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Effects of Organic and Pyrolysis Fuel on Ignition and Combustion Process

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ABSTRACT

The worries about the limitation of fossil fuel and the advantages of alternative fuel has been raised all through the previous year. This research investigates the effects of organic and pyrolysis fuel on ignition and combustion process. Rapid compression machine (RCM) was used to simulate the engine combustion phenomenon in order to study its physical and chemical behaviour at specific fuel injection pressures and ambient temperatures. There are two types of fuel were used which is organic biodiesel derived from organic resources and pyrolysis fuel derived from Tyre Pyrolysis fuel (TPO). There are few samples of organic fuel prepared for this experiment which is Crude Palm Oil (CPO), Waste Cooking Oil (WCO), Jatropha (JO) and Algae (A) that injected directly into the combustion chamber. In this research, CPO 10 composed of 10% of crude palm oil and 90% of biodiesel were injected directly into the combustion chamber. Fuel injection pressure is varied between 90 MPa and 130 MPa under variant ambient temperature of 750 K, 850 K 950 K. The results show that higher fuel injection pressure, shorter ignition delay and more obviously for CPO compared than TPO and organic biodiesel. In addition, increased ambient temperature, the ignition delay became shorter as all the fuels tested shows a similar trend.

Keywords: Organic biodiesel, pyrolysis fuel, combustion process, alternative fuel

1. INTRODUCTION

The worries about the limitation of fossil fuel and the advantages of alternative fuel has been raised all through the previous year. Analyst around the world have been finding the best approach to fathom this disturbing issue and thus, elective fuel are recommended to be the substitute fuel [1-5]. Anyway, to change over any substance into an oil that can be utilized in an engine is confounded. The implementation of alternative fuel must not damage the commonrail system and combustion chamber. Generally, biodiesel has a higher density, consistency, cloud point, octane number and a lower capricious and heating value contrasted with commercial evaluations of diesel fuel. Biodiesel can be utilized perfect or mixed in existing diesel engine without huge adjustment of the engine.

In 2005, Malaysia and Indonesia produced nearly 80% of 35 million tonnes total world production of palm oil, this had created an attention toward to specific palm oil biodiesel (POB) [6-10]. Waste to energy is the recent trend in the selection of alternate fuels. Bio-fuels like alcohol, biodiesel, liquid fuel from used tyres or plastics are some of the alternative fuels can be used for internal combustion engines. In order to prevent any waste rubber or plastics from damaging and polluting the environment, it is highly desirable to recycle this material in a useful manner and

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turns them into alternative fuels [11-12]. At initial, diesel engine to be powered by the pyrolysis fuel such as coal dust as fuel and some other organic fuels such as vegetable oil which is peanut oil [13-15]. For example, peanut oil was used to power the engine, then continues with the common, biomass, animal fat, biogas, coal liquefaction and natural gas [16-18]. In addition, diesel fossil fuel is still being used till now although many countries started to use another alternative fuel after developing worry of the earth and the impact of ozone harming substances likewise had accumulated an ever-increasing number of interests in the utilization of vegetable oils as a substitute of oil fuel [19-22].

This research investigates the effects of organic and pyrolysis fuel on ignition and combustion process. Rapid compression machine (RCM) was used to simulate the engine combustion phenomenon in order to study its physical and chemical behaviour at specific fuel injection pressures and ambient temperatures. There are two types of fuel were used which is organic biodiesel such as Crude Palm Oil (CPO), Waste Cooking Oil (WCO) and pyrolysis fuel derived from Tyre Pyrolysis fuel (TPO). There are few samples prepared for this experiment which is Crude Palm Oil (CPO), Waste Cooking Oil (WCO), Jatropha (JO), Algae (A) and Tyre Pyrolysis fuel (TPO) that injected directly into the combustion chamber. In this research, CPO 10 composed of 10% of crude palm oil and 90% of biodiesel were injected directly into the combustion chamber. Fuel injection pressure is varied between 90 MPa and 130 MPa under variant ambient temperature of 750 K, 850 K 950 K.

