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FUEL CONSUMPTION ANALYSIS IN SYNGAS FUEL COMBUSTION ENGINES WITH PURE OXYGEN AGENT GAS

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ABSTRACT

Gasification is a process of converting carbon-containing compounds to convert both liquid and solid materials into combustible gaseous fuels through a combustion process with limited air supply. The biomass gasification process in this study used horse manure which is livestock waste with a gas agent in the form of pure oxygen. The gasification reactor used in this study has a reactor diameter of 600 mm and a reactor height of 1500 mm. The research was carried out using the thermal decomposition method in which the gaseous agent used was pure oxygen with various flow rates (10, 15, 20 and 30 l/min). Next will be examined the effect of air flow rate in the gasification process on fuel consumption, seen from the engine speed of 1500, 2500, 3500 and 4500 rpm. The results of the research that has been done show that with the increasing flow rate of the gas agent, the resulting fuel consumption increases by an average of 18.9%, at the same engine speed. This happened more because the calorific value of the resulting syngas decreased by an average of 15.28%. Likewise, the greater the agent gas flow rate, the SFCE experienced an average increase of 19.75% for various variations of engine speed.

INTRODUCTION

Research to determine the effect of type and size of biomass on the gasification process using a downdraft gasifier. Sengon and mahogany wood are used as raw materials using two measurements of biomass, namely wood chips and beams. Each experiment was carried out for 90 minutes and 10 kg of biomass. Air is supplied at a speed of 3 m/s. The results showed that the type and size of the biomass affected the gasification temperature, flame characteristics and residue. Sengon wood chips gave the highest gasification temperature of 1239°C in the oxidation zone with a flame duration of 77 minutes and a residue of 9.1% by weight. For mahogany wood chips, the flash time is 1220°C for 68 minutes and the residue is 16.25 wt.%. Meanwhile, a mixture of sengon and mahogany wood chips gave a flame time of 55 minutes and a residue of 15.65 wt.% [1].

The research was conducted using a downdraft gasification reactor with coconut shell biomass as raw material. The gasification process is carried out with a continuous supply of biomass every 10 minutes of 0.45 kg, 0.48 kg, 0.5 kg and 0.52 kg for 120 minutes with a biomass size of (0.8-12.6) cm² and (12 ,7-50,3) cm². The research was conducted with 4 variations of air supply speed of 3.57 m/s, 4.37 m/s, 5.05 m/s and 5.64 m/s. The results showed that the lowest calorific value, syn-gas composition and flame were best at AFR 0.88 and coconut shell size (0.8-12.6) cm². The bottom heating value is 4718.33 kJ/m³, the syn-gas composition is 39.273% of the total volume and the resulting flame is blue. Meanwhile, the best gasification efficiency occurs at an AFR of 1.17 for a coconut shell size (0.8-12.6) cm² of 52.030% [2].

This research was conducted to compare coconut shell biomass and oil palm fronds in terms of their flammability and tar content. The fuel is burned in an updraft type gasification reactor until syngas is produced. The results showed that the coconut shell biomass could ignite for 43 minutes 14 seconds while the frond biomass of oil palm lasted 10 minutes 26 seconds. The weight of dry tar from the gasification process which was weighed using a digital scale for coconut shell biomass was 8.99 gr, while for palm frond biomass was 4.62 gr. The mass of tar in each liter of sample gas for Coconut Shell Biomass is 0.064 gr/lt while the Palm Oil Frond Biomass is 0.034 gr/lt [3].

Gasification is a process of converting compounds containing carbon to convert both liquid and solid materials into combustible gaseous fuels (CO, H_2, CO_2, CH_4 and H_2O) through a combustion process with limited air supply, namely between 20% and 40% stoichiometric air. The reactor where the gasification process takes place is called a gasifier. During the gasification process a process area will be formed which is named according to the temperature distribution in the gasifier reactor. These areas are: Drying, Pyrolysis, Reduction and Combustion. Each area occurs in a temperature range between 25°C to 150°C, 150°C to 600°C, 600°C to 900°C, and 800°C to 1400°C. The gas resulting from the gasification process is called producer gas or syngas.

The advantages and disadvantages of each reactor and the types of reagents commonly used for the gasification process. Despite the available advantages, it turns out that the thermal gasification process of biomass still has challenges in terms of excessive formation of tar and char and the low calorific value of syngas if the operating conditions do not match the characteristics of the biomass being processed [4].

Numerical simulation of steam-gasification of biomass (empty palm fruit bunches) using a thermodynamic equilibrium model. From the simulation, it appears that hydrogen production increases with increasing temperature. At low temperatures, hydrogen production is low and increases with increasing temperature until it reaches a peak and then hydrogen production decreases again [5]

The composition of syngas varies depending on the biomass raw material, but on average it can produce syngas with H_2 content of 18-20%, CO of 18-20%, CH_4 of 2-3%, CO_2 of 12%, H_2O of 2.5% and the rest N_2, with a gas calorific value of around 4.7 – 5 MJ/m³ [6]. The gasification that we are familiar with is gasification with coal feed and agricultural waste, but gasification with livestock waste feed, especially horse manure (biomass) has never been done, even though horse manure has great potential to be developed as a raw material for gasification. In this research, the use of horse dung as feed material in the gasification process will be developed with consideration of the fine grain size, the high content of carbohydrates, fats and crude fiber so that it can increase carbon production which will indirectly increase the production of methane and carbon monoxide.

