the maximum heat release rate (HRR) and maximum pressure rise rate (MRPR) both fell slightly. It was also noted that bio-diesel has much greater BSEC and BSFC (brake-specific energy consumption) than diesel fuel, although BTE is modestly lower. The BSFC and BTE performed better with a higher injection load than with the original 200 bar and lower FIP. Many such works are done with different types of plant products to obtain a better alternative for diesel. In this paper we have studied the performance of sesame oil as a bio-diesel, experimentally. In the present work two blends of sesame oil bio-diesel have been prepared and performance analysis of these two blends is done by using CRDI VCR Engine set up and compared with that of the regular diesel.

II. EXPERIMENTAL PROCEDURE

2.1Preparation of bio-diesel blends using Sesame oil

The trans-esterification technique is used to produce bio-diesel from triglycerides. Food-grade vegetable oils, non-food-grade vegetable oils, animal fats, and waste restaurant greases can all be used to make bio-diesel. Trans-esterification, also known as alcoholysis, is the general word for the major family of chemical reactions in which an ester is changed into another ester through the interchange of alkyl groups. Trans-esterification is an equilibrium reaction that takes place when the reactants are mixed together. The presence of a catalyst, on the other hand, hastens the correction of the equilibrium. There are four basic phases in the trans-esterification process. Acid treatment followed by settling process, Base treatment followed by settling process, water washing and dehydration. For this current experimental study two types of blends were prepared which were named as per there bio-fuel concentration. The blends are as following:

BLEND 1: B10+D90 – This blend contains 10% of sesame oil and 90% of diesel.

BLEND 2: B20+D80 – This blend contains 20% of sesame oil and 80% of diesel.

To ensure effective fuel efficiency, the bio-fuels must be combined in the right amounts. In this study, the engine is driven with 100% diesel (D100) and blends of Sesame Bio-diesel and diesel in various proportions, such as 90% diesel + 10% Sesame bio-diesel; 80 % diesel + 20% Sesame bio-diesel; i.e., D90B10, D80B20.

2.2Determination of physical properties of the blends

The density, kinematic viscosity, flash point, boiling point, calorific value, Sulfur content in the fuel, and Cetane number of the fuel were all measured after it was blended with Sesame bio-diesel. In terms of flash point, calorific value, and viscosity, the qualities of the various proportions of blends have been shown to be quite equivalent to diesel properties, with significantly improved values in the case of flash point, calorific value, and viscosity. The formula for determining the kinematic viscosity of any oil is given by Eq. 1:

$$v = At - B/t \qquad (1)$$

Where, v = kinematic viscosity (Centi-Poise). A and B are viscosity constants. A= 0.0026, B= 1.79 and t= time taken to collect 50c.c of oil. The physical characteristics of all the blends were measured experimentally and presented as below in **Table *1***:

Table 1 Physical properties of blended fuels

Physical Property	Diesel	Sesame oil	B10	B20
Density(kg/m^3)	830	896	843	858
Kinematic viscosity (*10^{-6}m^2/s)	2.9	5.18	3.17	3.4
Flash point(°C)	74	140	80	83
Boiling point(°C)	180-340	330-365	-	-
Gross calorific value (MJ/kg)	42	46	42.7	43.2
Sulphur content (%)	<0.005	<0.5	<0.5	<0.5
Cetane Number	52	54	52	53

2.3Performance Analysis using Common Rail Direct Injection Varying Compression Ratio (CRDI VCR) Engine Set-Up

Pure diesel (D100B0), blends of diesel and Sesame bio-diesel, 90 % Diesel + 10% Sesame bio-diesel in vol. (D90B10) and 80 % Diesel + 20% Sesame bio-diesel in vol. (D80B20) were tested for performance analysis using the CRDI VCR Engine set up under varying loads while keeping a constant pace.

