APPLICATION OF PRODUCER GAS FROM SOUTH SUMATERA

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APPLICATION OF PRODUCER GAS FROM SOUTH SUMATERA, INDONESIA, LOW RANK COAL GASIFICATION ON SPARK IGNITION ENGINE OR GASOLINE ENGINE

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ABSTRACT

The substitution of oil fuel to coal continued to increase by the government of Indonesia that has been implemented on energy mix program. In this study, the low rank coal of South Sumatera, Indonesia was converted to producer gas, using gasification process. The gasification process was carried out on the downdraft gasifier equipped with a cleaning system. The equivalent ratio of the gasification process was in the range of 0.24 to 0.25. Combustible gas produced was very stable from the beginning to the end of the process. The producer gas was used to drive a spark ignition engine on dual fuel operations. The study was conducted using a maximum electrical load of 1 kW. The results of the study showed, the gasoline consumption rate was increased from 0.53 L/h to 0.68 L/h with increasing of electrical load in dual fuel operation. The maximum and the average of gasoline savings were 16.6 % and 15.3%, respectively. The specific gasoline consumption rate decreased from 1.83 L/kWh to 0.68 L/kWh.

***KEYWORDS:** Gasification, Low Rank Coal, Producer Gas & Spark Ignition Engine*

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Original Article

1. INTRODUCTION

Coal is a fossil energy source that is almost used by all developing countries to produce electricity, where approximately 42% of the world's electricity is supplied from coal [1–3]. Increasing the role of coal in replacing oil fuels continues to be improved by the Indonesian government through the energy mix program in 2015 and national energy police 2025 [4], the composition of coal target increase from 27% to 30%. The electrification of rural area with power about 10 kWe (generator sets) is effort to support the government program. The use of small spark ignition engines (genset) has a huge advantage for people's lives caused be uses in remote area [5]. The conversion of coal into electrical energy can be done by various methods; one of method is gasification process. Coal is converted into producer or gas syngas on gasification. The downdraft is a type of fixed gasifier that could be used for coal gasification process [6]. Spark ignition engine is one of the internal combustion engines that can be applied as syngas or producer gas as fuel [7]. Several studies have been conducted to use the producer gas from biomass gasification in spark ignition engines [8–15]. The increasing of performance and decreasing of emission on small scale spark ignition have been done by [16–19]. The use of producer gas on the spark ignition engine can be done with a single fuel and dual fuel operation. Single fuel spark ignition operation is constrained by the low of calorific value of producer gas [20]. Muhammad et al., [21] used producer gas from coal gasification with a calorific value of 5891 cal/kg on single fuel spark ignition engine, the test results showed a decreasing about 45% of engine power when using producer gas. The research used producer gas from coal gasification to drive spark ignition engine with the dual fuel operation is still rare. Wusana et al., [22] carried out to research on the operation of dual fuel spark ignition engines using producer gas from gasification of rice husks, the results showed a maximum fuel savings of 20%. Fajri et al., [23] studied the application of producer gas from wood charcoal gasification on gasoline engine in dual fuel mode, the result showed the average of gasoline saving about of 19.8%. In this study, carried out is the utilization of producer gas from south sumatera, Indonesia, low rank coal gasification on the small spark ignition engine in dual fuel operation.

2. METHODOLOGY

The gasification system and the properties of south sumatera low rank coal (MT-46) were used as reported by Fajri et al., [24]. The construction of downdraft gasifier was used as shown in Figure 1 [25]. The properties of south sumatera low rank coal could be seen in Table 1. The size of low rank coal must be reduced before entered the gasifier as shown in Figure 2 The spark ignition engine with the name of gasoline generator was used in this study, as shown in Figure 3. The maximum of engine capacity was 2 kW. The combination of the gasification system and spark ignition engine is shown in Figure 4. The running of gasification process was done to observe the continuities of combustible gas and the air- fuel ratio of the gasification. The running of spark ignition engine was performed on various electrical loads from 0 kW to 1 kW in single fuel and dual fuel operation. The variations were made to see the effect of increasing load on the fuel consumption rate, specific gasoline consumption and fuel savings. Fuel savings were calculated based on the reduction of fuel consumption during dual fuel and single fuel operations [26].

