

The Effect of Equivalent Ratio on the Performances and Emissions of Diesel Engine

Thibordin Sangsawang¹, Supachai Wasananon and Aminan Amornpattarakiat

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Abstract

The research studies about the effect of equivalent ratio on the performances and emissions of diesel engine. The engine is the 2L-II Toyota diesel engine, which is tested by using diesel and biodiesel fuel (B10). An engine is tested at 2,400, 3,000, 3,500, 4,000 and 4,200 rpm respectively. The study presents that engine power of diesel and biodiesel fuel increased with increase in equivalent ratio. The lowest brake specific fuel consumption and the highest fuel conversion efficiency occur at equivalent ratio close to unity. For measuring an exhaust gas, the highest nitrogen oxide occurs at equivalent ratio close to unity. The hydrocarbon and carbon monoxide is higher with increase of equivalent ratio.

Keywords: Equivalent ratio, Performances, Emissions, Biodiesel, Diesel

Introduction

The transportation vehicles are powered by diesel engines have increased and likely to increase several fold in the next decade. This situation generates the increase of the carbon monoxide and carbon dioxide and releases to the atmosphere. It is cause of the Green House Gases and leads to the critical issue of climate change.

From the highly demand fossil fuel, while the resources of the fuel are decreasing, so the biodiesel fuel is used as an alternative fuel in diesel engines. Many researchers¹⁻⁵ studied the optimal blending ratio between the diesel and biodiesel, and reviewed effect on engine performance and emissions. *Altun et al.*² used sesame oil (B50) in IDI engine. The experimental results showed that the power and torque of the sesame oil–diesel fuel were closed to the values obtained from diesel fuel and the amounts of exhaust emissions were lower than those of diesel fuel. Similarly, various oils such as Karanja vegetable oil³, Marula oil⁴, Cottonseed oil, Soybean oil and Sunflower oil⁵. In addition, the studies of the effect of different parameters such as compression ratio, injection timing, injection pressure that affected on engine performance and emissions as well. *Sayin and Gumus*⁶ found that compression ratio, injection timing and injection

pressure significantly effected on the engine performance and exhaust emissions of a DI engine using biodiesel-blended diesel fuels. *Raheman and Ghadge*⁷ found that the differences of BTEs between diesel and mahua oil were also not statistically significant at engine settings. *Sangsawang et al.*⁸ suggested that 10% of crude palm oil in diesel was the best for a small, single cylinder diesel engine by the performances and emissions.

One of the engine parameters that effect to the performance and emissions is equivalent ratio. This parameter can be defined as “the ratio of the actual fuel-to-air ratio to the stoichiometric fuel-to-air ratio”.

In this studied, the effect of equivalent ratio on the performances and emissions of diesel engine using diesel and biodiesel fuel (B10) are examined.

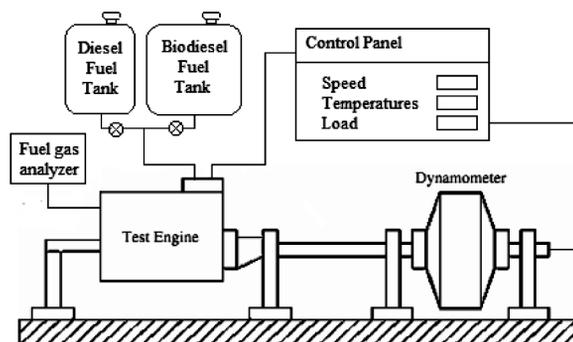
Experimental apparatus and procedure

The experiments were performed on a Toyota Hilux Mighty-X (2L-II), four cylinder, four-stroke, water-cooled, direct injection diesel engine. The basic specifications of the engine are given in table 1. It is equipped with a water brake dynamometer STUSKA XS-111 to investigate the engine power. The schematic of the experimental apparatus is shown in figure. 1.

¹ Department of Mechanical Engineering, Faculty of Engineering and Industrial Technology, Silpakorn University (Sanam Chandra Palace), Nakhon Phathom 73000, Thailand. Email: thibordin@su.ac.th.

Table 1 Technical specifications of the test engine.

Model of engine	Toyota Hilux Mighty-X (2L-II)
Type	OHC, 4 stroke, water-cooled, diesel engine
Cylinder number	4
Bore	92.2 mm
Stroke	92 mm
Displacement	2,446 cc
Compression ratio	22.2:1
Maximum power	61 kW at 4,200 rpm
Maximum torque	165 Nm at 2,400 rpm

**Figure1** The schematic diagram of the experimental setup

In the tests, diesel fuel and 10% of biodiesel fuel from used cooking oil (B10) were used. The engine was tested at full throttle condition and engine speeds of 2,400, 3,000, 3,500, 4,000, and 4,200 rpm respectively. The speed and load were recorded by digital indicator. A Testo 350 XL model gas analyzer with special probe was used to measure carbon monoxide (CO), hydrocarbon (C_xH_y) and nitrogen oxide (NO_x).