CRDI VCR ENGINE: The experiment setup includes a four-stroke, single-cylinder CRDI VCR engine that is coupled to an eddy current dynamo-meter for loading. It is a variable compression ratio diesel engine in which the compression ratio can be changed at any stage of the testing without halting the engine or modifying the design and geometry of the combustion chamber. The operating system open ECU in this engine has been programmed with the ignition angle, fuel injection time, and fuel injection angle at each point of operation based on the engine speed (in RPM) and mass air pressure. It aids in engine performance optimization while the engine is in operation across the whole operating range. The system open ECU, which regulates fuel flow, fuel pump, and fuel injector, is also coupled to sensors that detect mass air pressure, coolant temperature, air temperature, and trigger sensor. Instruments for measuring crank angle and combustion pressure are also included in the engine configuration.

For pressure crank angle diagrams, the data is interfaced with the computer, and the engine instruments are given to interface the measurements of load, fuel flow, air flow, and temperatures. The engine setup includes a stand, an individual panel box with two fuel tanks for diesel and bio-fuels (dual fuel), a manometer, an air box, air transmitters, a fuel and fuel flow measuring unit, a hardware interface, and a process indicator. For the engine's electric start arrangement, the engine is also equipped with rota-meters for cooling, a Calorimeter for measuring water flow, a starter, a battery, and a battery charger. Indicated power, brake power, frictional power, brake mean effective pressure, indicated mean effective pressure, indicated thermal efficiency, brake thermal efficiency, mechanical efficiency, volumetric efficiency, air fuel ratio, specific fuel consumption, heat balance, and combustion analysis are all part of the total engine setup.

2.4Emissions measurement using exhaust gas analyzer

The Technovation FEM-7 exhaust gas analyzer is used to measure various exhaust gas emissions when fuels are burned in a VCR test engine. The entire apparatus can be operated with the help of seven keys, and it has a simple architecture with effective performance and reliability. When connected to a computer via the USB port, this device can also store and download data. CO, NO2, CO2, HC, total combustion efficiency, and other emissions can all be calibrated. This is mostly used to determine the exhaust gases from boilers, furnaces, and kilns in order to manage pollution by calculating emissions.

III. RESULTS

The goal of this research is to study performance of the prepared bio-fuel blends by comparing the different parameters such as efficiency, specific fuel consumption and emissions of the blends with that of diesel. Performance analysis has been discussed in this section by comparing the parametric performance obtained for different blends (D100, B10, B20) varying loads (0kg,3kg,6kg,9kg,12kg).

3.1 Comparison of Brake Thermal Efficiency

Figure *1* shows the variation of brake thermal efficiency with different fuel blends. It is observed that for a given blend with increases load the brake thermal efficiency increases and for a given load B10 shows a little higher brake thermal efficiency. Maximum brake thermal efficiency is obtained for the blend B10 running at a load of 12kg and the value is 30.55%.