Table 1: The Properties of Low Rank Coal [24]

Parameter	Unit	Average Value
Total Moisture	Mass Fraction (%, Ar)	27.79
Proximate		
Moisture Inherent	Mass Fraction (%, Adb)	13.59
Ash	Mass Fraction (%, Ar)	5.13
Volatile	Mass Fraction (%, Ar)	33,72
Fixed Carbon	Mass Fraction (%, Ar)	33.37
Ultimate Analysis (dry basis)		**Value**
Carbon	Mass Fraction (%,Adb)	57.35
Hydrogen	Mass Fraction (%,Adb)	4.31
Oxygen	Mass Fraction (%,Adb)	17.37
Nitrogen	Mass Fraction (%,Adb)	0.77
Heating Value	**Unit**	**Value**
Gross CV	kcal/kg, (Ar)	4759
Gross CV	kcal/kg, (Adb)	5695

Figure 1: Downdraft Gasifier [25].

Figure 2: The MT-46 Low Rank Coal Before and After Reduzed Size.

Figure 3: Spark Ignition Engine.

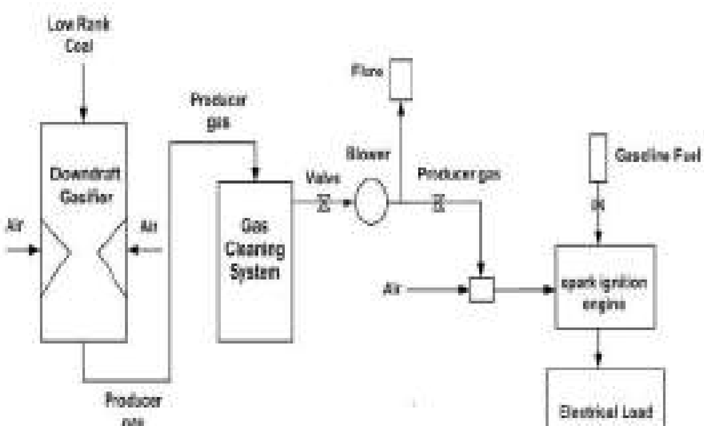

Figure 4: The Component of Gasification and Spark Ignition Engine System.

3. RESULTS AND DISCUSSIONS

The Running of the Gasifier

The conventional startup of gasifier using low rank coal as fuel needed the time of 30 minute to reach the self ignition. The combustible gas has been produced at 15 minutes after the self ignition was reached. The mechanism of combustible gas produced inside the gasifier is shown in Figure 5. The producing of combustible gas would stop, when the fuel inside of the gasifier were at below the throat of the gasifier. The continuity of combustible gas would exits, when the fuel inside of the gasifier was added until top of the gasifier. This was caused by reducing the amount of fuel inside of the gasifier, then the zone of the reaction would reduce, especially for drying and pyrolysis zones. The mass flow rate of the low rank coal was about 4.76 kg/h and the comparison of mass flow rate at input and output of the gasifier is shown in Figure 6. The equivalent ratio of gasification process was in the range of 0.24 to 0.25. The producer gas was injected to spark ignition engine about 14% of total gas produced.

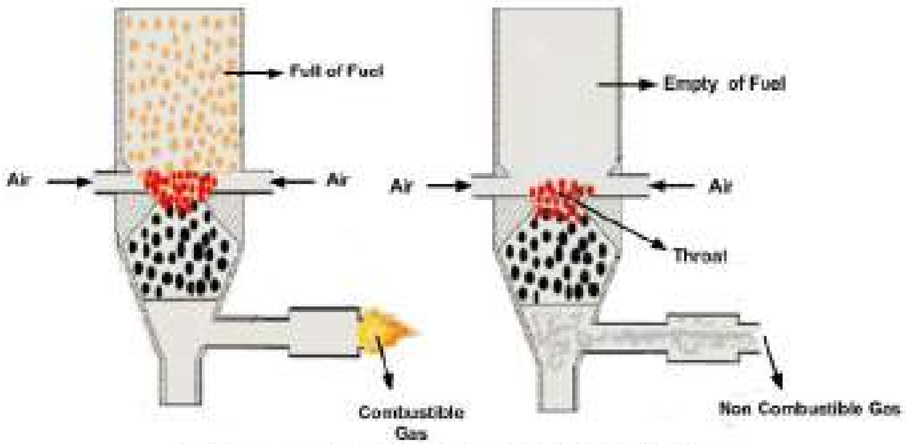

Figure 5: The Mechanism of Combustible Gas Produced.

