IOP Conference Series: Materials Science and Engineering

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IOP Conf. Series: Materials Science and Engineering 469 (2019) 012122 doi:10.1088/1757-899X/469/1/012122

A comparative study on performance characteristics of diesel engine fuelled by biodiesel blends with and without Ge-132 additive.

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Abstract. The demand for growing fuel in everyday life and its risk requires a serious problem for this world. Great attention is needed to solve this problem. Biodiesel considered as alternatives to minimize the usage of conventional fuels. However, by using biodiesel, the main drawbacks are like higher density, lower heat value, high-level consumption and high nitrogen oxides that contribute to produce less engine performance and increase the exhaust emission. In order to avoid the above disadvantages, fuel additives help plays a very important role in minimizing the disadvantages of biodiesel and maintaining international fuel standards. In this experimental study, the organic germanium Ge-132 with 5ppm,8ppm and 10ppm were added into blend biodiesel B20 to investigate the effect of the additive to the biodiesel blends. The blended fuels were experimentally tested with YANMAR TF120M diesel engine at engine loads of 25%, 50%, 75% and 100% at a constant 1800 rpm engine speed. The addition of Ge-132 causing no significant negative effect on physicochemical properties. The result performance reveals the brake fuel consumption improve by 1.22%,2.38% and 3.09% for B20Ge5, B20Ge8 and B20Ge10 compared to B20. Compare to B20, the percentage different of B20 with Ge-132 improve about 0.41%-6.17% and 0.51%-8.89% for brake thermal efficiency and exhaust gas temperature, respectively. The analysis of additive Ge-132 in biodiesel blends show the potential to be further researched as an additive due to significant improvement in performance characteristics.

1. Introduction

The growing demands of energy in the power and transport generation sectors as well as the limited availability of fossil fuels and the negative environmental effects arising from its scientist and researchers to find alternative fuels to minimize the usage of the fossil fuel. Due to the characteristic of nature-renewable and reduce the effect HC and CO emission, biodiesel received attention as alternative fuel among researchers[1]. On the contrary, the major problems of biodiesel are lower engine power, higher BSFC due to lower calorific values, higher density and viscosity. On comparing with diesel, the usage of biodiesel in engine did not produce the rated power due to its lower calorific value [2, 3]. Also, the presence of esters in the oils may affect the fuel line leads to chocking in fuel injector and decrease in fuel filter life. To attain the rated power with the biodiesel, many techniques were employed in diesel engine like thermal barrier coating, pre-heating, addition of an additive to fuel, varying the injection

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pressure and injection timing. Among the aforesaid techniques, addition of an additive to biodiesel were considered as the vital techniques for the better performance and emission characteristics.

To overcome some of biodiesel drawback, organics germanium with small proportion as additive has come out with great potential [4]. Bis-carboxyethyl germanium sesquioxide (Ge-132) also noted with chemical formula $C_6H_{10}O_7Ge_2$ is the additive to introduce to enriches with an oxygen content that can improve the thermophysical properties such as density, cetane number, calorific value, viscosity and boiling point. On the other hand, Ge-132 also capable easily attach to oxygen molecules that can improve the stability of the biodiesel blends. A literature search revealed a few such works with limited information which reveal Ge-132 as the additive. In order to o fill this gap, the study was aimed to improving a 20% mix of diesel fuel palm biodiesel with the help of additive Ge-132.

2. Material and fuel preparation

2.1. Fuel preparation
A standard JIS (Japan Industrial Standard) and pure palm biodiesel were purchased from local market in Pahang, Malaysia. The additive Ge-132 was bought from Japan Algae Co., Ltd. The B20 prepare by adding 80% diesel fuel and 20% palm biodiesel and stirred vigorously with mechanical stirrer at 600rpm for 10 minutes. An ultrasonic emulsifier Hielscher Ultrasonic GmbH UP400S was used to stir the Ge-132 additive in B20. It was set at 50% power and 0.5s duty cycle for 30 min to obtain a well suspended Ge-132 distribution in fuel blends. The blends were labelled as B20 for 20% diesel and 80% biodiesel, B20Ge5, B20Ge8 and B20Ge10 for 5,8 and 10ppm, respectively.

