Experimental validation of single cylinder diesel engine using engine simulation tools

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ABSTRACT - This paper show the experiment validation of single cylinder diesel engine deals with performance used biodiesel as a fuel. The LES was used to validate the experiment. The biodiesel used in the experiment was the B5 biodiesel which was 5% palm biodiesel and 95% diesel fuel. The engine speed was varied from 1500 to 3500 rpm The data from the experiment was stimulate in the LES for validate with the experiment data. The density and calorific value of the B5 biodiesel fuel is tuned in the simulation. The performances (power and torque) were compared with the simulation result. The results showed that the data from experiment and simulation have minor percentage error but the pattern of the graph of torque and power were same.

1. INTRODUCTION

Biodiesel is the one of the alternative fuel that had been used for the heavy duty transportation and also passenger vehicle that used diesel engine [1]. The main purpose in producing the biodiesel is to reducing the emission that produce from the diesel engine [4].

Biodiesel fuel is the mixture of blended of the substances with the petroleum diesel as a previous study [3]. Qui et al. [5] and Nagi et al. [3] found that the substances can be from vegetable, palm and others. The palm oil biodiesel is the liquid palm oil and its blend with petroleum diese [3]. The palm biodiesel is classified based on the ratio of the palm oil. Foon et al. [2] stated that the B5 biodiesel means the percentage of the palm oil is 5% and other 95% is the petroleum diesel. Khalid et al. [6] stated the performance of the biodiesel is based on the density, viscosity, octane number, flash point, calorific value, acid value, and flash point. Two main standard in producing the biodiesel which are European Standard for Biodiesel (EN 14214) and the American Standard Specifications for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels (ASTM 6751) [2].

In this study, the biodiesel B5 was tested in a 4-stroke single cylinder diesel engine. The performance (torque and power) was evaluated and validate the data using the LES. Lotus Engine software is a simulation program that can predict the performance of the engine system [8].

2. METHODOLOGY

The purpose of this study is experimental validation, which involved the experimental and simulation. The main result obtained were the engine performance (torque and power) for B5 biodiesel fuel.

2.1 Experimental Procedures

The experiment used 4 stroke single cylinder vertical diesel engines coupled with the dynomite engine dynamometer as shown in Figure 1.

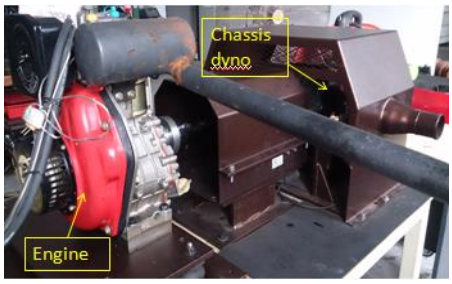

Figure 1 Single cylinder engine dynamometer

The engine specification is shown in table 1. The experiment run with B5 biodiesel under engine speed of 1500 to 3500 rpm. The result obtained was shown in term of the engine performance (power and torque) respectively.

Table 1 Specification of the engine [7]

Engine type	**Single cylinder vertical 4stroke, air cooled, direct injection**
Bore(mm)	70
Stroke(mm)	55
Compression ratio	19:1
Max Output(hp)	4.7
Max Fuel Capacity(l)	12.5

2.2 Simulation Procedure

The simulation used engine simulation tool to predict the engine behavior. The model of the engine was modeled in the simulation according the manufacturer engine specification. The properties of the B5 biodiesel was supplied to the simulation based on the density and calorific value shown in table 2. The

data from simulation was compared to the experiment for validation

Table 2 Properties of B5 biodiesel [2]

Density	Calorific value
0.8459 kg/l	44 MJ/kg

3. RESULTS AND DISCUSSION

The results for this experimental is shown in term of engine performance represented by torque and power against engine speed (rpm). Figure 2 shows torque (Nm) versus engine speed (rpm).