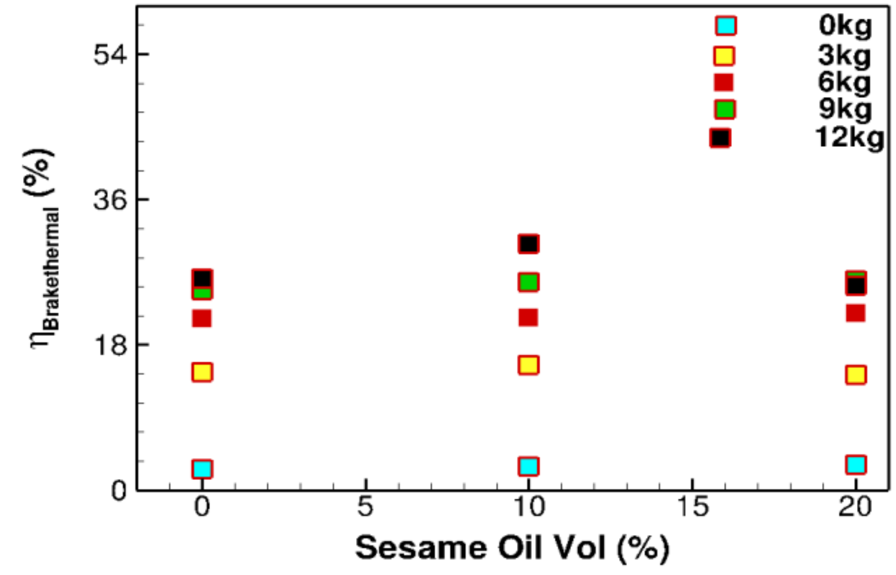

Figure 1Variation of Brake Thermal Efficiency with different types of bio-diesel

3.2 Comparison of Indicated Thermal Efficiency

Figure *2* shows the variation of Indicated thermal efficiency with different fuel blends.

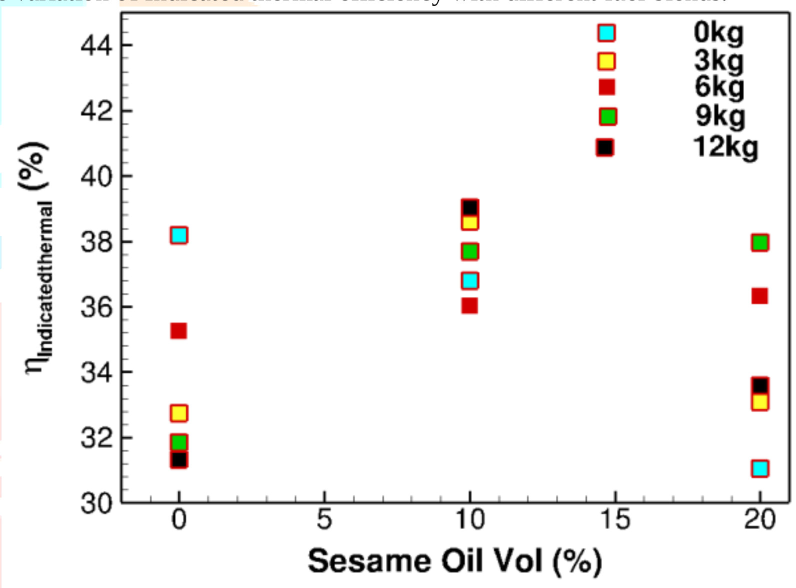

Figure 2Variation of Indicated Thermal Efficiency with different types of bio-diesel

It can be observed that for D100 the indicated thermal efficiency decreases with increasing load and for B10 indicated thermal efficiency increases as the load increases from 0kg to 3kg then it decreases when the load increases 6kg and again it increases as the load is increases 6kg to 12 kg. For B20 indicated thermal efficiency increases by increasing the load from 0kg to 9kg then suddenly decreases when the load is increased to 12kg. Maximum indicated thermal efficiency is obtained for the blend B10 for the load of 12kg and the value is 39.04%.

3.3 Comparison of Mechanical Efficiency

Figure *3* shows the variation of Indicated thermal efficiency with different fuel blends.

