Engineering and Technology Journal e-ISSN: 2456-3358

Volume 09 Issue 05 May-2024, Page No.- 4158-4160

DOI: 10.47191/etj/v9i05.36, I.F. – 8.227

Analysis of Gas Characteristics Produced in an Updraft Type Gasification Reactor with Various Gas Agent Flow Rates

Rudy Sutanto[1], I Gede Bawa Susana[2]

[1,2]Departmen of Mechanical Engineering, Faculty of Engineering, Mataram University, Mataram, Indonesia.

ABSTRACT: Gasification is a process of converting compounds containing carbon to change both liquid and solid materials into combustible gaseous fuel (CO, H_2, CO_2, CH_4 and H_2O) through a combustion process with a limited air supply, namely 20-40% of the air stoichiometry. The aim of this research is to obtain syngas that is renewable natural gas quality. The gasification reactor used in this research has a reactor diameter of 600 mm and a reactor height of 1500 mm. Research on the characterization of the gasification process in updraft gasifiers made from horse manure using the thermal decomposition method where the gas agent used is air. Variations in the flow rate of the gas agent used are 10, 15, 20 and 30 lt/minute. The results of the research that has been carried out show that the greater the flow rate of the gas agent, the CO gas levels will increase with an average increase of 15%, however the increase in CO gas is followed by a decrease in CH_4 gas levels, namely an average of 13%. Likewise, CO_2 gas levels decreased by an average of 14%.

KEYWORDS: Gasification, updraft, syngas, flow rate, gas agent

I. INTRODUCTION

Syngas is one of the green technology products currently being developed. This is because the gas is produced from the thermal decomposition process of solid biomass by providing a certain amount of heat with a limited oxygen supply to produce synthesis gases or combustible gases consisting of CO, H_2, CO_2, CH_4 and H_2O (hereinafter referred to as syngas) as the main product. and small amounts of carbon char and ash as by-products. In this case, of course, CO, H_2, and CH_4 gases are used which have a calorific value that can be used as fuel. In general, the gasification process involves 4 process stages, namely drying, pyrolysis, partial oxidation and reduction.

Research to determine the effect of biomass type and size on the gasification process using a downdraft gasifier. Sengon and mahogany wood are used as raw materials using two biomass sizes, namely wood chips and blocks. Each experiment was carried out for 90 minutes and 10 kg biomass. Air is supplied at a speed of 3 m/s. The research results show that the type and size of biomass influence the gasification temperature, flame characteristics and residue. Sengon wood chips provide 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 sequence is 1220°C, the ignition time is 68 minutes and the residue is 16.25 wt.%. Meanwhile, a mixture of sengon and mahogany wood chips provides a flame time of 55 minutes and a residue of 15.65 wt.% [1].

The research was carried out 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 amounting to 0.45 kg, 0.48 kg, 0.5 kg and 0.52 kg for 120 minutes with biomass sizes of (0.8-12.6) cm² and (12.7-50.3) cm². The research was carried out 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 research results showed that the lower heating value, syn-gas composition and flame were best at AFR 0.88 and coconut shell size (0.8-12.6) cm². The lower heating value is 4718.33 kJ/m^3, the syn-gas composition is 39.273% of the total volume and the flame produced is blue. Meanwhile, the best gasification efficiency occurs at AFR 1.17 for coconut shell size (0.8-12.6) cm² of 52.03% [2].

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

The composition of syngas varies depending on the biomass raw material, but on average it can produce syngas with H_2 levels 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 heating value of around 4.7 – 5 MJ/m^3 [4]. The gasification that we are familiar with is gasification using coal and agricultural waste as feed, however gasification using livestock waste as feed, especially horse manure (biomass) has never been carried out, even though horse manure has great potential to be developed as a raw material for gasification. In this research, the use of horse manure as a feed material in the gasification process will be developed by considering the fine grain size, high content of carbohydrates, fats and crude fiber so that it can increase carbon production which will indirectly increase the production of methane gas and carbon monoxide.