2. FUEL PREPARATION

2.1 Fuel

There are two biodiesel standards mostly used in Malaysia, the European Biodiesel Standard (EN 14214) and the B100 Blend Stock for Distillate Fuels (ASTM D6751) Standard Specification for Biodiesel Fuel. The standard implication was to let the researcher who would like to study biodiesel know the standard of the fuel to be used and the content of the blended diesel fuel in this standard [21-24]. The conversion of biodiesel undergoes a series of base catalysed transesterification under transesterification process. Properties of organic biodiesel CPO, WCO, JO and Pyrolysis fuel TPO are listed in Table 1. The density of pyrolysis fuel TPO are higher compared to organic biodiesel.

Table 1 Properties of Organic and Pyrolysis Fuel Specification

Property	**Palm Oil**	**Waste Cooking Oil**	**Jatropha Oil**	**Diesel**	**Tyre Pyrolysis Fuel**
Viscosity (mm/s)	4.91	5.3	5.25	2.91	16.39
Density (g/m^3)	878	897	940	839.0	956.3
Flash point (°C)	17.9	19.6	16.6	71.5	50.0
Cloud point (°C)	14	-	-6	-	-
Pour point (°C)	5	-11	-	-	-3.00

Figure 1 shows the mixing machine and Figure 2 shows the blending machine that used to mix the standard diesel fuel and biodiesel. The mixing machine is to mix together bio powers with mineral diesel to deliver distinctive evaluation of biodiesel fuel. There are two types of fuel were used which is organic biodiesel derived from organic resources and pyrolysis fuel derived from Tyre Pyrolysis fuel (TPO). There are few samples of organic fuel prepared for this experiment which is Crude Palm Oil (CPO), Waste Cooking Oil (WCO), Jatropha (JO) and Algae (A). The blending ratio which the fuel required is CPO 10&15, WCO 10&15, JO 10&15 and TPO 10&15. Least time taken for the mixing procedure ought to be roughly 1 hour and the mixing machine can mix up to 5 litres of fuel at some random time. The way toward mixing is in basic way. Water is added to the holder and the compartment is warmed up to 90°C. The blending of biodiesel and diesel was mixed at 270 rpm speed inside a warmed compartment persistently to deliver an ideal blend. Following an hours of mixing process, the fuel should be chilled off around 30 minutes before fit to be tested.

Figure 1. The blending machine.

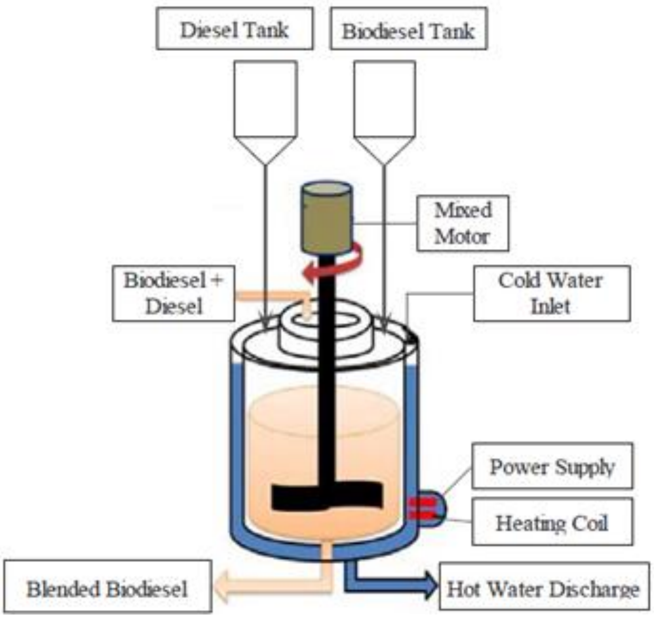

Figure 2. The schematic diagram of blending machine.

2.2 Rapid Compression Machine

Figure 3 and Figure 4 show the schematic diagram and the exploratory arrangement for the rapid compression machine (RCM). Prior to beginning the heating system and gathering the entire part, the combustion chamber and liner were cleaned by liquor. At that point, the injector and cylinder piston were amassed. A free-piston type rapid compression machine (RCM) was used to simulate diesel combustion in a constant volume. Gas pressure inside the combustion chamber was measured by a piezoelectric pressure transducer (Kistler, 601A).

