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Two strokes engine performance using waste cooking oil

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ABSTRACT:
The aim of this research is optimise the biodiesel fuel that can be produced from waste cooking oil for two stroke engines and study the performance of two stroke engines work on the proposed fuel from the first stage. Firstly, the waste cooking oil will be characterised and improve its poor properties using chemical additives. Secondly, biodiesel production method from waste cooking oil will reviewed, assessed and optimised to obtain the most appropriate biodiesel fuel. Thirdly, the performance of two stroke engines that run on the optimised fuel will be investigated. The successful completion of this project will create opportunities to highly consider the usage of the proposed biodiesel fuel for two stroke engines.

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I. INTRODUCTION

Two strokes engines are widely used in various machineries due to their high power with low mechanical losses compared to the four strokes engines. One of the main advantages of two stroke engines compared to the four stroke engine is the high mechanical efficiency since there is no poppet valves and the number of power strokes in each cycle, [1]. In the last decade, two stroke engines have been banded by many countries due to their high pollution production, [2]. The advanced technology in developing two stroke engines adaptation gasoline direct injection (GDI) technology gives two stroke engines new path in the current years, [3, 4]. The lubricant of the two strokes engines is mixed with the gasoline in the fuel tank to be supplied into the combustion chamber. The main purpose of the lubricant is to protect the engine component during operation. Commercially, there are three types of two stoke engine oils which are mineral, synthetic, and Semi-synthetic. The common and most importance characteristics among the three times are the viscosities atlow and high temperature; which are in range of 48 cSt, and 7.9 cSt at 40º C, and 100º C respectively with viscosity index of 134. In recent work by Alotaibi and Yousif [5], it has been reported that the waste cooking oil with some additives can be a good substitute to current commercial two stroke engine oils. The potential of using the waste cooking oil at certain percent in two stroke engines will assist in solving many current issues related to the emission of two stroke engines, disposing of waste cooking oil, independency from fossil products. It should be mentioned here, oil-to-energy supply chains is in high demand in productive countries such as china, [6].

With regards of the interest of using waste cooking oil, it should be known that Current global waste is approximately 12 billion tons/year and it is expected to reach 18 billion tons in 2020, [7]. In china alone, the waste cooking oil is around 5 million tons a year, [6]. This urges the industries and researchers to explore the potential of using waste cooking oil (WCO) in different applications such as conversion to biofuel, lubricant, gridding aid, coolant etc. Conversion of WCO into biofuel is covered comprehensively by the literature and there are many factories are established already. On the other hand, it has been found that WCO has good lubricity characteristics which give it the potential to be used as lubricant or assisting in reducing the synthetic lubricant by blending the WCO with synthetic oil.

In this current project, a two-stroke electrical generator will be operated with different blends of gasoline/synthetic oil/ and modified waste cooking oil. The performance of the generator in term of emission and power will be determined. The waste cooking oil is collected from local fish and chips restaurant.

As mentioned in the introduction, the usage of waste cooking oil is still limited despite of the high generated WCO in the world. There main usage of the WCO is to be converted into biodiesel. However, there are many issues with that since there is some sticking and blocking in the nozzles of the engines due to the high viscosity of the WCO. From

the literature, it has been found an interest to use the WCO as lubricant and the lubricity of the WCO has been determined and found to be equivalent to the two-stroke engine oil. The potential of real application of WCO in two-stroke engines will be investigated in this work.

The core aim of this work it to investigate the usage of waste cooking oil in two strokes engines in real applications since two stroke generator will be used.

II. OIL PREPARATION AND BLENDING PROCEDURE

Castrol2T is used as synthetic two strokes engine oil which has been purchased from supercheap store in Toowoomba, QLD, Australia. The details of the engine oil can be found in the web side of the company at http://www.castrol.com/en_us/united-states/motorcycle-oil/2-stroke-engine-oil/2t-2-stroke-motorcycle-oil.html.

Waste cooking oil collection and preparation

Waste cooking oil is provided by fish and chips restaurant in Toowoomba, QLD, Australia. The oil was cooked for a week and used at cooking temperature. The oil first filtered with sieve to get rid of the big residual fish or potatoes. The oil then filleted with cloth filter of very low porosity. Before using the filter, the oil was heated up to reduce the viscosity since it was difficult to get it through the filter.