Results and discussion

After the engine reached the stabilized working condition for each test, engine power, brake specific fuel consumption, fuel conversion efficiency and exhaust gases emission were investigated on the engine using diesel and biodiesel fuel.

Engine power

From figure 2a and 2b shows that the engine power is increased with the higher of the equivalent ratio due to the greater of torque from the fuel consumption. Maximum engine power occurred at the equivalent ratio of 1.0 to 1.2 for both fuel and not significantly different can be found from the figure 2a and 2b Brake specific fuel consumption (BSFC)

Brake specific fuel consumption is the ratio of the fuel flow rate to engine power. From figure 3a and 3b in engine speeds of 2,400, 3,000 and 3,500 rpm, the BSFC is lower with the greater of equivalent ratio while decreased with the higher equivalent ratio at the engine speed of 4,000 and 4,200 rpm. The figure 3 shows that the best BSFC occur at equivalent ratio close to unity due to the stoichiometric combustion. The diesel and biodiesel mode present the slightly different BSFC.

Fuel conversion efficiency (η_f)

Fuel conversion efficiency is inversely proportional to BSFC. From figure 4a and 4b in engine speeds of 2,400, 3,000 and 3,500 rpm, the η_f decreased with the higher of equivalent ratio due to the BSFC increase cause of incomplete combustion. Therefore, η_f can be reduced while the BSFC increased in the engine speeds of 4,000 and 4,200 rpm. As mention above, the best η_f occurs at the equivalent ratio close to unity due to the stoichiometric combustion.

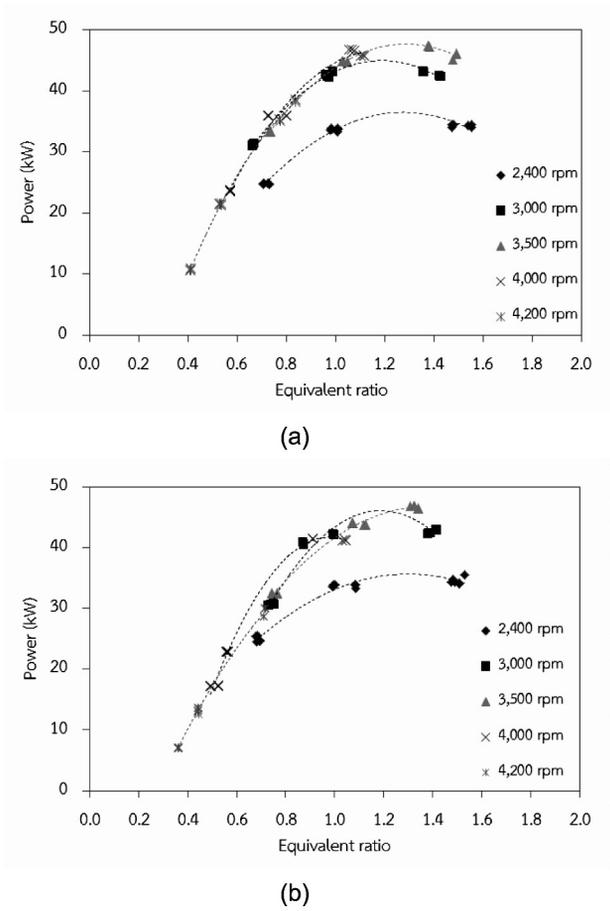


Figure 2 Engine power & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

Hydrocarbon emissions (C_xH_y)

The C_xH_y is increases with the rich fuel conditions which equivalent ratio is greater than unity due to the incomplete combustion as appeared in the figure 5a and 5b. The C_xH_y is not significantly difference between diesel and biodiesel.

Carbon monoxide emissions (CO)

CO would be generated from the incomplete combustion as C_xH_y. The amount of O₂ in the combustion chamber is deficiency to combust completely. The equivalent ratio is more than unity. As present in figure 6a and 6b, the CO is increase with the higher of equivalent