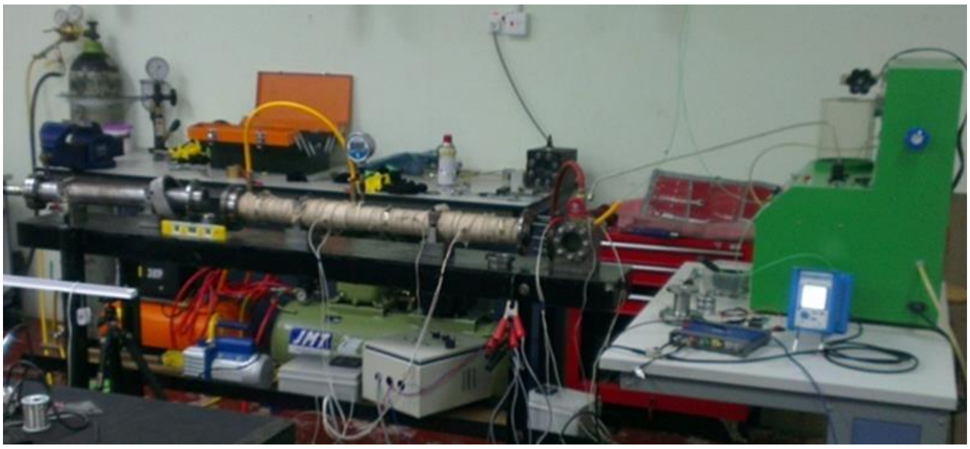

Figure 3. Experiment setup of RCM.

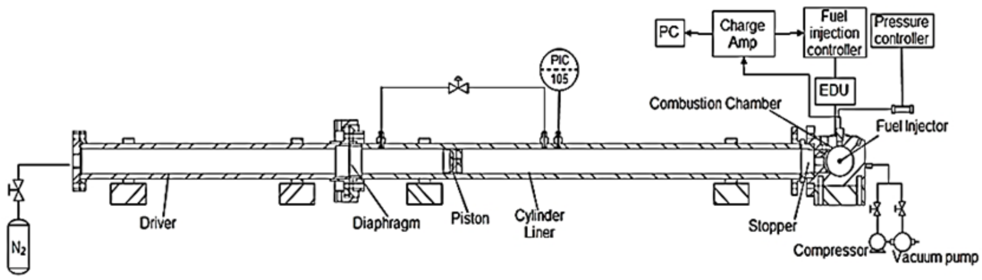

Figure 4. Schematic diagram of experiment setup.

Table 2 shows the parameter of the ambient temperature and the variable of the injection pressure and the percentage of the biodiesel blended that used in this experiment. Fuel injection pressure is varied between 90 MPa and 130 MPa under variant ambient temperature of 750 K, 850 K 950 K.

Table 2 Experiment Specification

No	Parameter	
1	Fuel	CPO10, CPO15, WCO10, WCO15, JO10, JO15 and TPO10, TPO15
2	Fuel injection pressure P_{inj} **[MPa]**	90 MPa and 130 MPa
3	Temperature $\mathbf{T_i}$, **[K]**	750, 850, and 950

3. RESULTS AND DISCUSSION

3.1 Effect of Organic and Pyrolysis fuel under Variant Fuel Injection Pressure

In this section, the effects of the organic biodiesel, Standard diesel (EURO 5) and pyrolysis fuel on ignition and combustion process were investigated in detail. Fuel injection pressure was varied between 90 MPa and 130 MPa together with ambient temperature was held at 950K. Figure 5 shows the effect of organic and pyrolysis fuel on combustion process and ignition delay. This graph highlights several fuel such as Crude Palm Oil (CPO), Waste Cooking Oil (WCO), Jatropha (JO), Algae (A), Standard Commercial diesel (EURO 5) and Tyre Pyrolysis fuel (TPO). It seems that the peak pressure contributes from J10 and EURO 5 for both condition of injection pressure compared than CPO10 influences the lowest pressure.