Gasification is a process of converting compounds containing carbon to change both liquid and solid materials into combustible gas fuel (CO, H_2, CO_2, CH_4 and H_2O) through a combustion process with a limited air supply, namely between 20% and 40% stoichiometric air. The reactor where the gasification process occurs 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 25ºC to 150ºC, 150ºC to 600ºC, 600ºC to 900ºC, and 800ºC to 1400ºC. The gas resulting from the gasification process is called producer gas or syngas. The biomass thermal gasification process still has challenges in terms of excessive tar and char formation and low syngas calorific value if the operating conditions do not match the characteristics of the biomass being processed [5]. The results of other research show that as the gas agent flow rate increases, the resulting fuel consumption increases, as well as SFCE also increases [6].

The gasification that we are familiar with is gasification using coal and agricultural waste as feed, however gasification using livestock waste as feed, especially horse manure (biomass) has never been carried out, even though horse manure has great potential to be developed as a raw material for gasification. In this research, the use of horse manure as a feed material in the gasification process will be developed by considering the fine grain size, 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 gas.

Horse manure has a high enough carbon content that it has the potential to be used as fuel. One method that can be used to process horse manure into fuel is gasification. With the gasification technique, it is hoped that horse manure can be a potential source of fuel (syngas) to overcome the energy crisis, but so far the production of syngas through gasification techniques from livestock waste (feces) has not been tried and researched, therefore research to utilize livestock manure horse (feces) as an alternative material for a new renewable and environmentally friendly energy source needs to be carried out immediately and thoroughly until its implementation.

II. RESEARCH METHODS

The research method that will be used to achieve the research objectives is to test the potential of horse manure as feed material in updraft type gasification reactors using the thermal decomposition method using a gas media agent in the form of air.

a. Research variable

In this research, the variables chosen include:

Fixed variable

- The composition of syngas consists of a mixture of CO, CO_2, CH_4 gases
- Operating temperature: 30ºC
- Updraft type gasification reactor

Variables Change

- gas agent flow rate: 10 lt/minute; 15 lt/minute; 20 lt/minute and 30 lt/minute
- agent gas: air

b. Tools and materials

1. Equipment used in research:
   - Gasifier series
   - Gas Analyzer
2. Material
   - horse manure
3. Testing tools

   The gasifier used in this research has a reactor diameter of 600 mm and a reactor height of 1500 mm.

c. Testing Procedure

The main ingredient needed in this research is livestock (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. Therefore, initial processing of horse manure needs to be carried out. The initial processing consists of reducing the water content of horse manure (feces) through a drying process first. The research continued with the process of making syngas using horse manure as feed material, in this case an updraft type gasification reactor was used and a thermal decomposition method was used with a gas media agent in the form of air and flowed using a compressor. The gas agent flow rate was varied to 10, 15, 20 and 30 lt/minute respectively. The gas composition is then detected using a gas analyzer, the test is carried out at the new and renewable energy laboratory at Mataram University, which will then be examined for the effect of air flow rate on the gas composition and the calorific value of the gas coming out of the gasifier.

d. Data analysis

This data analysis was carried out after and referring to experimental data, by comparing the CO, CO_2, CH_4 gas content produced in the gasification process with horse manure feed with various variations in gas agent flow rates, knowing the relationship between the gas agent flow rate and the composition of the gas that comes out. from the gasifier.

III. RESULTS AND DISCUSSION

The results of the research that has been carried out show that the greater the flow rate of the gas agent, the CO gas levels will increase with an average increase of 15%, as shown in Fig 2, however the increase in CO gas is not followed by an increase in methane gas levels, but there is a decrease methane gas (CH_4) content, on average, decreases by 13% along with the greater flow rate of the gas agent as shown in Fig 1. This is because the process of burning the feed material (horse manure) in the gasification reactor runs more perfectly so that CO_2 gas is released. more and more heat is produced and the higher the temperature. If the heat produced in the oxidation process is higher, it will have an influence on the pyrolysis process running well so that the greater the carbon formed.