2.2 Fuel properties testing
The properties of the fuel blends such as density, viscosity and calorific value are important to investigate the performance and emission of the diesel engine. These are the physicochemical properties that reflect the quality of the fuel. Density and viscosity consider most significant parameter of fuel properties because the fuel need to flow through different nozzle, orifice and pipeline. The fuels physicochemical properties characterization was done strictly following ASTM characterization. Apparatus, standard and measured fuel properties of the fuels are given in Table 1.

The fuel density measurement was conducted at 20ºC, according to ASTM D127, using a portable density meter (model DA-130N). A Cannon-Fenske Column and Oil Bath was used to measure the fuel kinematic viscosity at a constant temperature of 40ºC ± 0.1, according to ASTM D-445. The IKA apparatus model C2000 basic calorimeter-automatic was used to measure the calorific value based on ASTM D240 standard. All the fuel blending was measure with the strict ASTM method as prescribed by manufacturer. Those tests were directed under controlled room temperature.

Table 1. Apparatus, standard and measured fuel properties of fuels

Properties	Standard ASTM	Equipment	D100	B20	B20Ge5	B20Ge8	B20Ge10
Density (Kg/m^3)	D127	MRC laboratory equipment manufacturer, Israel	875	838	842	845	847
Kinematic viscosity (mm^2/s)	D445	Thomas scientific, US.	4.91	4.05	4.08	4.11	4.12
Calorific value(MJ/kg)	D240	IKA, UK	39.9	43.92	43.96	44.15	44.21

2.3 Test engine
The experimental setup with necessary instrumentation has been shown in Figure 1 In this experiment, a single-cylinder direct-injection diesel engine (model YANMAR TF120M) was used. The technical

specifications of engine summarized in Table 2. The engine is coupled to an eddy current dynamometer of maximum electric power output of 15kW power was mounted in spherical bearings and fitted directly to the test engine to measure the engine brake torque. The fuel mass flow rate was measured by recording the time required to consume a specific mass of the fuel on a digital weight scale CAS (model TCS-6 up to 6kg). The ambient air temperature, exhaust gases temperature and fuel temperature were measured using a thermocouple logger (model PicoLog TC-08 USB). For this purpose, three K type thermocouple probes were installed in locations as shown in Figure 1. In addition to this, three more thermocouples were included to measure wet-bulb temperature, exhaust tailpipe temperature and engine oil temperature. All the signal output from the load cell sensor, temperature thermocouples, digital weight scale, air flow meter sensor and speed sensor were recorded and displayed on monitor through DasyLab software. The method was follow from the previous research article by Ang F. Chen et al [5].