Figure 6 illustrates the effects of variant fuel injection pressure on ignition delay of combustion. The figure compares the ignition delay between the pyrolysis fuel and organic biodiesel. Based on the graph it shows that at 90 MPa, the shortest ignition delay was TPO10 and TPO15 which is 0.78 ms and 0.81 ms compared to CPO10 and CPO15 which is at 0.88 ms and 0.87 ms and 0.97 ms for the organic. For the JO10 and JO15, the ignition delay was 1 ms and 1.2 ms while for the WCO10, WCO15 and A2 the ignition delay was 1.5 ms, 1.4 ms and 1.2 ms respectively.

As the increasing the pressure at 130 MPa, the ignition delay become slightly longer for CPO10 and CPO15 which is 0.92 ms, 0.89 ms while for TPO10, TPO15 and organic biodiesel, the ignition delay was slightly increasing at 0.98 ms, 1.07 ms and 1.1 ms. In addition, increased pressure will have resulted in shortening the ignition delay.

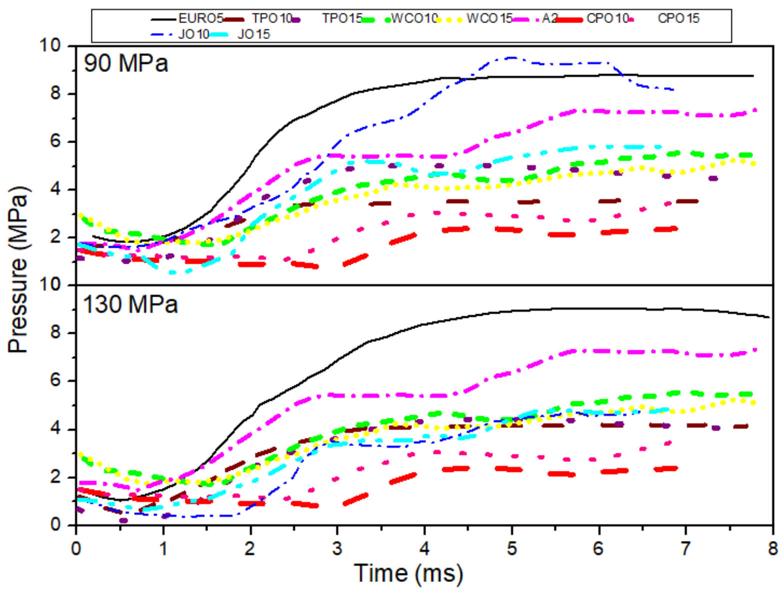

Figure 5. Effect of organic and pyrolysis fuel on variant pressure for ignition delay.

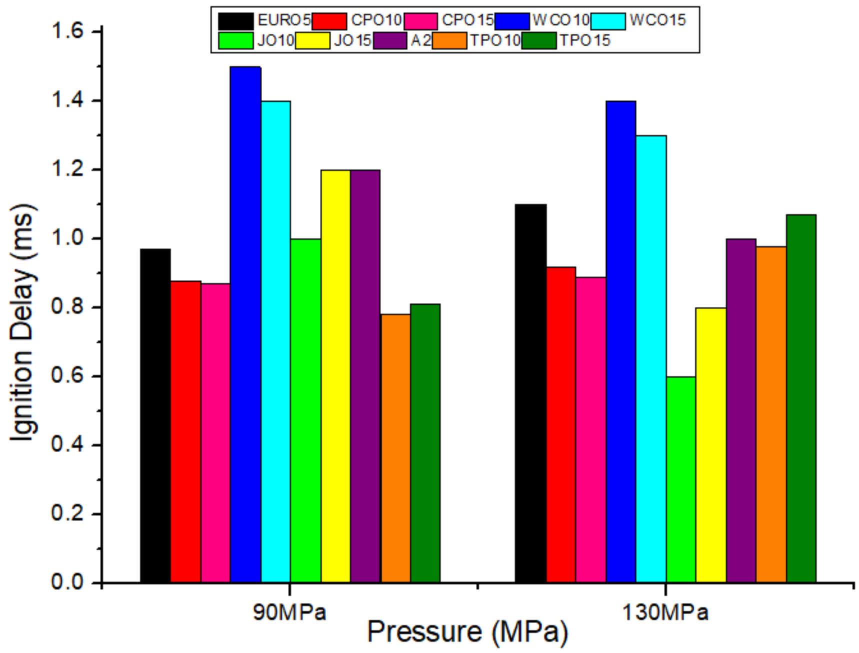

Figure 6. Effect of fuel injection pressure on ignition delay of diesel combustion.

