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RESEARCH & KNOWLEDGE

Research Article

Development of Measuring Technique of Start Combustion using Ion Current Measurement in a Controlled Reactivity Engine

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Abstract: This project aims to develop a technique for measuring the start of the combustion. The principle of ion current measurement is used in the controlled reactivity engine combustion. The engine used in the test is 4-stroke diesel engine (Mitsuki Brand Model 186F). The displacement volume is 406 cc. Test fuel is diesel mixed with gasohol E85 at different ratio. The start of fuel injection can be measured by needle lift sensor, and the start of combustion can be measured by ion current sensor. Then, signals of the start of fuel injection and the start of combustion are used to find the ignition delay. The engine is performed at a constant engine speed of 1,500 RPM with various engine loads of 25%, 50% and 75%. The results showed that the maximum load of the engine is obtained in case of the conventional diesel. The start of injection of blended fuels of E85 shows insignificant difference compared to diesel. The increase of blend increases the ignition delay.

Keywords: Ion Current; Start of Combustion and Controlled Reactivity Engine.

1. Introduction

In the compression ignition engine (CI), the combustion position results in engine efficiency and exhaust pollution. The start of combustion is an important parameter to adjust pump and injector, when the new fuel replacing diesel or alternative fuels are introduced. For dual fuel engines using both natural gas and diesel, the mixing ratio between natural gas and diesel fuel (Z) is varied from70% to 92%. The heat release rate was analyzed. This research work differentiates between abnormal and normal combustion. If the mixture ratio increases, the engine cannot control the start of combustion. In addition, experiments were carried out on this engine by varying diesel injection timing of 20, 30, and 45 before top dead center (BTDC) when the amount of natural gas in fuel (Z%) is more than 88%. The near knocking combustion occurs at injection timing of 20 BTDC and knocking combustion occurs at injection timing of 30 and 45 BTDC (Nuntapap, et al., 2013).

To measure the injection timing, needle lift sensor can be used. (Kato et al., 2005) showed that needle lift and the start of injection can be measured by using hall effect sensors and Neodymium magnetic. For measuring the start of combustion, it was done by using a dynamic pressure transducer. It was installed at the cylinder head to measure in-cylinder pressure of combustion. Then the start of combustion can be estimated by heat rate release rate that is greater than 5J/CA (Mehresha, and Soudera, 2010). Beside dynamic pressure, the measurement of ion current can be used as a tool to detect the ignition, especially in gasoline engine to prevent advanced ignition. The principle of ionization of the mixture is that burns in the combustion chamber generated the ion when start of combustion occurred. The ion sensor can be used instead of dynamic pressure sensors that are commonly used in current engine research. The ion sensor can display the signal as a cycle to the cycle. It can predict the start of combustion (Mehresha, and Soudera, 2010; Rao and Honnery, 2017; Rolf and Reitz, 2010; Saeed and Henein, 2001). However, there is a gaps in the practical use of ion sensors for the engine research, especially in the controlled reactivity engine.

From the reasons mentioned above, the objective of this work is to develop the measuring technique of start combustion using ion current measurement in a controlled reactivity engine. Then, the start of injection, ignition delay and start of combustion are studied.

2. Methodology

Fig. 1 show comparison of start of combustion between (a) cylinder pressure measure from a dynamic pressure

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transducer, (b) heat rate release rate calculated from dynamic pressure transducer can be estimated by Eq.1

$$\frac{dQ}{d\theta} = \frac{\gamma}{\gamma - 1} P \frac{dV}{d\theta} + \frac{1}{\gamma - 1} V \frac{dP}{d\theta} \qquad (1)$$

Where

Q Total released heat (J)

θ Instantaneous crank angle $(Degree)$

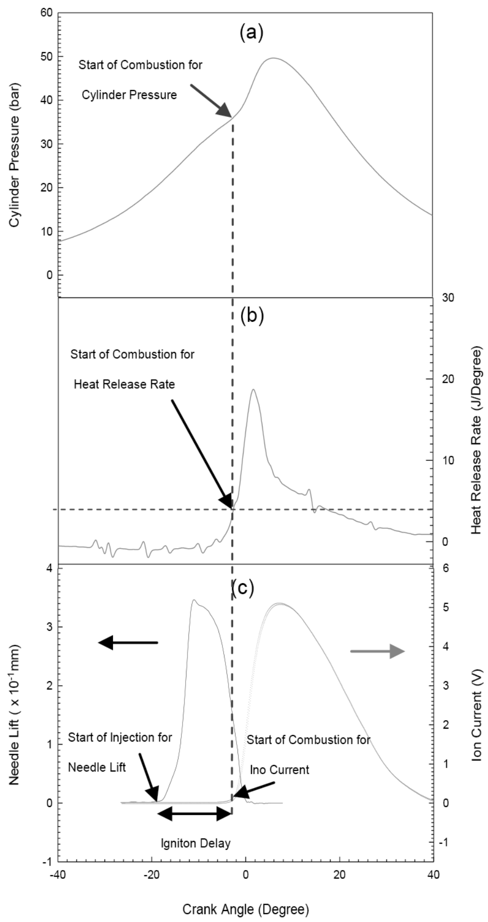

Fig. 1 Comparison of start of combustion between (a) Cylinder pressure (b) Heat Release Rate (c) Needle Lift and Ion Current with crank angle