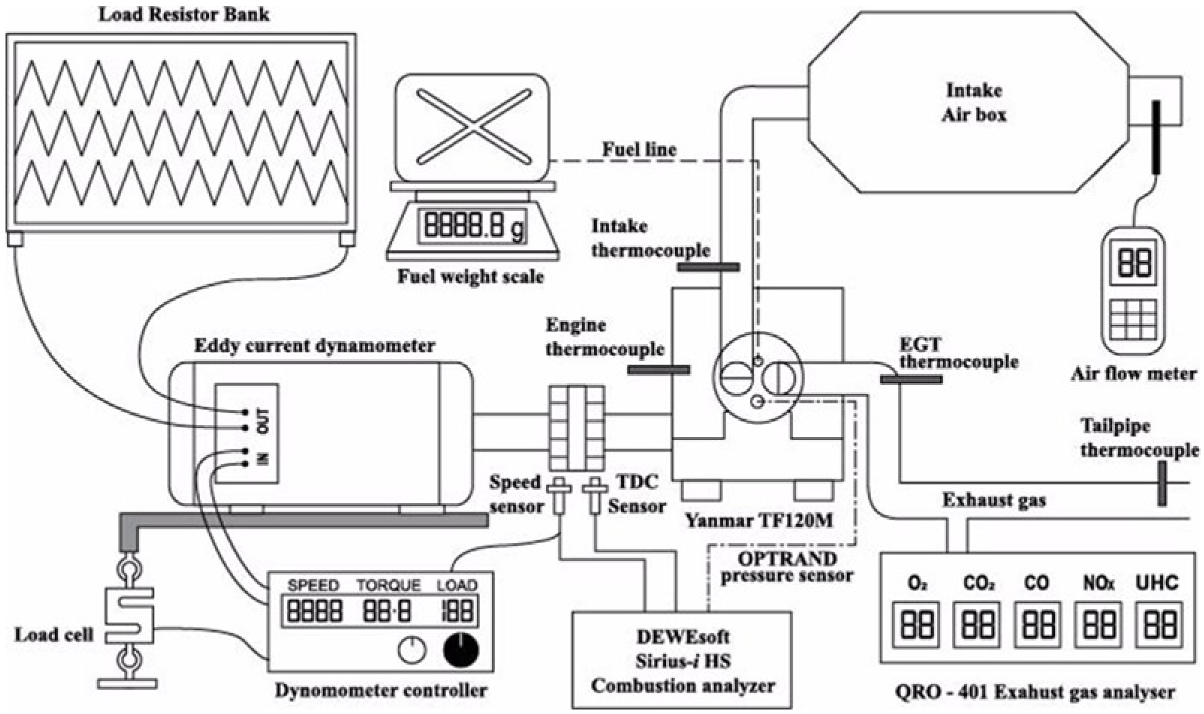


Figure 1. Schematic diagram of experimental set-up

Table 2. Specification of the engine

Engine type	Four stroke DI diesel engines
Number of cylinders	One
Aspiration	Natural aspiration
Cylinder bore x stroke, mm	92 x 96
Displacement ,L	0.638
Compression ratio	17.7
Max. engine speed ,rpm	2400
Max. power, kW	7.7

2.4 Engine test cycle and test procedures

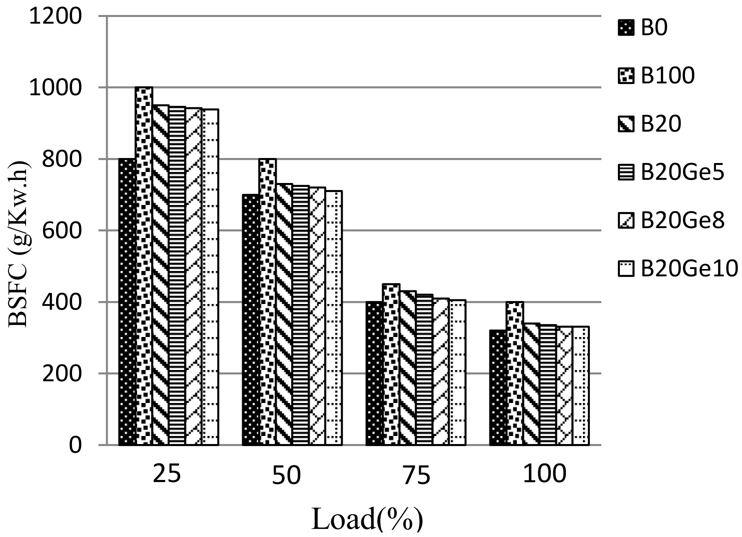
The experiment began by fuelling the engines with D100 and B100. The data will form a basic standard or baseline, which could be used as a comparison with blending biodiesel with additive Ge-132. DF was used to warm-up the engine for 10min. The study was carried out with a constant speed of 1800rpm and engine loads of 25%0–100% with increment of 25%. The parameters were selected because this would yield the same amount of brake power output for each respective engine load, thus the results of Brake

Specific Fuel Consumption (BSFC),Brake Thermal Efficiency (BTE) and Exhaust Gas Temperature (EGT) could be compared. The engine speed of 1800rpm was selected because the YANMAR TF120M engine had the highest BTE at 1800 rpm as prove by previous study [2].