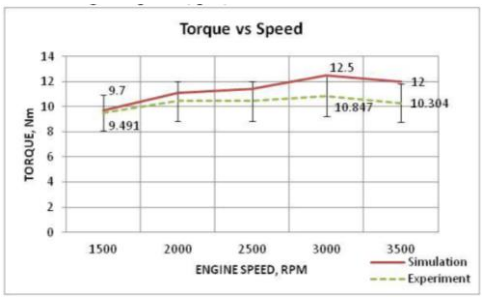

Figure 2 Engine torque (Nm) against speed

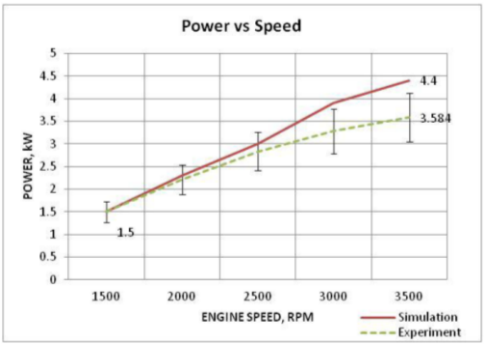

Figure 3 Power (kW) against engine speed

The engine speed was varied from 1500 rpm to 3500 rpm. The simulation data give the minimum value of torque from 9.7 Nm and the maximum value of 12.5 Nm at 3000 rpm. However, when compared to the experimental, the result shows that the minimum value of torque was 9.4 Nm and the maximum value was 10.8 Nm at 3000 rpm. All of the torque values from simulation fall within 15% error from the experimental values.

Figure 3 show the performance (power, kW) against the engine speed. The simulation data give the minimum value of power from 1.5 kW and the maximum value of 4.4 kW. However, when compared to the experimental, the result shows that the minimum value of power was 1.5 kW and the maximum value was 3.6 kW. For result in Figure 3, most of the lower end readings fall within 15% error bar from experimental values while only higher ends data at engine speed above 3000 rpm deviate more than 15%.
Comparing the experiment data against simulation showed that the different between them only in the range of 10.3% for torque and 11.8% for power. This range is acceptable due to the fact that most of the readings ranges within 15% error bar as shown in both Figure 2 and 3.The behavior of these result show similar trends and agreed to each other. .

The different value between the experiment and simulation can be caused by several potential hypothesis like the engine condition and the surrounding for the experiment. The engine have been utilizing it for various study and make the engine loss it efficiency.

4. CONCLUSIONS

This investigation provides an overview of engine behavior and correlation between experimental data and simulation for single cylinder diesel engine performance running with B5 palm oil based biodiesel. Therefore, the result would be useful for predicting the engine performance in term of torque (Nm) and power (kW) with the B5 palm oil biodiesel.

5. ACKNOWLEDGEMENT

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5. REFERENCES

[1] J. I. R. Lalvani, K. Kirubhakaran, M. Parthasarathy, R. Sabarish, K. Annamalai. Performance characteristics and Emission Analysis of a Single Cylinder Diesel Engine Operated on Blends of Diesel and Waste Cooking Oil. IEEE(2013).pp 781-785.

[2] C. S. Foon, C. Y. May, Y. C. Liang, M. A. Ngan, Y. Basiron. Palm Biodiesel: Gearing Towards Malaysian Biodiesel Standards. Malaysia Palm Oil board. pp 28-34.

[3] J. Nagi, S. K. Ahmad, F. Nagi. Palm Biodiesel and Alternative Green Renewable Energy for the Energy Demands of the Future. ICCBT (2008). PP 79-94.

[4] R.Wang, M.A.Hanna, W.W.Zhou, P.S. Bhadury, Q.Chen, B.A.Song. Production and selected fuel properties of biodiesel from promising non-edible oils: Euphorbia lathyris L., Sapium sebiferum L. and Jatropha curcas L. Bioresource Technology ,Vol.102,(2011), pp 1194-1199.

[5] F.Qiu, Y.Li, D.Yang, X.Li, P.Sun. Biodiesel production from mixed soybean oil and rapeseed oil. Applied Energy , Vol.88,(2011),pp 2050-2055.

[6] A. Khalid, S.A.Osman, M.N.M.Jaat, N.Mustaffa, S.M.Basharie, B.Mansoor. Performance and Emission Characteristic of Diesel Engine Fuelled by Biodiesel Derived from Palm Oil. Applied Mechanics and Materials, Vol. 315 (2013).pp 517-522.

[7] Yanmar Service Manual Industrial Diesel Engine. Retrieved from http://www.pramacparts.com/MANUAL.pdf.