3.2 Effects of Organic and Pyrolysis Fuel under Variant Ambient Temperature

Next, the effect of organic and pyrolysis fuel was discussed based on variant ambient temperature. Figure 7 shows effect of ignition delay at variant ambient temperature. Based on the Figure 7, all the fuel was tested at different temperature. At 750K, the longest ignition delay was WCO10 and WCO15 which is 2.1ms and 2ms. Next, for JO10, JO15 and A2 the ignition delay was 0.9ms, and 1.1ms. For TPO10 and TPO15, the ignition delay was both 1.1ms while for CPO10 and CPO15, the ignition delay is 1.01ms and 0.97ms and Organic(biodiesel) was 1.07ms respectively.

Figure 8 depicts the effect of organic, pyrolysis fuel and variant ambient temperature on combustion pressure and ignition delay. Based on Figure 8, it seems different peak pressure for both organic and pyrolysis fuel at variant temperature. At 750K and 950K, the highest peak pressure is pyrolysis fuel which is Organic and the lowest are CPO15 and CPO10 which is organic fuel at temperature 750K and 950K. For temperature 850K, the peak pressure was change that the highest are Algae fuel (A2) while the lowest are CPO15 and both of fuel are organic fuel.

At 850K the ignition delay was showed reduced for organic fuel such as CPO10 and CPO15, ignition delay was 0.99ms and 0.96ms. It followed for the WCO10, WCO15 and A2 that the ignition delay reduced at 1.6ms,1.5ms and 1ms. For JO10 and JO15 the ignition delay also reduced at 0.7ms and 0.9ms. for the TPO10, TPO15 and Organic, the ignition delay was slightly increased at 1.26ms,1.17 ms and 1.2 ms respectively.

Furthermore, the fuel was tested at 950K that showed that the shorten of ignition delay. For CPO10 and CPO15, the ignition delay was reduced to 0.92 ms and 0.89 ms followed by WCO10 and WCO15. On the other hand, A2 shows the ignition delay is 1.4 ms, 1.3 ms and 0.8 ms. The trend continued followed for JO10 and JO15 that ignition delay was 0.6ms and 0.8 ms. Lastly, for TPO10, TPO15 and Organic, the ignition delay also reduced which is 1.1 ms, 0.9 ms and 1.1 ms respectively.

Figure 8 also depicts that the ambient temperature increased, the ignition delay decreased, CPO10 the ignition delay reduces from 1.01 ms to 0.99 ms and 0.92 ms. CPO15 also experienced the same which reduced from 0.97ms to 0.96ms and lastly to 0.89ms. In addition, all the organic basis fuel was influenced the reducing the ignition delay as the increasing the temperature with the different of 0.1ms to 0.2ms. Furthermore, increasing the temperature, reducing the ignition delay due to decrease the bond dissociation energy at higher temperature and this enhance better fuel atomization and air-fuel mixing process.