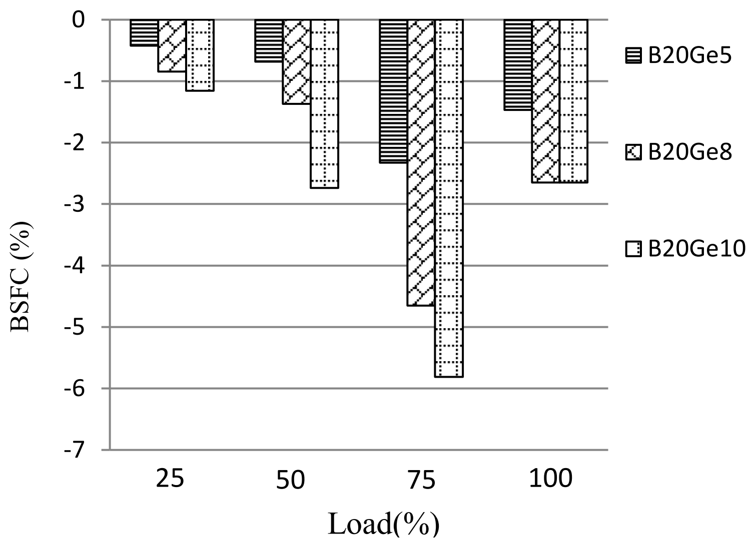
3. Results and discussion

3.1. Brake Specific Fuel Consumption (BSFC)

Figure 2 shows the brake specific fuel consumption for all the fuels at different loads. The performance of the test fuels can be assessed by BSFC, which indicates the mass of fuel consumed to produce a unit of power. As seen in the Figure 2 (a), BSFC decreases with the increasing of engine loads. At low engine load, the in-cylinder gas temperature is relatively low, leading to incomplete and low efficiency combustion, resulting in higher BSFC. While at higher engine load, the in-cylinder and gas temperature was higher, leading to more complete and efficient combustion which producing in lower BSFC [6, 7]. Refer to figure, B100 and B20 produced about 14.9% and 4.71% higher BSFC, respectively, compared to B0. Increasing the share of biodiesel enhances the fuel density and subsequently reduces the heating value of the diesel-biodiesel blends. In Figure 2 (b), fuel samples that contain fuel additives showed an improvement in BSFC values under all loading conditions compared to B20. The addition of Ge-132 to B20 increases its calorific value further. Furthermore, this contributes to decreasing the BSFC, a finding that is concordant with previous studies [4]. The addition of 5ppm, 8ppm and 10ppm Ge-132 to B20 resulted in mean reductions in BSFC of 1.22%, 2.38% and 3.09%, respectively.



(a) BSFC of test fuels with respect to engine load

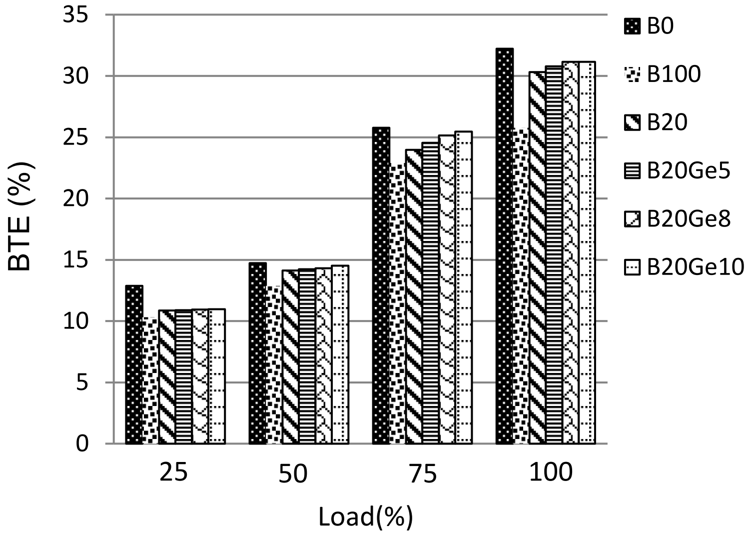


(b) Percentage of BSFC variations between B20 and B20 with Ge-132 blends at different concentration