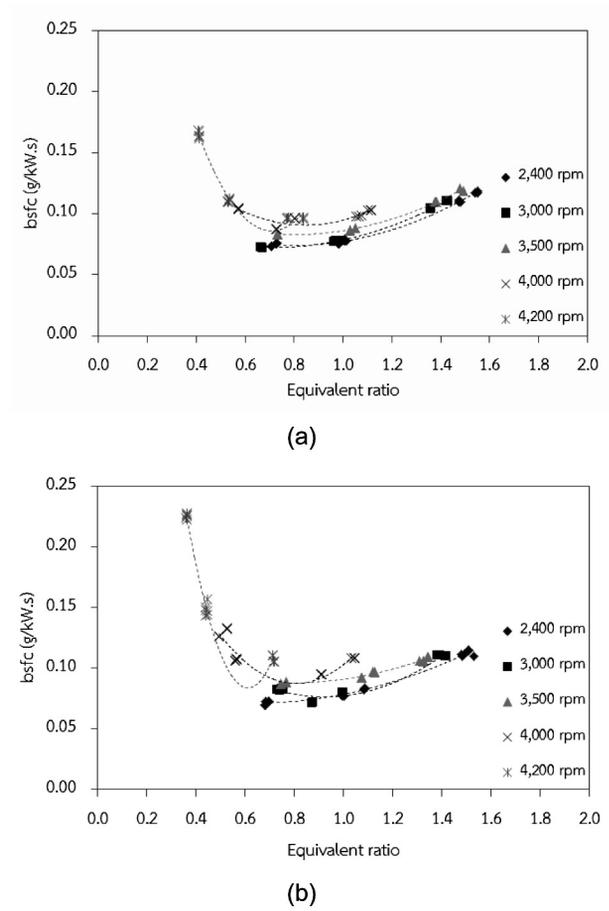


Figure 3 Brake specific fuel consumption & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

ratio as mentioned. The CO from biodiesel is less than that of diesel because of the oxygen in the composition of biodiesel and make the more complete combustion than those of diesel.

Nitrogen oxide emissions (NOx)

The high temperature and plenty of O₂ in the combustion process will generate NOx. The change in the NOx emissions is displayed in the figure 7a and 7b. The figure shows that the highest value of NOx is at equivalent ratio close to unity due to the maximum combustion efficiency. The NOx from the engine using diesel and biodiesel are not significantly difference on comparison.

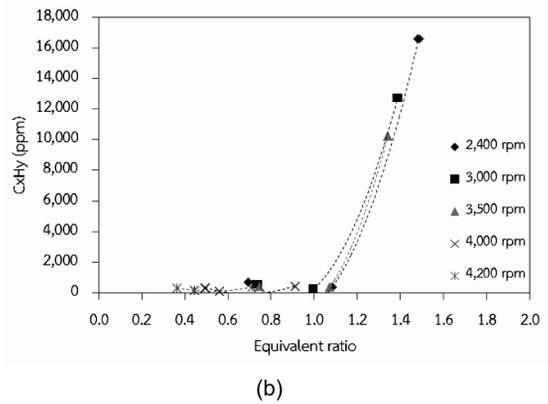
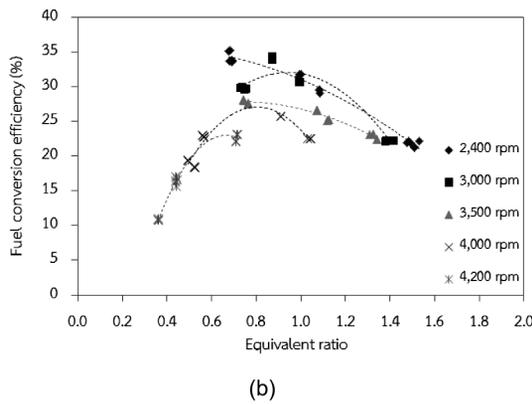
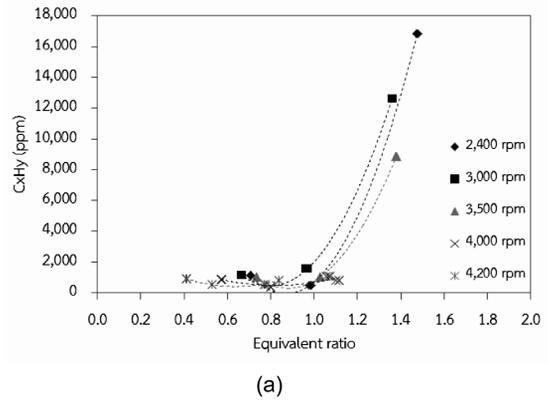
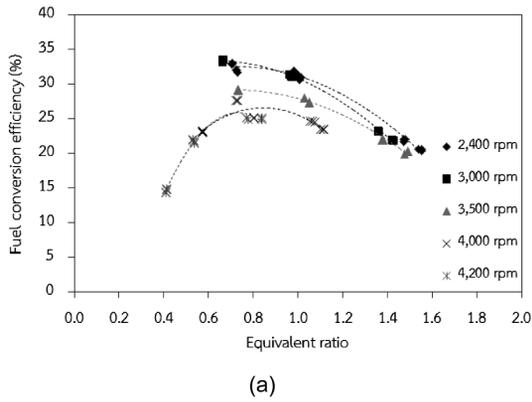