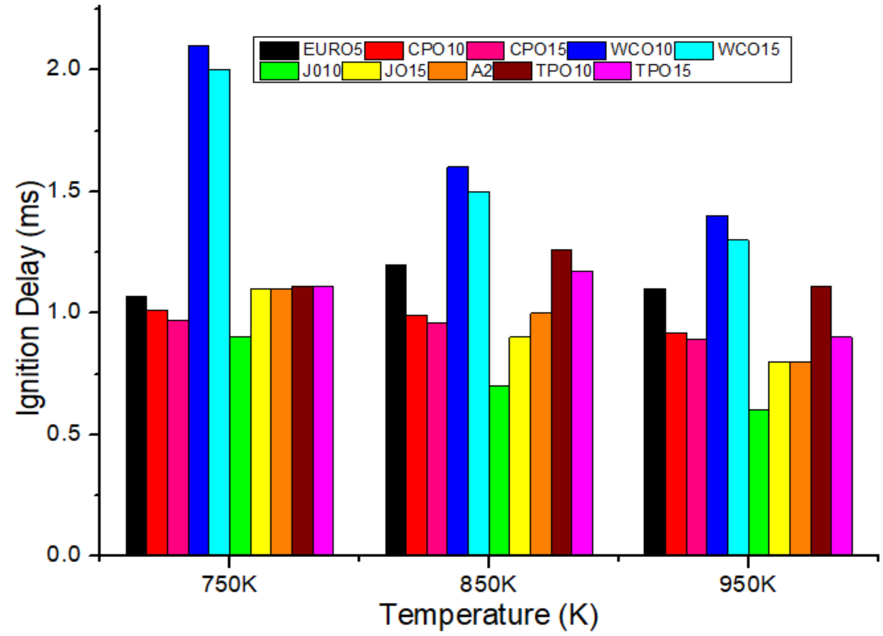

Figure 7. Effect of ignition delay under variant ambient temperature.

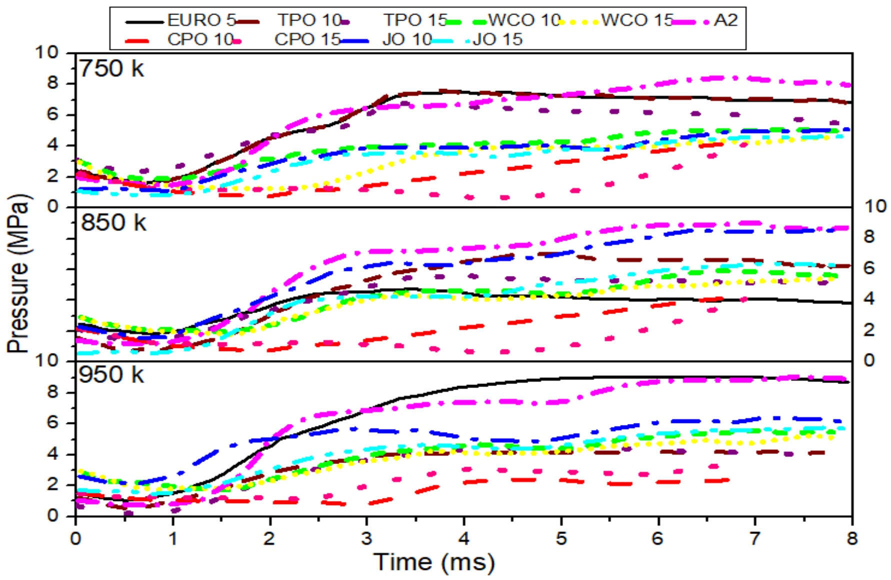

Figure 8. Effect of organic, pyrolysis fuel and variant ambient temperature on combustion pressure and ignition delay.

4. CONCLUSION

The effects of organic and pyrolysis fuel on ignition and combustion process had been discussed. There are two types of fuel were used which is organic biodiesel derived from organic resources and pyrolysis fuel derived from Tyre Pyrolysis fuel (TPO). There are few samples of organic fuel prepared for this experiment which is Crude Palm Oil (CPO), Waste Cooking Oil (WCO), Jatropha (JO) and Algae (A) that injected directly into the combustion chamber. While expanding blended ratio of fuels, the ignition delay likewise expanded, it been recorded for TPO fuel that at 90 MPa the delay was 0.78 ms for TPO10 and 0.8 ms for TPO15 for the pyrolysis fuel and for the organic fuel, this example happened to JO that at 130 MPa JO10 accomplish 0.6ms and JO15 accomplish 0.8 ms for the delay. This pattern not followed by other biodiesel fuel such CPO that at 130 MPa CPO10 has accomplish 0.92 ms and diminished to 0.89 ms for CPO15. This behaviour may contribute from the CPO has low consistency properties that permit great fuel atomization. The air-fuel mix improvement completely mixed especially during ignition delay period. In addition, the fuel properties have great influences to improve fuel vaporization and extended fuel reactivity, subsequently reflects to mixture formation, ignition proses and heat release. Next, the impact of delay dependent on the variation ambient temperature. In view of the outcome, it shows the expanding the temperature, the ignition delay was abbreviated. As expanded the temperature help improving the air-fuel blend development that added to better premixed burning that came about abbreviated of ignition delay.

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