III. EXPERIMENTAL SETUP

A portable Yamaha engine (two strokes) is used for the current experiments. The engine is connected to electrical generator as shown in figure 3.2. it is one of the common generator in Australia which is used for camping and rural area and home applications. General specification of the generator is provided by http://www.sagenerator.co.za company and given in table 3.2. the output power is 780 Watts. The capacity of the tank is 4 litre. Mixing fuel and two stroke engine oil is 401:21 as recommended by the manufacturer.

The blends of the oil is prepared at different ratios of 0-100% by volume. The blends are used with the patrol fuel as recommend ration. The engine then started and the power is measured at the peak loading condition.

IV. EXPERIMENTAL PROCEDURE

The generator is connected to a heater of three level of heating which reach up to 2000 watts. At the first stage, the oil and the fuel is mixed and 0.5 litre is used for the operating condition. After switch on the engine, the full load of the electrical heater is on the generator and the Ampere is measured while the engine working to monitor any drop or fluctuation in the current level. The exhaust emission will be measured while the engine working. At the end of the test the tank will; be cleaned to ensure there is no blends left in the tank. The operating will be repeated for the different blends and the experimental data will be collected. EMS gas analyser was used in the experiment measuring CO, CO2, O2, AFR, NOx, and HC. In the operating of the analyser, the engine start first for about 10 mins and then the analyser inlet was inserted in the exhaust of the engine to measure the gases level.

V. RESULTS AND DISCUSSION

viscosity variation of waste cooking oil (WCO)

The viscosity the prepared lubricant of waste cooking oi (WCO) mixed with semi synthetic (Mobil) oil is displayed in Figure 1. The results are given at two temperatures of 25 ^{o}C and 40 ^{o}C. The figure shows that the increase in the temperature reduce the viscosity of all the prepared blends. This is the nature behaviour of the oil since at high temperature the viscosity reduces due to the increase in the lubricity of the oil. With regards to the influence of the addition of waste cooking oil into the semi-syntactic oil, the figure shows that the increase in the amount of the waste cooking oil reduce the viscosity as well for both tested temperature. The pure WCO showed a value of 78 and 44 mPas at 25 ^{o}C and 40 ^{o}C, respectively. Capuano, Costa [8] reported similar value for the soybean, rapeseed, palm and peanut oil. In that work, the oil was used directly into diesel engine as fuel and the results were promising despite there were some issues in the nozzles. Chhetri and Watts [9] reported similar values which indicate that the current work is in high agreement with the recent published works.

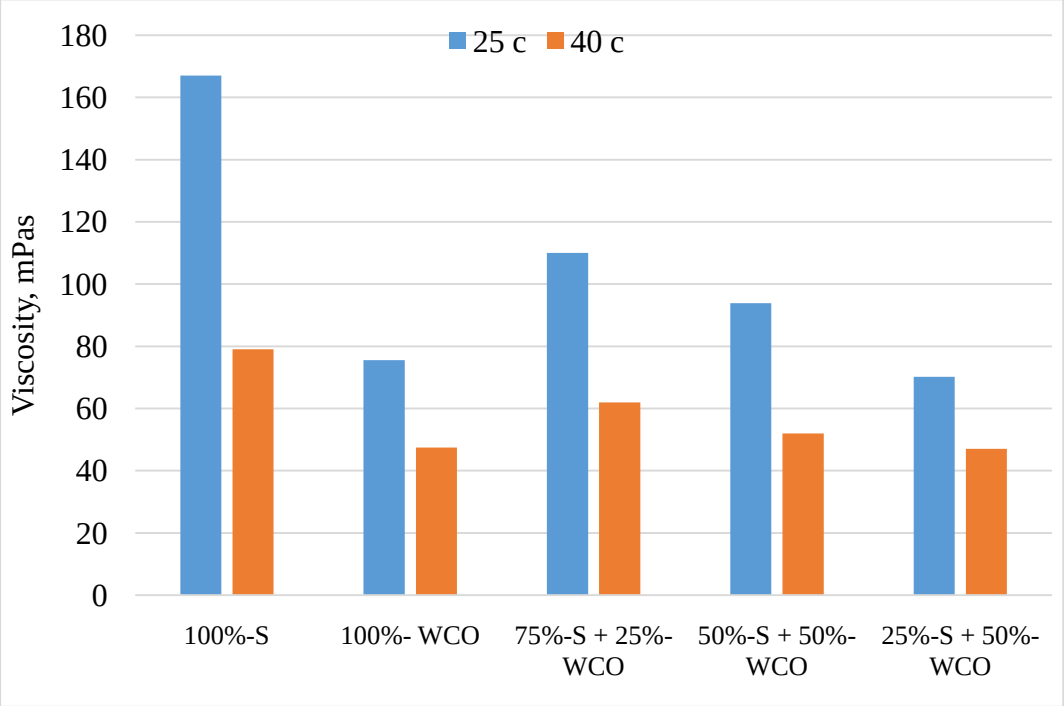

Figure 1 Viscosity of the blended lubricant at different [percent of waste cooking oi (WCO).