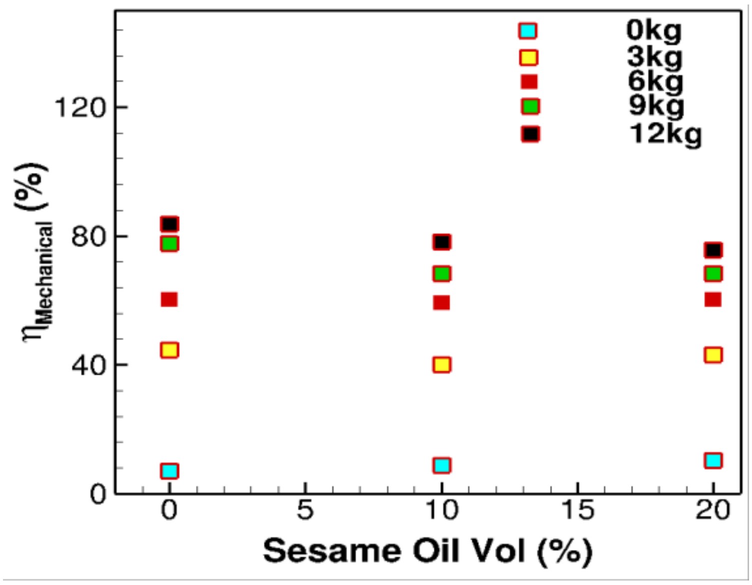

Figure 3 Variation of Mechanical Efficiency with different types of bio-diesel

It is observed that for a given blend with increases load the mechanical efficiency increases and for a given load D100 shows a little higher mechanical efficiency. Maximum mechanical efficiency is obtained for the blend D100 running at the load of 12kg and the value is 83.71%.

3.4 Comparison of Specific Fuel Consumption

Figure *4* shows the variation of Specific fuel consumption with different fuel blends.

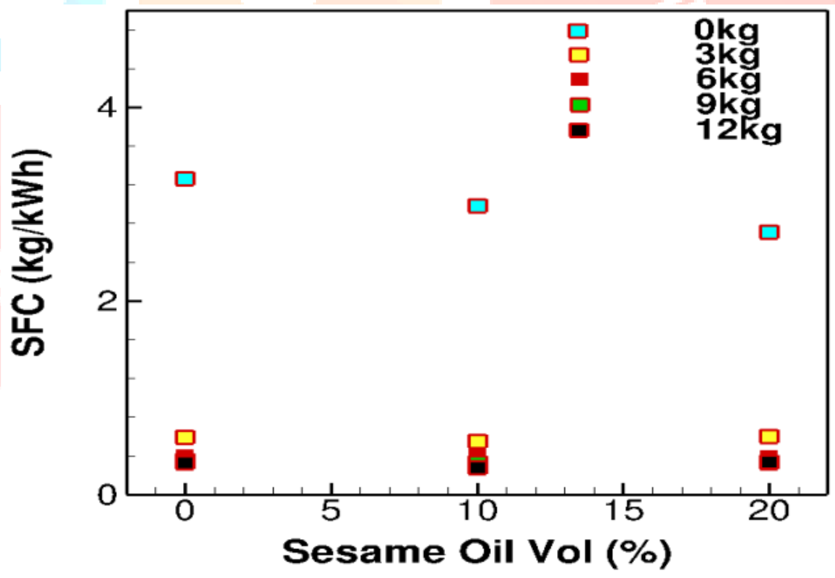

Figure 4 Variation of SFC with different types of bio-diesel

It is observed that for a given blend with increases load the Specific fuel consumption decreases and for a given load D100 shows a little higher Specific fuel consumption. Maximum Specific fuel consumption is obtained for the blend D100 for the load of 0kg and the value is 3.26kg/kWh.

3.5 Comparison of Carbon Monoxide emission

Figure *5* shows the variation of Carbon monoxide emissions different fuel blends.