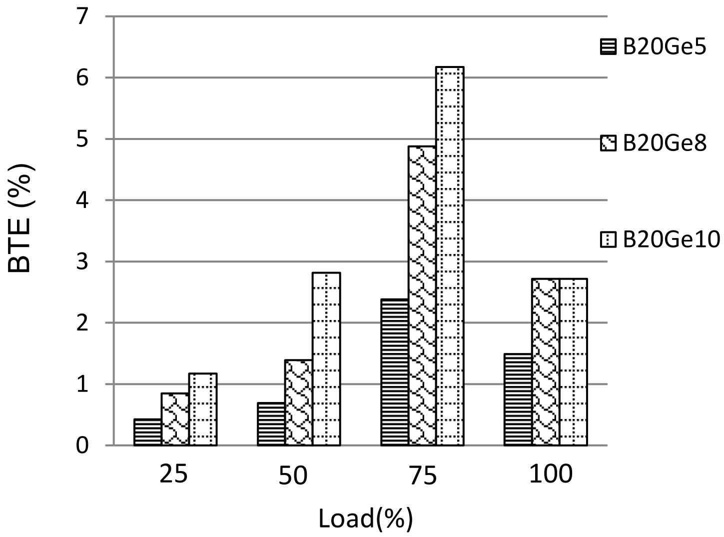
Figure 2. Comparison BSFC of different test fuels at all engine loads

3.2 Brake Thermal Efficiency (BTE)

Exhaust gas temperature is an indication of the cylinder combustion temperature and engine lifespan. BTE is the efficiency of a heat engine measured by the ratio of the work performed by it to the heat supplied to it. Energy introduced is the product of the injected fuel mass flow rate and the calorific value. From Figure 3 (a) depict the comparison BTE with engine load for different fuel. It can have observed that, the maximum value of BTE at 100% load for B0, B100, B20, BGe5, BGe8 and BGe10 were 32.21%, 25.77%,30.32%,30.77%,31.14% and 31.14% respectively. The average value of BTE for B0, B100, B20, BGe5, BGe8 and BGe10 were 21.40%, 17.98%, 19.82%, 20.10%, 20.38% and 20.52%. From Figure 3 (b) percentage different BTE of B20 and B20 with additive. It shows that, the increasing the concentration additive Ge-132 increase the BTE of blends fuel. It could attribute to the effects of the calorific value of the blend fuel [8]. The highest percentage different is at 75% engine load from B20Ge10 (6.17%) followed by B20Ge8 (4.87%) and B20Ge5 (2.38%). This could attribute to the higher power output and lower BSFC compared to B20.



(a) BTE of test fuels with respect to engine load

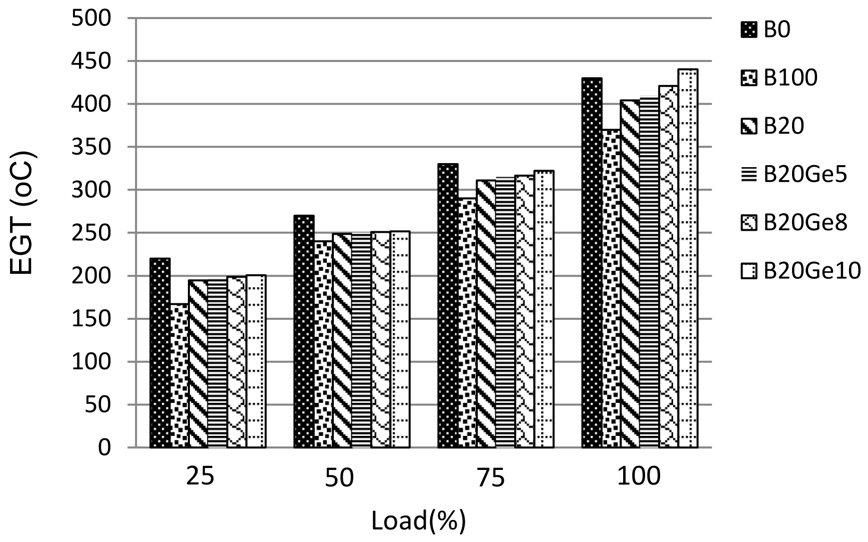


(b) Percentage of BTE variations between B20 and B20 with Ge-132 blends at different concentration