Gas emission results

After the engine was operated for about 10 mins the EMS gas analyser was fixed into the exhaust exit and the left for about 5 mins to grain the stabile results. The output parameters are given in the following sections.

Air fuel ratio (AFR)

Air fuel ratio is very important parameter to determine the combustion quality. Figure 2 shows that the increase in the percent of the WCO in the lubricant blend increases the AFR. It is recommended that the AFR for two strokes engine to be in the range of 20-25 as reported by Carlucci, Ficarella [10]. In other words, the addition of the WCO improves the AFR of the two strokes engine. In the recent work by Andwari, Aziz [11] it is found that the AFR within the range of 15–22 ± 0.5 is the optimum for the two strokes engine. This is significantly encouraging results for the current study since the addition of the WCO enhance the AFR of the two strokes engines.

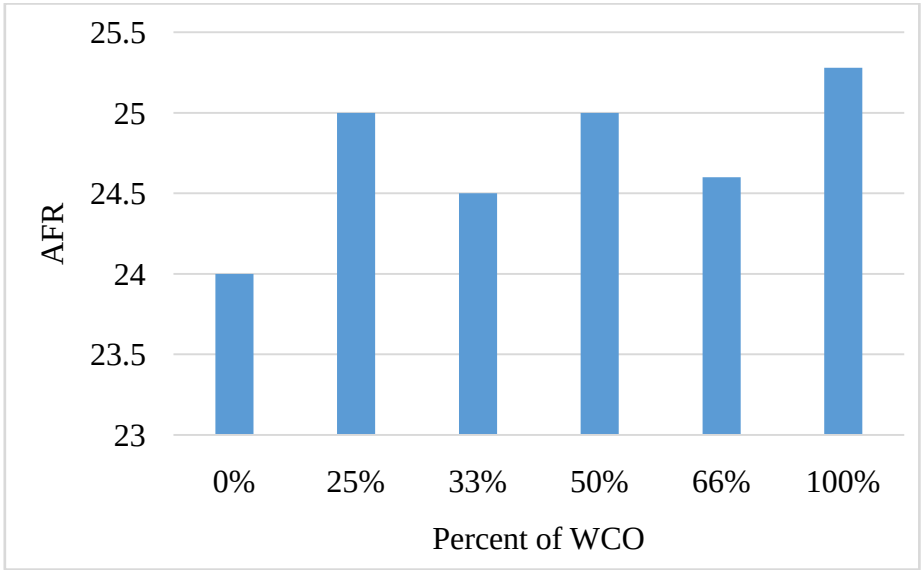

Figure 2AFR at different percent of two strokes engine using different lubricant containing different percent of WCO

O2

The level of the oxygen in the exhaust of the two-stroke engine at different lubricant is given in Figure 3. The figure indicates that the adding of the waste cooking oil slightly reduces the oxygen level. However, the level of the reduction is not that high especially in comparing the result of the pure synthetic oil and the pure WCO which showed almost similar oxygen level. This is promising results which give a potential of using waste cooking oil as lubricant in the two strokes engines.