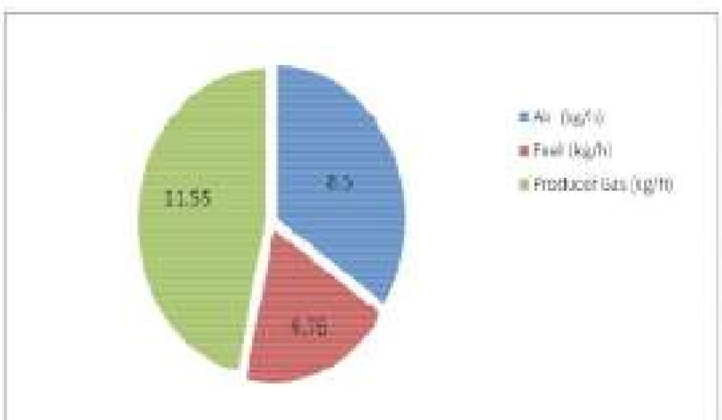

Figure 6: The Comparison of Mass Input and Output of the Gasifier.

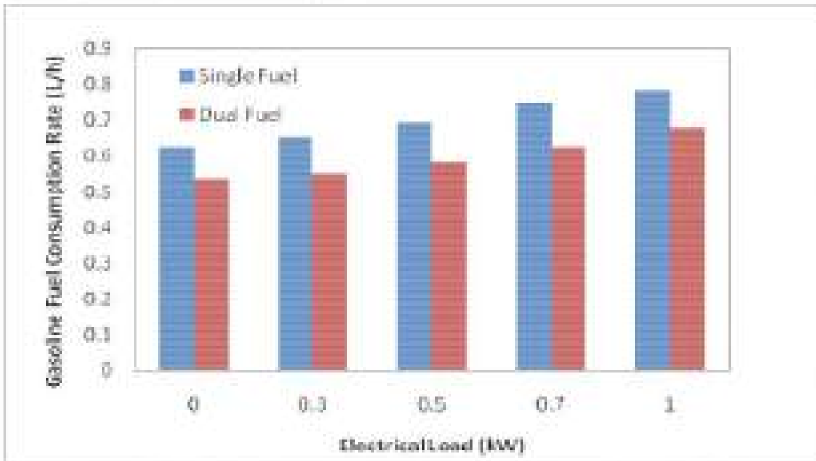

Figure 7: Gasoline Consumption Rate at Variation of Electrical Load.

The Effect of Electrical Load increasing on the Fuel Consumption Rate

Figure 7 shows the effect of increasing the electrical load on the rate of fuel consumption. An increase of the electrical load would increase the use of gasoline fuel both in single fuel and dual fuel operations. In single fuel and dual fuel operation, the fuel consumption rate increased respectively from 0.63 L/h to 0.78 L/h and from 0.53 L/h to 0.68 L/h. It was caused by the increasing load that would increase the energy requirements supplied by the fuel (energy content of the fuel). In dual fuel operation, gasoline consumption was lower than single fuel operation for each electrical load. This was caused a replacement of gasoline by the producer gas. These results had same trend with the study reported by Harmanpreet et al., [27] and Monorom et al., [28]. The averages of increasing of fuel consumption rate were 5.6% and 6.1% for single fuel and dual fuel operations respectively. The results were not much different from the results reported by Wasana et al., [22].