Horse manure (feces) has a variety of shapes and sizes as well as fine grain sizes. In addition, horse manure also has a high water content. As gasification feed, if used directly, horse manure will be difficult to process and can interfere with gasification performance. Therefore, the initial processing of horse manure needs to be done. The initial treatment is in the form of reducing the water content in horse manure. Meanwhile, the production ratio of horse manure (feces) reaches 5.5 tons/year/head with an energy conversion coefficient of 14.9 Gjoules/ton [7].

Research Methods

The research method that will be used to achieve the research objective is to test the potential of horse manure as feed material in gasification reactors using the thermal decomposition method with a gaseous agent in the form of pure oxygen.

In this research there are two kinds of variables being measured, namely:

a. Fixed variable

The fixed variable is the variable that is the main concern of the researcher, by analyzing the fixed variable it is hoped that the answer or solution to the problem can be found. The fixed variables in this test are:

1. The composition of the syngas consists of a mixture of CO, CO_2, CH_4 gases.
2. Updraft gasification reactor

b. Changed Variables

Changed variables are variables that affect the fixed variable. As for the changed variables in this study, namely:

1. gas agent flow rate: 10 lt/minute (fuel A); 15 lt/minute (fuel B); 20 lt/minute (fuel C); 30 lt/minute (fuel D)
2. gaseous agent: pure oxygen.
3. engine speed: 1500, 2500, 3500 and 4500 rpm.

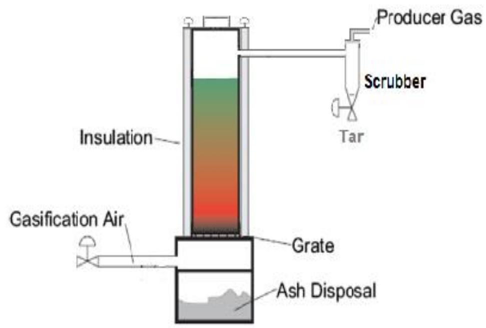

Figure 1. Gasification Reactor Test Installation

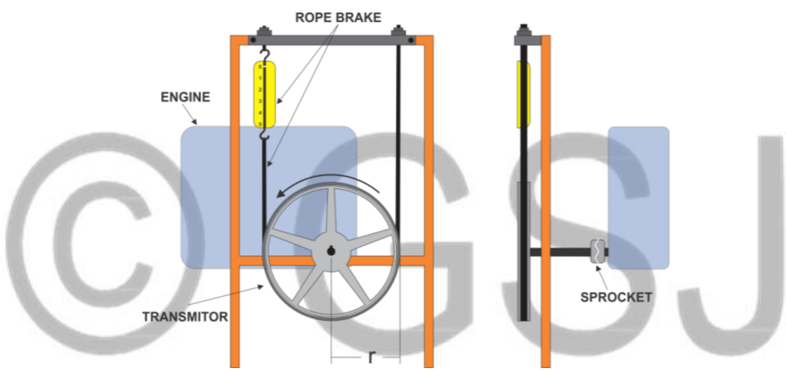

Figure 2. Installation of combustion engine testing

The gasifier used in this study has a reactor diameter of 600 mm, and a reactor height of 1500 mm (figure 1) and a 110 cc engine with 4 steps (figure 2). The main material needed in this research is horse manure, horse manure has a high water content. As gasification feed, if used directly horse manure will be difficult to process and can interfere with gasification performance. Initial processing of horse manure needs to be done through a drying process first. The research was continued with the process of making syngas with horse dung as feed material, in this case an updraft type gasification reactor was used and a thermal decomposition method was used with a gaseous agent in the form of pure oxygen and flowed using a compressor. The gas agent flow rates were varied, respectively 10, 15, 20 and 30 l/minute. Furthermore, it will be investigated the effect of the gas coming out of the gasifier on the performance of the combustion engine. Judging from the fuel consumption at various engine speeds, namely 1500, 2500, 3500 and 4500 rpm.

Results and Discussion

The results of the research are presented in Fig 3, namely the relationship between engine speed and fuel consumption, as shown in Fig 3 that the fuel (syngas) consumed by the engine increases as the gas agent flow rate increases. Increased fuel consumption by an average of 18.9% at the same engine speed. This situation arises as a consequence of the calorific value of the synthesis gas produced in the gasification process decreases as the flow rate of the gas agent increases. The decrease in the calorific value of 15.28% coincides with the increase in the flow rate of the gas agent in the gasification process.

