The Effect of Cylinder Head Variations on the Mixture of Bio-Oil and Diesel Fuel on The Noise Value, Specific Fuel Consumption, and Gas Opacity

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Abstract. The increasing number of motorized vehicle users causes increasing air pollution in atmosphere. This condition is due to the exhaust gas content generated by the consumption of this fuel. To resolve this, one of the efforts is to use a mixture of bio-oil in diesel fuel. Bio-oil is a dark brown liquid composed of highly oxygenated compounds produced through pyrolysis, where its properties are close to heavy fuel oil. This study aims to determine the effect of cylinder head variations on the mixture of bio-oil and diesel fuel on the performance of an engine. The engine used in this research is a single-cylinder engine with a direct injection system. When the standard cylinder head variations are used, the best noise, specific fuel consumption, and gas opacity values are obtained. The best noise value is 92.1 dB with a composition of 15% bio-oil and 85% diesel fuel. Meanwhile, the best specific fuel consumption value is 0.236 gram/watt.second with a variation of 20% bio-oil and 80% diesel fuel mixture. The best opacity value is obtained at 30.3% when bio-oil fuel composition is 15% and diesel is 85%.

1. Introduction

Diesel engines are widely used because of their high fuel efficiency and power compared to gasoline engines. This makes diesel engines widely used as a driving force in heavy vehicles and transportation equipment in the industrial and automotive industries. Another advantage of diesel engines is the flexibility of the types of fuels that can be used such as diesel, Jatropha, and renewable energy butanol, methanol, and ethanol [1][2][3]. This is because the combustion that occurs does not require controlling the sparks. To obtain high heat to ignite the fuel, the diesel engine must have a higher compression ratio than the gasoline engine compression ratio [4].

Diesel engines have compression ranges from 12:1 to 18:1. The compression pressure can reach 400 to 700 Psi and the compressed air temperature can reach 1000°F. The greater the engine speed, the greater the power generated because the load is also large. From the above explanation, the author wants to use biodiesel from plastic waste as a fuel mixture that is applied directly to a single-cylinder diesel engine by varying [5][6].

The limitation of the problem in this study are:

a. The engine used is a single-cylinder diesel engine
b. The fuel used is a mixture of bio-oil and fuel diesel with variations B15 and B20
c. Not discussing the manufacture of bio-oil
d. Bio-oil which is used as a biodiesel blend  
e. Only discusses variations of the cylinder head on a single-cylinder diesel engine  
f. Only discusses noise, specific fuel consumption, and gas opacity  
g. Not discussing the compression ratio

2. Method  
This type of research is experimental. The equipment used is a single-cylinder four-stroke diesel engine [7]. The fuel used is a mixture of vegetable oil and diesel which is modified by the surface of the cylinder head to determine the optimum performance of the engine.

2.1. Types of Variations  
To determine the optimal engine performance, modifications were made to the surface of the cylinder head with standard variations (180 mm), modification 1 (thickness reduction 2 mm), and modification 2 (additional thickness 2 mm).

2.2. Testing of Diesel Engines  
The testing process was carried out at Automotive Machinery Laboratory Politeknik Negeri Madiun. The tools used are a sound level meter (noise test), a burette (specific fuel consumption test), and an opacity smoke meter (gas opacity test).

2.3. Research Schemes  
The test scheme in this study can be seen in Figure 1.

![Fig. 1. Testing engine](image)

From Figure 1 it can be seen that to determine the best performance of a diesel engine, testing is carried out using equipment including an opacity smoke meter, sound level meter, burette, blower, stopwatch, tachometer, generator, modified cylinder head, and light panels.

3. Results and Discussion  
3.1. Noise Testing Results  
The amount of load lamp given to the machine influences the noise value. The results of noise testing at various variations can be seen in Table 1.

| Variation  | Fuel | Noise value (dB) | Load lamp (watt) |
|------------|------|-----------------|-----------------|
|            |      | 1500  | 3000  | 4000  |
| Standard   | B15  | 92.1 dB | 92.4 dB | 93.2 dB |
| head       |      |        |        |        |
It can be seen in Table 1 that the higher the loading on the machine, the noise value obtained increases. The best noise value is obtained when the standard cylinder head variation is 15% bio-oil and 85% diesel fuel. This is because the amount of loading will cause an increase in the sound in the exhaust gas so that the noise test also increases [8].

3.2. Specific Fuel Consumption (SFC) Test Results

In addition to the noise value, the amount of load lamp on the engine also affects the specific fuel consumption value. The results of specific fuel consumption test on variations of the cylinder head can be seen in Table 2.

| Variation       | Fuel | Load lamp (watt) |
|-----------------|------|-----------------|
|                 |      | 1500     | 3000     | 4000     |
| Standard head cylinder | B15  | 0.216    | 0.123    | 0.107    |
|                 | B20  | 0.236    | 0.135    | 0.110    |
| Modification 1  | B15  | 0.167    | 0.098    | 0.089    |
|                 | B20  | 0.132    | 0.100    | 0.112    |
| Modification 2  | B15  | 0.167    | 0.098    | 0.089    |
|                 | B20  | 0.123    | 0.100    | 0.079    |

It can be seen in Table 2 that the higher the loading on the engine, the smaller the value of the specific fuel consumption obtained. The best specific fuel consumption is obtained when the standard cylinder head variation with the composition of 20% bio-oil and 80% diesel is 0.236 gram/watt.second. This is because the amount of loading will cause the amount of fuel to be injected into the combustion chamber to increase so that the engine speed remains stable [9].

3.3. Gas Opacity Test Results

The gas opacity value of an engine is also influenced by the amount of load lamp applied to the diesel engine. The results of testing the gas opacity value at variations of the cylinder head can be seen in Table 3.

| Variation       | Fuel | Load lamp (watt) |
|-----------------|------|-----------------|
|                 |      | 1500     | 3000     | 4000     |
| Standard head cylinder | B15  | 30.3%    | 50.2%    | 67.6%    |
|                 | B20  | 53.5%    | 61.7%    | 68.9%    |
| Modification 1  | B15  | 59.6%    | 59.5%    | 65.6%    |
|                 | B20  | 59.9%    | 79.0%    | 82.5%    |
| Modification 2  | B15  | 41.1%    | 62.7%    | 75.4%    |
|                 | B20  | 43.9%    | 53.0%    | 64.7%    |

It can be seen in Table 3 that the amount of load lamp on the engine causes gas opacity value increases [10]. The best exhaust gas opacity value is obtained when the standard cylinder head variation with bio-oil composition is 15% and diesel fuel is 85% which is 30.3%. This is because a
large amount of lamp loading on the engine will cause the exhaust gas to concentrate [11][12].

4. Conclusions

From the results of the tests that have been carried out, the results show that the best noise value is 92.1 dB with a fuel composition of 15% bio-oil and 85% diesel. Meanwhile, the best specific fuel consumption value is 0.236 gram/watt.second with a standard cylinder head variation of 20% bio-oil and 80% diesel fuel. For the best opacity value is obtained when the standard cylinder head variation is the composition of 15% bio-oil and 85% diesel fuel with a value of 30.3%

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