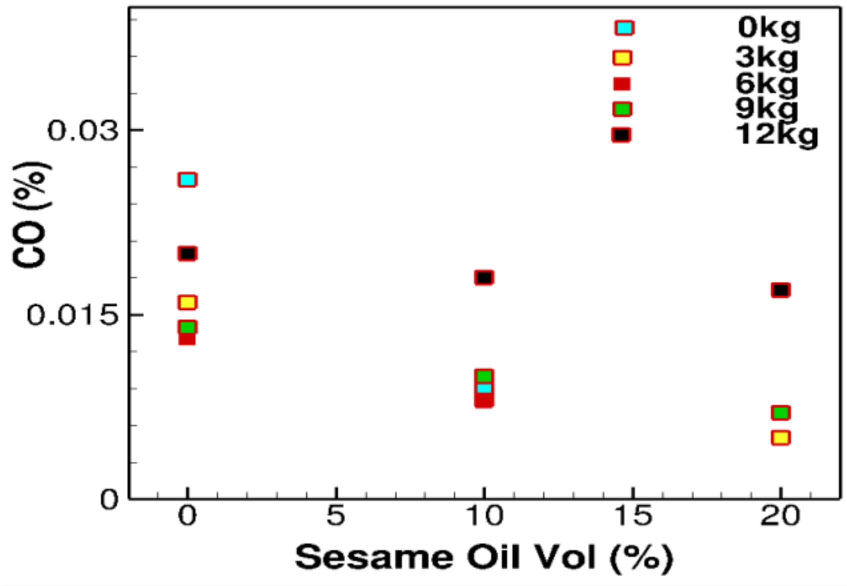

Figure 5 Variation of CO emissions with different types of bio-diesel

It is observed that for D100 with increases load from 0kg to 6kg the CO% is decreases and then by increasing load from 6kg to 12kg the CO % is increases and for B10 with increases load from 0kg to 6kg the CO % is decreases and then by increasing load from 6kg to 12kg the CO% is increases. For B20 with increases load from 0kg to 3kg the CO % is decreases and then by increasing load from 6kg to 12kg the CO % is increases. Maximum CO emissions are found for the blend D100 running no load and the value is 0.026%.

3.6 Comparison of Carbon Dioxide emission

Figure *6* shows the variation of Carbon dioxide emissions different fuel blends.

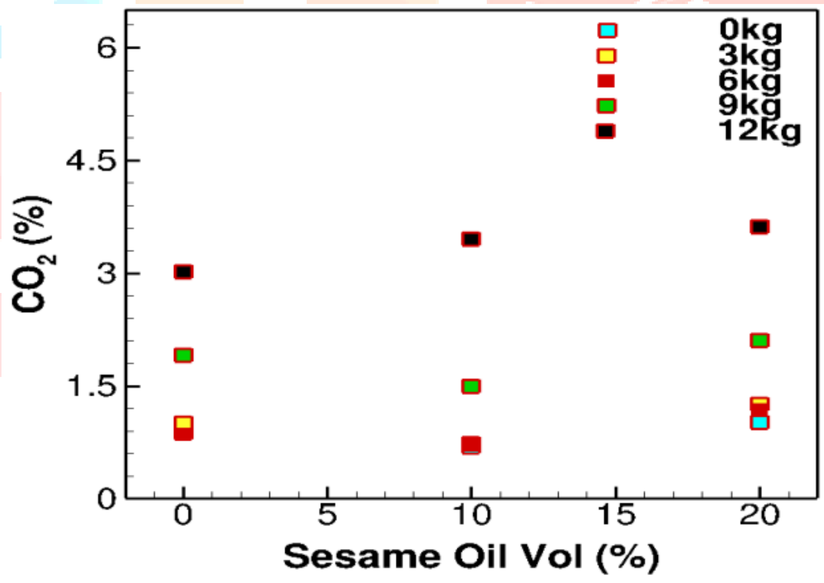

Figure 6 Variation of CO_2 emissions with different types of bio-diesel

It is observed that for a given blend with increases load the Carbon dioxide emissions increases and for a given load B20 shows a little higher Carbon dioxide emission. Maximum Carbon dioxide emissions are obtained for the blend B20 for the load of 12kg and the value is 3.62%.

IV. Conclusion

From the performance analysis of different blends of sesame oil bio-diesel we have observed that:

1. Maximum brake thermal efficiency is obtained for the blend B10 at which the load is 12kg and the value is 30.55% and the maximum indicated thermal efficiency is obtained for the blend B10 at which the load is 12kg and the value is 39.04%. maximum mechanical efficiency is obtained for the blend D100 at which the load is 12kg and the value is 83.71%.
2. Maximum Specific fuel consumption is obtained for the blend D100 at which the load is 0kg and the value is 3.26kg/kWh.
3. Maximum CO emissions are obtained for the blend D100 at which the load is 0kg and the value is 0.026%. Maximum Carbon dioxide emissions are obtained for the blend B20 at which the load is 12kg and the value is 3.62%.

Out of the two blends B10 shows somewhat promising performance and in future more blends can be tested and compared to get a clear picture as to which composition provides a better alternative option for diesel.

V. ACKNOWLEDGMENT

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