Figure 4 Fuel conversion efficiency & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

Figure 5 Hydrocarbon emissions & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

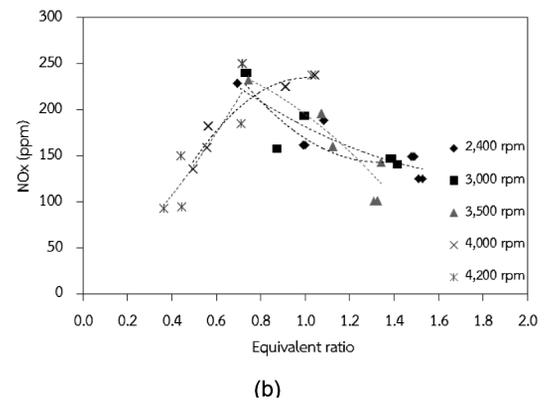
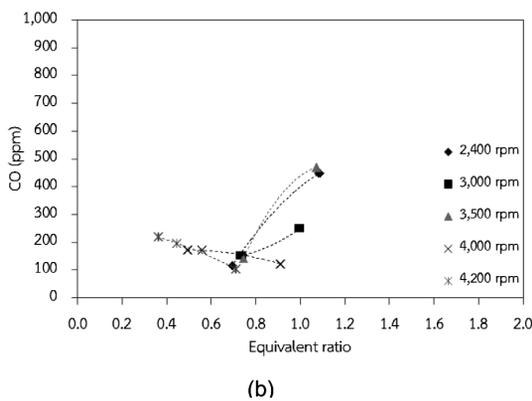
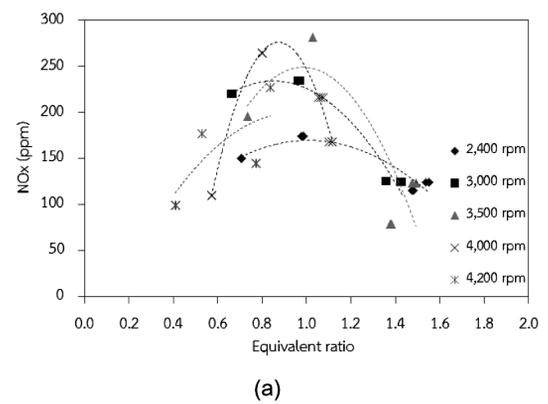
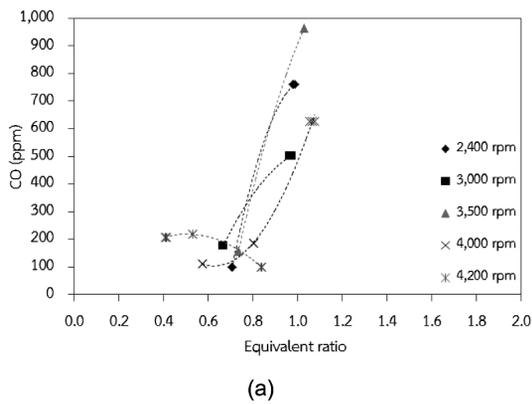


Figure 6 Carbon monoxide emissions & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

Figure 7 Nitrogen oxides emissions & equivalent ratio (a) Diesel fuel, (b) Biodiesel fuel

Conclusions

In this study, the effects of equivalent ratio on the engine performance and exhaust emissions of diesel engine using diesel and biodiesel fuel was experimentally investigated. Based on the results of this study, the conclusions can be drawn as follows:

1. The engine power that using diesel and biodiesel fuel are similar. The engine power increased with the increase in the equivalent ratio for the both fuels. The brake specific fuel consumption that using diesel and biodiesel fuel are lowest in the equivalent ratio close to unity. The brake specific fuel consumption that using diesel and biodiesel fuel are similar.

2. The fuel conversion efficiency that using diesel and biodiesel fuel will be highest in the equivalent ratio close to unity. The fuel conversion efficiency that using diesel and biodiesel fuel are slightly different.

3. The hydrocarbon emissions increased with the increase in the equivalent ratio. The C_xH_y emissions of diesel fuel are similar to biodiesel in range of the equivalent ratio more than unity and at high load.

4. The lowest carbon monoxide occurs at equivalent ratio close to unity. The CO emissions of diesel fuel are higher than biodiesel in range of the equivalent ratio more than unity and at high load.

5. The highest nitrogen oxide occurs at equivalent ratio close to unity. The NO_x emissions of diesel and biodiesel fuel are slightly different.

Acknowledgements

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