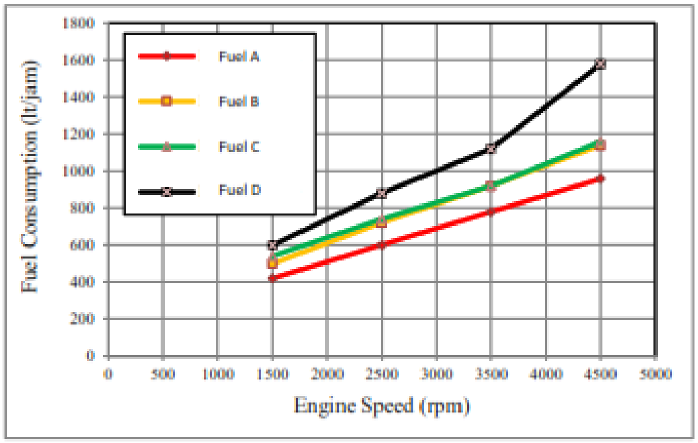

Figure 3. The relationship between engine speed and fuel consumption

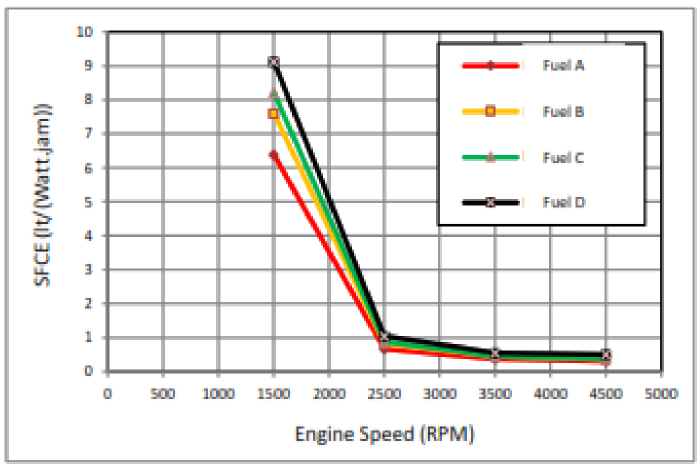

Figure 4. The relationship between engine speed and SFCE

Fig 4 shows the relationship between engine speed and SFCE, it can be seen that the specific fuel consumption effective required by the engine decreases as the engine speed increases, this occurs because the higher the engine speed, the fuel consumption used per hour to produce each kW shaft power or effective power more and more. As for fuel consumption, it will increase along with increasing engine speed (fig 3), this shows that the higher the engine speed of a fuel engine, the greater the fuel consumption, although fuel consumption increases, it is also followed by an increase in shaft power or effective power. Likewise, the greater the agent gas flow rate, the SFCE experienced an average increase of 19.75% for various variations of engine speed.

Conclusion

The conclusion that can be drawn from the results of this study is that the gasification process can not only be carried out with agricultural waste and coal feed ingredients, but for livestock solid waste can also be carried out with good results. The influence of the gas agent flow rate (pure oxygen) has an impact on the resulting calorific value which will be lower with a decrease of 15.28%. Meanwhile, fuel consumption experienced an average increase of 18.9% in line with the greater flow rate of gas agents for various variations of engine speed. Likewise, the greater the agent gas flow rate, the SFCE experienced an average increase of 19.75% for various variations of engine speed.

References

[1] Faishal Mufid and Samsudin Anis, 2019, “Pengaruh Jenis dan Ukuran Biomassa terhadap Proses Gasifikasi Menggunakan Downdraft Gasifier”, Jurnal Rekayasa Mesin, vol. 10, no. 3, pp. 217-226.

[2] Lailun Najib and Sudjud Darsopuspito, 2012, “Karakterisasi Proses Gasifikasi Biomassa Tempurung Kelapa Sistem Downdraft Kontinyu dengan Variasi Perbandingan Udara-Bahan Bakar (AFR) dan Ukuran Biomassa”, Jurnal Teknik ITS vol. 1, no. 1, pp. 12-15.

[3] Abrar Ridwan and Budi Istana, 2018, “ Analisis Pengaruh Variasi Bahan Bakar Biomassa Terhadap Ampu Nyala Dan Kandungan Tar Pada Reaktor Gasifikasi Tipe Updraft”, Jurnal ENGINE Vol. 2 No. 1, pp no: 7-17.

[4] Wang, L., Weller, C.L., Jones, D.D. and Hanna, M.A., 2008, Contemporary issues in thermal gasification of biomass and its application to electricity and fuel production, Biomass and Bioenergy 32, 573-581.

[5] Adjar Pratoto and Slamet Raharjo, 2008, “Gasifikasi-uap Biomassa untuk Menghasilkan Hidrogen – Simulasi dengan Model Kesetimbangan”, Seminar Nasional Tahunan Teknik Mesin (SNTTM) VII, Manado.

[6] Haifa Wahyu, Imam Djunaedi, M. Affendi, Sugiyatno and Yusuf Suryo Utomo, 2011, “Perancangan dan Pengembangan Model Reaktor Circulating Fluidized Bed Untuk Gasifikasi Biomassa”, Research Centre fo Physics, LIPI.

[7] Hall, D. O, 1993, “Biomass for Energy : Supply Prospects”, in: Renewable Energi, Johansson, T. B. eds., pp.594, Washington, Island Press.