γ Ratio of specific heat $\left(\frac{C_p}{C_v}\right)$

P Measured cylinder pressure (Pa)

V Cylinder volume (m^3)

The start of combustion is defined from heat rate release rate if the heat release rate is greater than 5J/CA (Nuntapap, et al., 2013) as shown in Fig. 1 (c). The ignition delay defines as time from the start of injection to the start of combustion. The area of injection amount can be estimated by Eq.2

$$A_f = \int_{\theta_0}^{\theta_1} L_{avg} d\theta \qquad (2)$$

Where

A_f Area of Injection Amount (mm.CA)

θ Instantaneous crank angle $(Degree)$

L_{avg} Average distance of needle lift (mm)

2.1 Experimental Setup

The principle of measurement ionization of the mixture that burns in the combustion chamber using the spark plug install in the cylinder head shows in Fig. 2

The experiments were carried out on a 1-stroke CI engine connected to a dynamometer that provided the engine loads. The torque of the dynamometer calculated from force measured by a load cell. The measuring instruments install ion current, cylinder pressure, and needle lift shown in Fig. 3

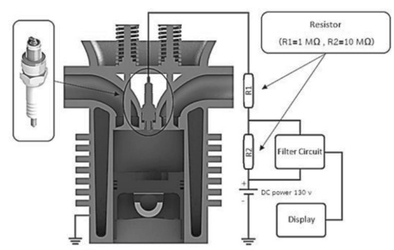

Fig. 2 System of measuring instruments start of combustion using ion current.

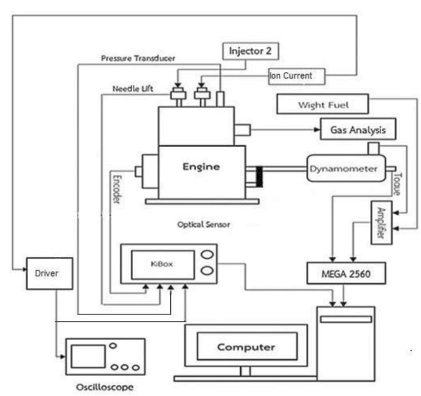

Fig. 3 Schematic diagram of the measuring technique of start combustion using ion current measurement in a controlled reactivity engine.

2.2 Experimental Condition

Table 1. shows the lower heating value of gasohol (E85) and diesel.

Table 1. Shows the properties of test fuels

Fuel	**Lower Heating Value (MJ/kg)**
Gasohol (E85)	33.13
Diesel	43.45

The blend ratio between diesel and E85 is varied from diesel 100%, Diesel 95% (DE95), and 90% (DE90) by mass.

3. Results and Discussions

The needle lift signals are used to observe the start of injection. The results showed that the needle lift signals are similar for all fuels. But increase of the ratio of E85 prolongs ignition delay, because the higher heat of vaporization and lower Cetane number occurs in case of blended fuels for engine load of 25% and 50% as shown in Fig.4 and Fig. 5, respectively. So, the start of combustion of blended fuels occurred near TDC. End of combustion is also longer, especially DE 90.

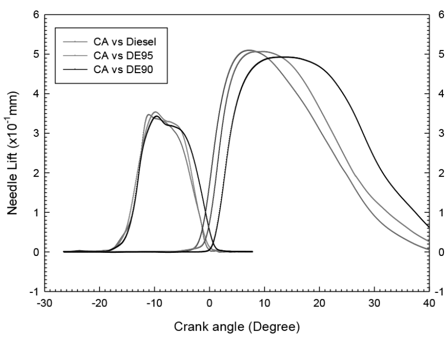

Fig. 4 Comparison between Diesel, DE95, and DE90 under normal combustion process: Variation of Needle Lift; Ion current with crank angle N=1500 rpm; at 25% load engine

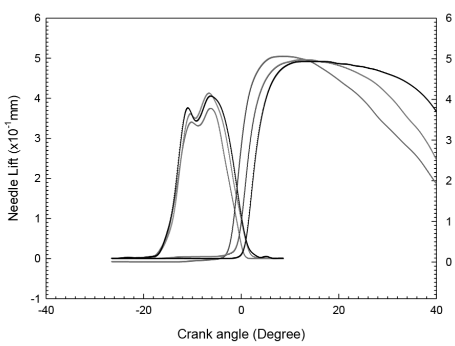

Fig. 5 Comparison between Diesel, DE95 and DE90 under normal combustion process: Variation of Needle Lift; Ion current with crank angle N=1500 rpm; at 50% load engine

At 75% of the load engine, the area of injection amount of DE90 is higher than diesel due to the same energy requires more fuel, resulting in more space than diesel include the start of combustion after diesel because of DE90 certain number more than lower diesel result ignition delay is longer show in Fig. 6