Meanwhile, in the reduction process, CO_2 and carbon gas will be broken down into carbon monoxide gas. Thus, the greater the flow rate of the gas agent (air), the greater the CO gas formed will be (Fig 2). Because most of the CO_2 gas produced in the oxidation process has been broken down into CO gas in the reduction process, only a small portion of the CO_2 gas comes out along with the synthesis of gas produced in the gasification process as the flow rate of the gas agent increases (Fig 3). CO2 gas levels decreased by an average of 14%.

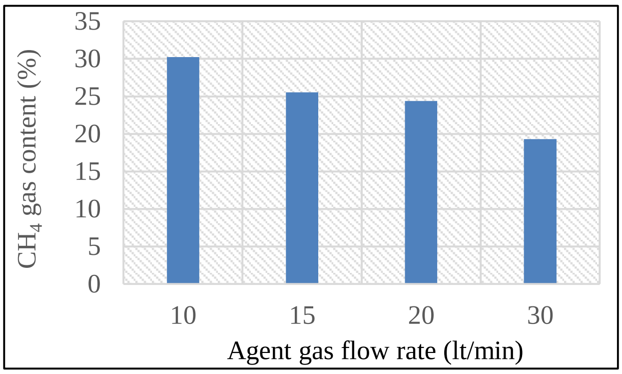

Figure 1. Graph of the relationship between variations in gas agent flow rate and CH_4 gas.

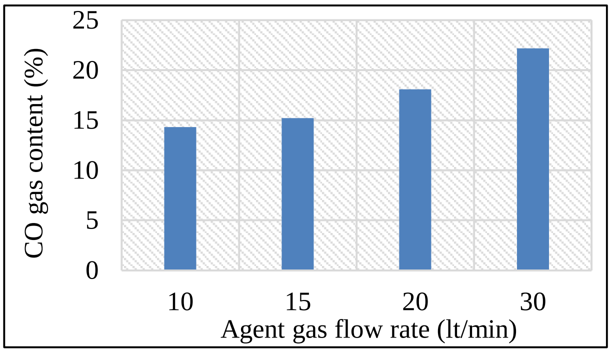

Figure 2. Graph of the relationship between variations in gas agent flow rate and CO gas.

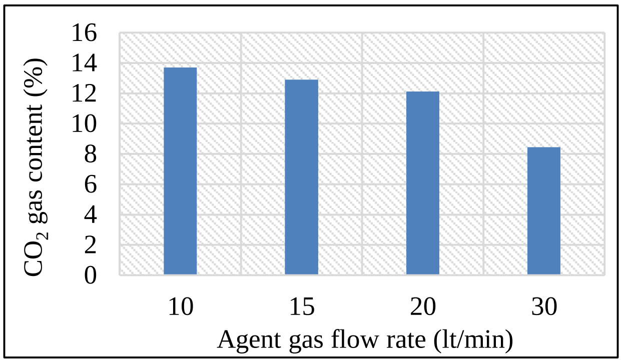

Figure 3. Graph of the relationship between variations in gas agent flow rate and CO_2 gas.

CONCLUSIONS

The research results show that the gasification process can not only be carried out with agricultural waste and coal as feed materials, but for livestock solid waste it can also be carried out with truly extraordinary results. The influence of the gas agent flow rate has an impact on CO gas production which is greater as the agent gas flow rate increases. This is inversely proportional to CH_4 gas and CO_2 gas which decrease with increasing gas agent.

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. 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.
5. 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.
6. Rudy Sutanto and Sujita, 2023, "Fuel Consumption Analysis in Syngas Fuel Combustion Engines with Pure Oxygen Agent Gas", Global Scientific Journal: Volume 11, Issue 2, pp. 874-878.