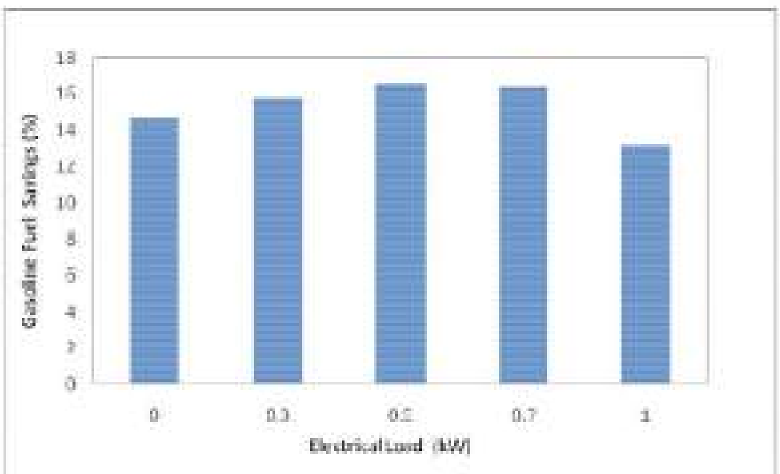

Figure 8: Gasoline Savings at Variation of Electrical Load.

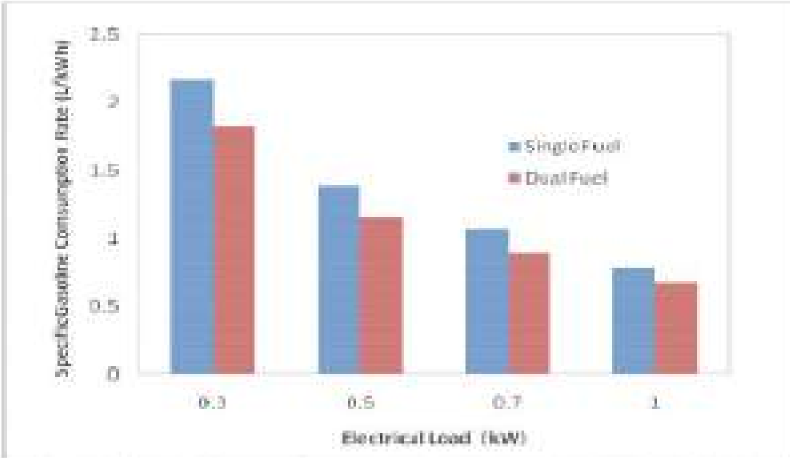

Figure 9: Specific Gasoline Consumption Rate at Variation of Electrical Load.

The Effect of Electrical Load Increasing on the Fuel Savings

Figure 8 shows the percentage of gasoline fuel savings at dual fuel operations for each load. The percentage fuel savings on variation of load of 0 to 1 kW were 13.15 % to 16.57 %. The maximum of fuel savings was 16.57 % and the average of fuel savings was 15.33%. These results could be compared to the reported by [22-23]. The differences in fuel savings was caused by the differences on fuel used and engine specification.

The Effect of Electrical Load Increasing on the Specific Gasoline Consumption Rate

Figure 9 shows the effect of increasing of the electrical load on the specific gasoline consumption rate. The increasing of electrical load tended to decrease of the specific gasoline consumption rate in both single and dual fuel operations. In single fuel and dual fuel operation, it decreased respectively from 2.17 L/kWh to 0.78 L/kWh and from 1.83 L/kWh to 0.68 L/kWh. It was caused on the lower of load, the mixing of fuel and air did not carried out properly, so that the combustion did not yet taken place completely. On the higher of loads, the mixing of fuel and air carried out properly so that complete combustion takes place [28-29]. The energy of fuel could be converted maximally in complete combustion then the amount of fuel per unit power decreased. The averages of decreasing of gasoline specific consumption were 28.6% and 27.8% for single fuel and dual fuel operations, respectively. This result is almost the same as that reported by Wusana et al., [22].

4. CONCLUSIONS

The results of the study shows, the producer gas from south sumatera, low rank coal (MT-46) gasification could be used in dual fuel gasoline engine operations. The savings of gasoline could be obtained maximum of 16.6 %, and the average of gasoline savings was 15.3 %. The lower specific gasoline consumption rate was obtained about 0.68 L/kWh in dual fuel operation.

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