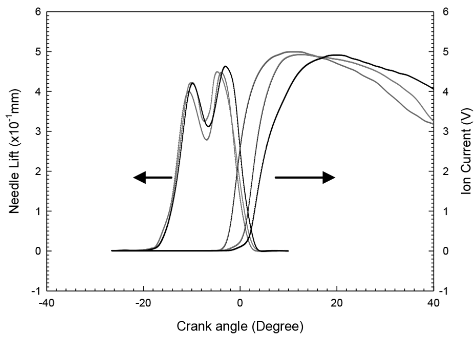

Fig. 6 Comparison between Diesel, DE95 and DE90 under normal combustion process: Variation of Needle Lift; Ion current with crank angle N=1500 rpm; at 75% load engine

Diesel thermal efficiency is higher than DE95 and DE90 due to the low heat of diesel higher than gasohol E85. When increasing the E85 gasohol into the blend fuel engine, the combustion efficiency is low. When increases load from 25% to 75% load found thermal efficiency increases all condition due to injection amount increases resulting in better combustion and higher combustion temperatures shows in Fig.7

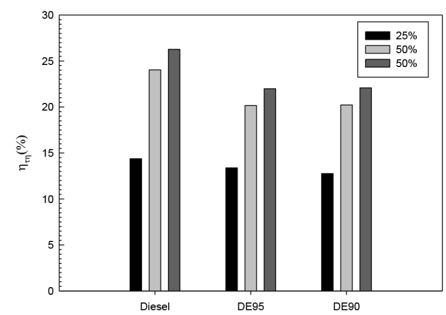

Fig. 7 Comparison between Diesel, DE95 and DE90 Thermal efficiency Variation N=1500 rpm; at25% to 75% load

From Fig.8, it is found that if increase 25% to 75% load start of combustion increase when increasing gasohol E85 from Diesel to DE90 start of combustion reduces are nearly before top date center (BTDC)

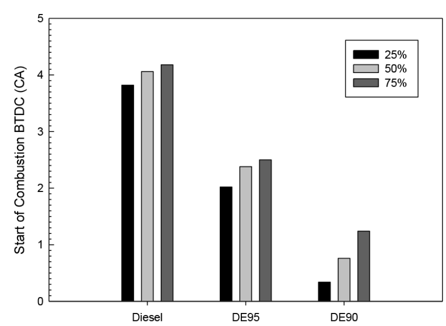

Fig. 8 Comparison between Diesel, DE95 and DE90 start of combustion Variation of Needle Lift N=1500 rpm; at25% to 75% load

The mixture ratio that affects ignition delay regular fuel injection by using blend fuel between diesel and gasohol E85. From the experiment, it was found that for D100, DE95 and DE90, it was found that the ignition delay increased according to the increase in the gasohol E85. Also found that when increasing the loaded fuel injection increasing found that the ignition delay was slightly decreased because when the load increases, the temperature in the combustion chamber and the wall of the combustion chamber increases, resulting in faster burning shows in Fig.9.

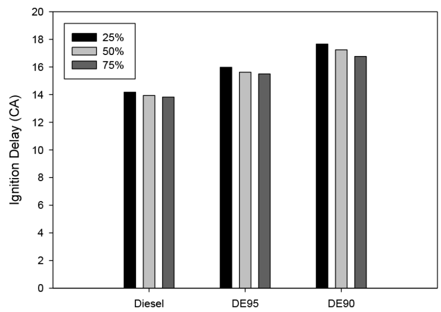

Fig. 9 Comparison between Diesel, DE95 and DE90 ignition delay variation N=1500 rpm; at25% to 75% load

The result of the injection when E85 is increased in the blend ratio shows that the fuel injection increases with increase of E85. The low heating value (LHV) of gasohol less than diesel when it increases gasohol E85 resulting in low heating value (LHV) of the fuel must be reduced, thereby increasing the fuel injection shows in Fig.10

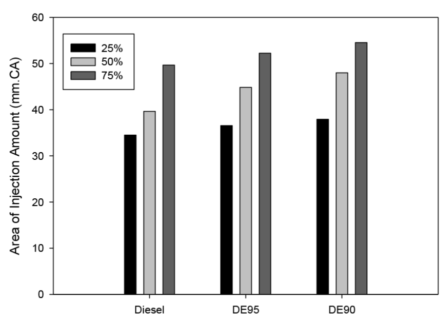

Fig. 10 Comparison between Diesel, DE95 and DE90 area injection amonut N=1500 rpm; at25% to 75% load

4. Conclusion

This study shows that the measuring technique of start combustion using ion current measurement can detect the start of combustion in the controlled reactivity engine. Blended fuels of diesel and gasohol E85 are tested in the engine to prove the ability of this technique. The conclusions are as follows:

Start of combustion is near (TDC) when the ratio of E85 is increased.

Increase of the ratio of E85 also shows low thermal efficiency, longer end of injection, longer ignition delay and increasing injection area of injector.

Increasing load shows high thermal efficiency and short injection delay for the controlled reactivity engine.

5. References

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