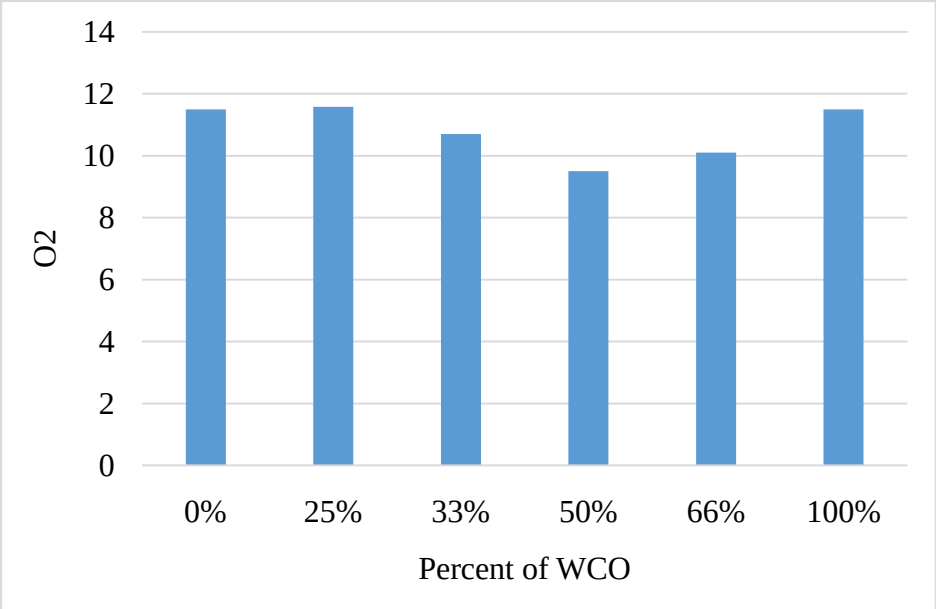

Figure 3 O2 level in the exhaust of two strokes engine operated with different lubricant containing different percent of WCO

HC

Hydrocarbon amount in the exhaust of the engine is given in Figure 4 for all types of lubricants. Interestingly, the increase in the amount of the WCO reduces the HC amount in the exhaust. Comparing with the four stroke engines, Ramasamy, Goh [12] found 1800 ppm HC in the exhaust of a 4 strokes engines with different patrol fuel types. In the current study, the amount HC in the two strokes engine is very comparable to the four-stroke engine bear in mind that the two stroke engines always has high power than the four strokes engines.

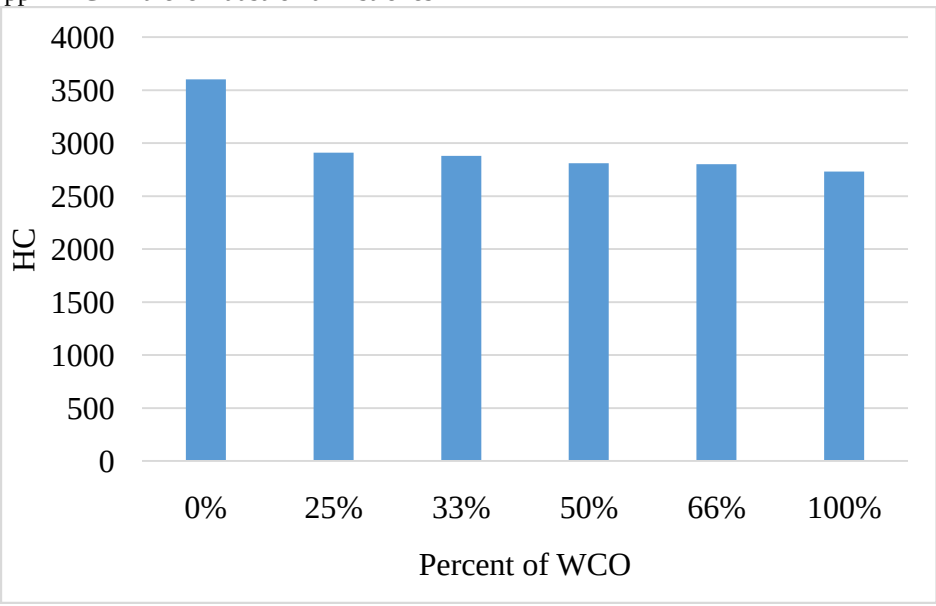

Figure 4HC level in the exhaust of two strokes engine operated with different lubricant containing different percent of WCO

CO

The most effect exhaust gas on the environment is the CO. this is the main point of limiting the usage of two strokes engine in various applications. Figure 5 displays the amount of the CO in the exhaust of the two strokes engine operated with different lubricants based on waste cooking oil and semi-synthetic oil. it is clear that the addition of the waste cooking oil significantly dropped the amount of the CO in the exhaust. This is a dramatical finding which will greatly contribute to the knowledge of the two strokes engine and will allow to utilize the usage of such engine in different industrial applications. In four stroke engines, the amount of the CO was about 2 per value as reported by Ramasamy, Goh [12] 4 strokes engine and 450 ppm with the case of diesel engine operated with biofuels, [13]. Senatore, Buono [14] attempted to reduce the emission of two strokes engine by using bio-diesel. In that work, the amount of the reduction in the CO is very similar to the amount of reduction in the CO took place in this work which is about 50%.

