PERFORMANCE SMALL SPARK IGNITION

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PERFORMANCE SMALL SPARK IGNITION ENGINE USING PRODUCER GAS FROM COAL GASIFICATION: DUAL FUEL OPERATION

使用煤气化产生的生产气的高性能小型火花点火发动机：双燃料运行

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Abstract

This study proposed a dual fuel operation of a mix of gasoline and producer gas from coal gasification on the spark ignition engine. The experiment was carried out on a constant load with variations in speed for single fuel operation of gasoline and dual fuel operation of a mix of gasoline and producer gas to see the influence on speed, torque, power, and braking (effective pressure). The power produced was compared to power produced by the single fuel of producer gas that has been reported in the literature. The result shows an increase of speed would increase torque, power, and braking (effective pressure) for single fuel operation of gasoline and dual fuel operation of a mix of gasoline and producer gas. The power operation of dual fuel of a mix of and gasoline and producer gas will decrease by about 10.9% compared to operation of single fuel of gasoline, and the power operation of the single fuel of producer gas will decrease by about 20% compared to the operation of the single fuel of gasoline. The maximum shaft power produced by dual fuel operation is 1.49 kW at a load of 5 kg and a speed of about 3,500 rpm.

Keywords: Coal, Gasification, Spark Ignition Engine, Power, Dual Fuel

摘要 该研究提出了在火花点火发动机上使用来自煤气化的汽油和发生炉煤气的混合物的双燃料操作。该实验是在恒定负载下进行的，对于汽油的单燃料运行和汽油和生产气混合燃料的双燃料运行，在速度变化的情况下进行，以查看对速度、扭矩、功率和制动（有效压力）的影响。将产生的功率与文献中报道的由单一燃料产生的气体产生的功率进行比较。结果表明，对于汽油的单燃料操作和汽油和生产气混合气体的双燃料操作，速度的增加将增加扭矩、功率和制动（有效压力）。汽油与发生炉煤气混合双燃料发电运行较汽油单燃料运行下降约 10.9%。发生炉煤气单燃料

发电运行下降约20%。操作单一燃料汽油。双燃料运行产生的最大轴功率为1.49千瓦，负载为5公斤，转速约为3,500转速。

关键词: 煤、气化、火花点火发动机、动力、双燃料

NOMENCLATURES

T: Torque (Nm)
SP: Shaft Power (kW)
BMEP: Brake Mean Effective Pressure (kPa)
W: Dead Weight (N)
S: Spring Balance (N)
r: Distance from center of the drum to the tangential force (m)
N: Engine Rotation (rpm)
n: Number of crank revolutions (using value of 2)
V: Displacement volume (m^3)

I. INTRODUCTION

Power generation is dominated by coal as a fuel [1]. According to the report by Dai et al. [2], coal supplies about 41% of the world's electricity needs. Coal gasification has been known about for a long time, is technically very acceptable, and has advantages in the field of environmental friendliness [3], [4]. At this time, coal gasification is an established technology [5]. Coal gasification is an alternative energy source to replace petroleum fuels and is promising [6]. The coal gasification process product is producer gas. Producer gas can be used to drive spark ignition engines where its utilization can be done with two methods, namely single fuel and dual fuel (mixed with petroleum oil) operations. The combination of a small-scale gasification system and a small-scale spark ignition engine is a potential and low cost of method for energy generation [7].

Several studies have been conducted to measure the spark ignition engine performance, especially the shaft power, that is produced when using gas producer as a single fuel. Chunkaew et al. [8] conducted a study of producer gas application as a single fuel on the small-scale spark ignition engine; in that study, it produced a maximum shaft power of 1,443.6 W. Homdoung et al. [9] performed spark ignition engine testing and simulation using a single producer gas fuel from biomass gasification; the test results showed that the shaft power generated was approximately 3 kW. Babu et al. [10] did a comparison of spark ignition engine testing using gasoline and producer gas as a single fuel; the results of the tests showed a reduction in shaft power by 20.66% using producer gas. Homdoung et al. [11] conducted a study on spark ignition engines using single fuel producer gas from biomass gasification; the results showed a maximum generated shaft power of 3.5 kW. Gobbato et al. [12] tested the effect of producer gas from biomass gasification on a spark ignition engine as a single fuel. The test results showed that this producer gas reduced the brake power to 50% of what was reported in other studies.