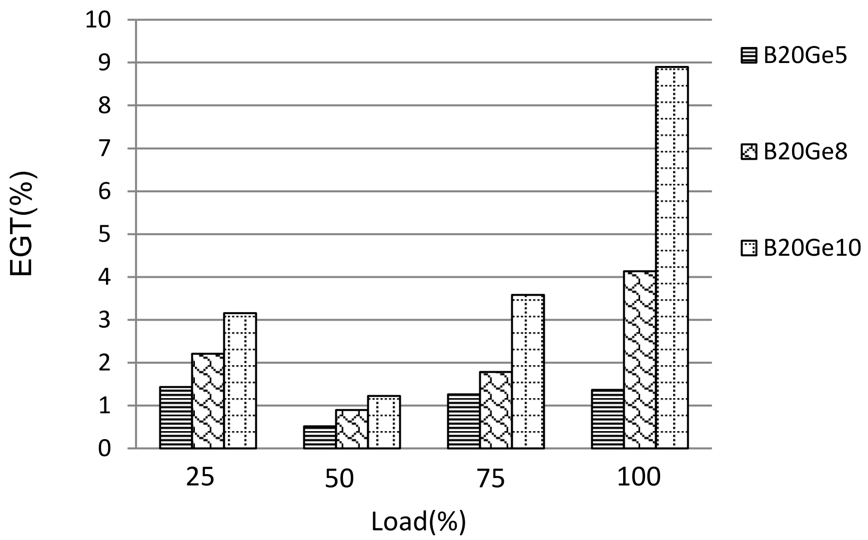
Figure 3. Comparison BTE of different test fuels at all engine loads.

3.3 Exhaust Gas Temperature (EGT)

Exhaust gas temperature is an indication of the cylinder combustion temperature and engine lifespan. BTE is the efficiency of a heat engine measured by the ratio of the work performed by it to the heat supplied to it. Energy introduced is the product of the injected fuel mass flow rate and the calorific value. From Figure 4 (a) depict the comparison BTE with engine load for different fuel. It can have observed that, the maximum value of BTE at 100% load for B0, B100, B20, BGe5, BGe8 and BGe10 were 32.21%, 25.77%,30.32%,30.77%,31.14% and 31.14% respectively. The average value of BTE for B0, B100, B20, BGe5, BGe8 and BGe10 were 21.40%,17.98%, 19.82%, 20.10%, 20.38% and 20.52%. From Figure 4 (b) percentage different BTE of B20 and B20 with additive. It shows that, the increasing the concentration additive Ge-132 increase the BTE of blends fuel. It could attribute to the effects of the calorific value of the blend fuel [8]. The highest percentage different is at 75% engine load from B20Ge10 (6.17%) followed by B20Ge8 (4.87%) and B20Ge5 (2.38%). This could attribute to the higher power output and lower BSFC compared to B20.



(a) EGT of test fuels with respect to engine load



(b) Percentage of EGT variations between B20 and B20 with Ge-132 blends at different concentration

Figure 4. Comparison EGT of different test fuels at all engine loads

4. Conclusions

The aim of this experimental work was to investigate the effect of organic germanium Ge-132 on the performance characteristics of engines fuelled with palm biodiesel and its blends. The following conclusions can be drawn based on the experimental results.

- The addition of Ge-132 increased the kinematic viscosity, density and calorific value.

- The result performance reveals the brake fuel consumption improve by 1.22%,2.38% and 3.09% for B20Ge5, B20Ge8 and B20Ge10 compared to B20.
- Compare to B20, the percentage different of B20 with Ge-132 improve about 0.41%-6.17% and 0.51%-8.89% for brake thermal efficiency and exhaust gas temperature, respectively.

5. Acknowledgment
The authors sincerely thank the Universiti Malaysia Pahang – DSS, Ministry of Higher Education (Malaysia) for the financial support through the MyBrain15 programme and the Fundamental Research Grant Scheme (FRGS) RDU130134.

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