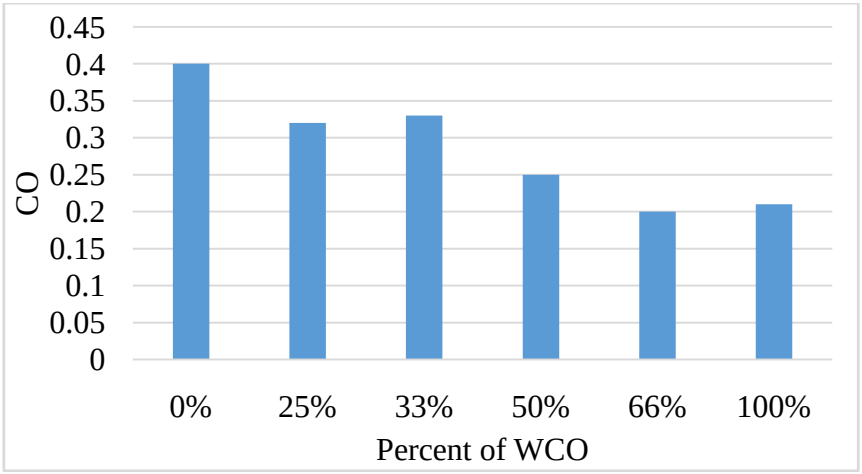

Figure 5CO level in the exhaust of two strokes engine operated with different lubricant containing different percent of WCO

CO2

The amount of the CO2 in the exhaust of the two strokes engine is given in Figure 6 using different lubricant based on the percent of the WCO. The amount it seems reduces with the increase of the amount of the WCO. This can be due to the less amount of carbon in the WCO compared to the semi-syntactic oil. Semi-synthetic oil is made of petroleum product which has very high amount of carbon. Meanwhile the amount of the carbon in the vegetable oil is less. Also the carbon bond in the petroleum product is double which in the vegetable oil is single which easy the combustion with less amount of carbon. Çelik and Önder Özgören [13] reported that 8% of the exhaust of diesel with biofuel is CO2. In other words, the recent results should be acceptable from environmental side.

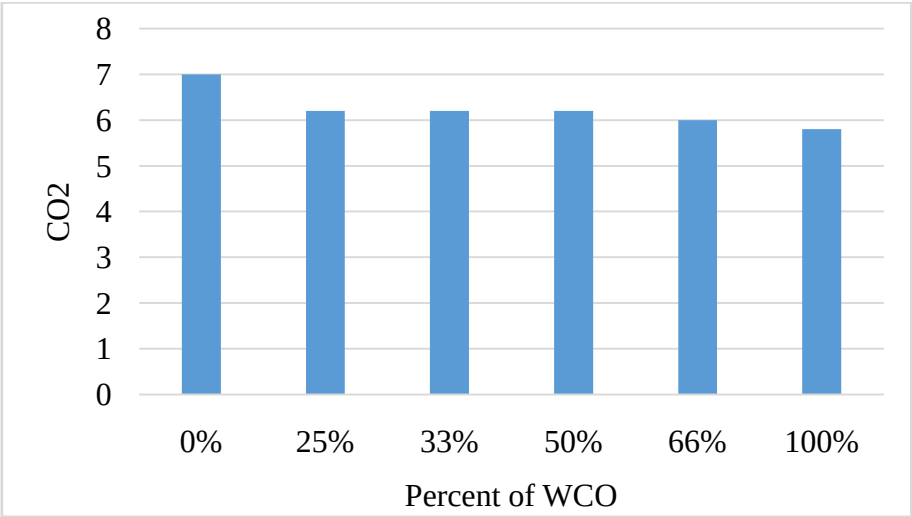

Figure 6CO2 level in the exhaust of two strokes engine operated with different lubricant containing different percent of WCO

VI. CONCLUSIONS

- Different blends of waste cooking oil mixed with semi—synthetic oil was prepared as lubricant and the viscosity of the blends were measure. The results showed that the waste cooking oil dropped the viscosity of the lubricant in general.
- It can be concluding that the addition of the waste cooling oil in the semi-synthetic oil produces very promising results in term of the emissions level. There is great drop in the CO and NOx level when fully waste cooking oil used compared to the fully semi-synthetic oi.
- The power of the engine was not affected by the change of the lubricant types

There are a lot of works need to be done to get better understanding on how the waste cooking oil can be used in the two stokes engine. This can include the followings

- Effect of the WCO on the engine performance in term of power, torque, brake power …etc.
- How the new lubricant effect the engine component since there is some water seen in the exhaust which may corrode the component or block some of the valves.

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