Other studies reported a reduction in electric power if a spark ignition engine used producer gas as a single fuel. Chaves et al. [13] conducted a study on spark ignition engines using gasoline (single fuel) and producer gas (single fuel) from wood waste gasification, and test results show that the producer gas reduced nominal power by 50%. Efendi et al. [14] tested producer gas, produced from coal gasification, as a single fuel in a spark ignition engine. The results of the test showed a decrease in electric power by 46% when using the producer gas as fuel.

As the review above shows, the reduction in engine power that comes from using producer gas as a single fuel has been extensively documented. The use of producer gas as a single fuel in a spark ignition engine will reduce the power significantly, from about 20 to 50%. One method for solving this problem is to use dual fuel, a mixture of gasoline and producer gas.

In this study, a comparison of single fuel gasoline and dual fuel (gasoline and producer gas from coal gasification) was carried out on a spark ignition engine. Variations in engine speed and constant loads to observe the torque, power and brake mean effective pressure were tested. The power result is compared to the literature report regarding the power produced by a single-fuel operation of the producer gas. The goal of this study is to utilize coal as fuel on spark ignition engines and to compare the power produced by a single fuel of gasoline and a gasoline–producer gas mix. The experiment calculated the torque, shaft power, and brake mean effective pressure (BMEP) of a small-scale spark ignition engine using dual fuel composed of a mix of gasoline and producer gas from Indonesia's low-rank coal gasification. The comparison of power on the operation of a single fuel of gasoline, the dual fuel of a mixed gasoline–producer gas and the single fuel of producer gas makes this study different from other reports in the literature.

II. Methodology

In this study, the coal gasification process was carried out in the downdraft gasifier [15]. The coal used was low-rank coal with proximate and ultimate analysis as explained by [16]. The spark ignition engine uses a small type with specifications as shown in Table 1. The shaft power and BMEP of the engine are obtained through torque measurements using the rope brake dynamometer with U configuration [17] as shown in Figure 1. Equations 1 to 3 were used to calculate torque, shaft power, and BMEP. The full arrangement of the experimental setup is shown in Figure 2.

$$T = (W-S).r \text{ (Nm)} \quad (1)$$

$$SP = 2.\pi.N.T / 60000 \text{ (kW)} \quad (2)$$

$$MEP = SP.n.60 / V.N \text{ (kPa)} \quad (3)$$

Table 1.
Engine specification

No	Parameter	Value
1	Maximum Power	3.6 kW
2	Speed	3600 rpm
3	Bore	6.8 cm
4	Stroke	4.5 cm
5	Capacity	163 cc
6	Number of Cylinder	1
7	Type of Engine	4 strokes
8	Ratio of Compression	8.5 :1
9	Fuel	Gasoline

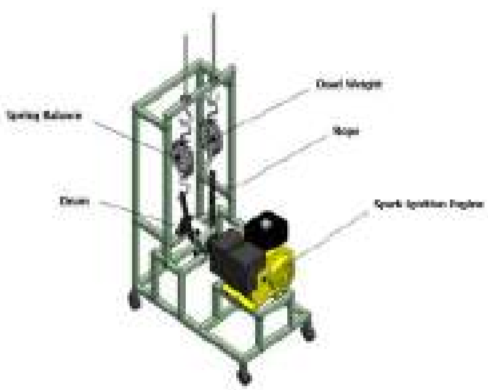

Figure 1. Engine and rope brake dynamometer with U configuration

Figure 2. The full arrangement of the experimental setup

III. Results and Discussion

A. The Comparison of Torque between a Single Fuel of Gasoline and the Dual Fuel of Mixed Gasoline and Producer Gas

Figure 3 shows the comparison of torque on a single fuel of gasoline and the dual fuel of mixed gasoline and producer gas. A higher speed will increase the torque generated in both operations. In dual fuel operation, torque reduced with an average reduction in torque of 11.2 % compared to single fuel. The maximum torque for single fuel and dual fuel operations was 4.42 Nm and 4 Nm, respectively, at a speed of about 3500 rpm.

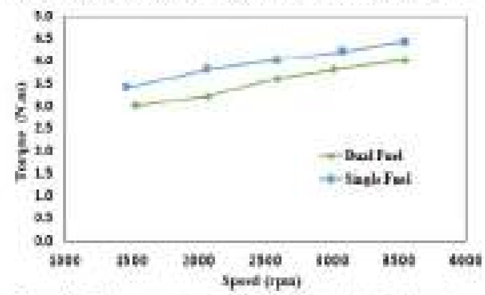

Figure 3. The comparison of torque on single fuel operation of gasoline and dual fuel operation of mixed of gasoline and producer gas

B. The Comparison of Power between the Single Fuel Operation of Gasoline and Dual Fuel Operation of a Mix of Gasoline and Producer Gas

Figure 4 shows that an increased speed will increase the shaft power generated in both the single fuel operation of gasoline and dual fuel operation of mixed gasoline and producer gas. Dual fuel operation will reduce the power produced. The average of power reduction was about 10.9 % compared to the single fuel operation of gasoline. The maximum power produced by the single fuel operation of gasoline and dual fuel operation of mixed gasoline and producer gas, was 1.64 kW and 1.49 kW at an approximate speed of 3500 rpm. The single fuel operation of producer gas based on the report by Chaukaew et al. [8], on almost the same the speed, could generate an approximate shaft power of 1.32 kW. It is about 20% lower than the single fuel operation of gasoline. The power generated in the dual fuel operation of mixed producer gas and gasoline is still higher than the single fuel operation of producer gas—with the comparison shown in Figure 5—this is due to the low energy density of syngas compared with gasoline [10], [18], [19], [20], [21], [22].

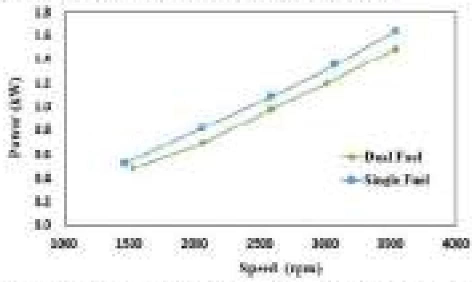

Figure 4. The comparison of power on single fuel operation of gasoline and dual fuel operation of mixed of gasoline and producer gas.

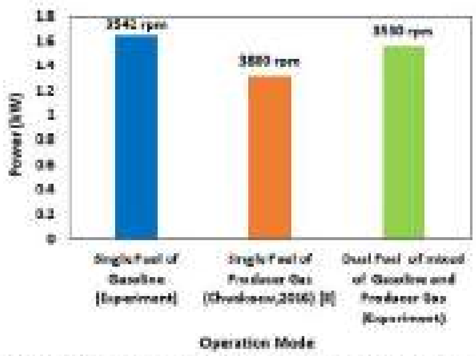

Figure 5. The comparison of the result of the experiment to the literature reported of single fuel operation of producer gas

C. The Comparison of BMEP between the Single Fuel Operation of Gasoline and Dual Fuel Operation of a Mix of Gasoline and Producer Gas

Figure 6 shows the comparison of BMEP in the single fuel operation of gasoline and dual fuel operation of mixed gasoline and producer gas in the variations of speed between 1500 to 3500 rpm. The addition of producer gas to gasoline fuel causes a decrease in the BMEP. The average of BMEP reduction is 11.3%. The maximum BMEP for the single fuel of gasoline and dual fuel of mixed gasoline and producer gas was 341 kPa and 310 kPa respectively at a speed of approximately 3500 rpm.

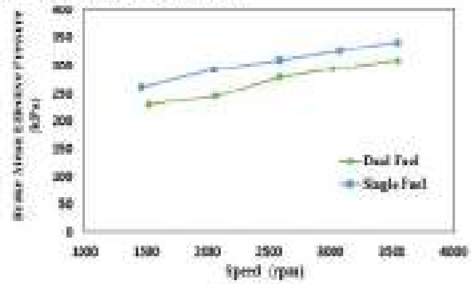

Figure 6. The comparison of BMEP on single fuel operation of gasoline and dual fuel operation of mixed of gasoline and producer gas

IV. Conclusion

From the results of the tests that have been carried out, it is found that the effect of increasing speed will increase torque, power, and brake mean effective pressure both in the single fuel operation of producer gas and dual fuel operation of mixed gasoline and producer gas. Dual fuel operation of mixed gasoline and producer gas produced lower torque, power, and brake mean effective pressure than the single fuel of gasoline. The average reduction in power is 10.9 % compared to the single fuel of gasoline. The maximum torque, power, and BMEP generated in the dual fuel operation of mixed gasoline and producer gas is 4 Nm, 1.49 kW, and 310 kPa respectively, at an approximate speed of 3500 rpm and a load of 5 kg. The result of the experiment shows the operation of dual fuel could save the use of gasoline in the current situation as the power drop is lower than the operation of the single fuel of producer gas. The purpose of the experiment is to utilize producer gas from Indonesia's low rank coal gasification to investigate the comparison of torque, power, and brake mean effective pressure of spark ignition engines, to the power of operating single fuel gasoline, the dual fuel mix of gasoline and producer gas and the single fuel of producer gas.

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