Characterization of Syngas Gasification of Coal and Sugarcane Bagasse with a Downdraft Type Gasifier

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Abstract. The increasing population growth of a country causes an increase in energy consumption, high energy consumption also has an impact on environmental conditions. Greenhouse gases (GHG) are problems that arise with the use of conventional energy. In 2030 Indonesia will reduce GHG by 29%. Efforts are being made for this by diversifying energy resources, namely reducing the use of conventional energy and implementing new renewable energy. Syngas is a type of renewable energy obtained from the conversion process of solid fuels such as coal and biomass with gasification technology which can be used as a renewable energy resource. The gasification process is carried out with a set of downdraft type gasifier prototypes in the Sriwijaya State Polytechnic energy engineering laboratory for study parameters on the quality of syngas from the coal gasification process based on the calorific value and biomass of bagasse. From research it is known that the calorific value of coal and the type of raw material influence the composition of syngas, the composition of CO in syngas is directly proportional to the calorific value of coal and bagasse where bagasse with a calorific value of 2,651 cal/gr has the lowest CO composition, namely 8.91 % while Coal C with a calorific value of 5,191 cal/gr has the highest CO composition, namely 19.56%. The same is true for the CO composition, the composition of H2, CH4 is also directly proportional to the calorific value of coal and bagasse.

Keywords: Syngas, Gasification, Caloric Value.

1 Introduction

The ever-increasing development of the human population is directly proportional to energy consumption. Conventional solid fuels have increasingly become the largest use of energy consumption in Indonesia due to their adequate availability. Based on data from the Ministry of Geology and Mineral Resources (ESDM) in 2020, Indonesia has total coal resources of 143.73 billion tons with coal reserves reaching 38.80 billion tons, which is supported by data according to BP Statistical Review of World Energy 2021, Indonesia occupies ranked seventh as the country with the largest coal reserves in the world1. In accordance with PP no. 79 of 2014 concerning National Energy Policy, the new and renewable energy mix target in 2025 is at least 23% and

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34% on 2050[1]. Syngas is an alternative gas fuel, namely gas produced from the gasification process, can be developed into a new renewable energy source [2].

Gasification is a thermochemical process technology that converts solid coal into combustible gas. In the gasification process, the main product desired is syngas[3,4]. By heating in a gasifier, biomass/coal raw materials will decompose into hydrogen gas, methane, carbon monoxide, carbon dioxide, nitrogen, pollutants and ash5. Hydrogen, methane and carbon monoxide called flammable gases are components of syngas that can be used as fuel, whereas, syngas content in the form of CO2, N2 and O2 is a non-combustible gas.[4,6]

Coal and bagasse are the two most frequently used raw materials for syngas. With reserves of 186.6 billion tonnes spread over nearly all regions, including 52% on the island of Sumatra, 47% on the island of Kalimantan, and 1% on other islands, Indonesia is one of the world's top producers of coal [7]. When petroleum production is currently declining, so is the utilization of coal energy sources. That being said, Indonesia has a potential for 146.7 million tons of biomass annually, and plant and animal waste, including food crops and plantations that generate a significant quantity of waste, can all be used and expanded.[8].

The composition of the syngas produced is influenced by the type of coal used; lignite coal produces more H2 gas than bituminous and anthracite coal9. In addition, the gasification agent used has a significant impact on the quality of the syngas produced; available gasification agents include air, oxygen, steam, and CO210. Therefore, this study will compare the heating values of syngas products produced from coal in downdraft type gasification equipment to those produced using oxygen.

2. Material And Method

2.1. Equipment and Raw Material

The tool used in the study was a set of downdraft type gasifier prototype tools. The research was carried out at the Energy Engineering Laboratory of Sriwijya State Polytechnic. The raw material used is bagasse and coal with a calorific value of 3500 kcalori, 4500 kcalori and 5900 kcalori

2.2. Research Procedure

Raw Material Preparation

Bagasse and coal raw materials before use are reduced in size, dried in the oven. and packaging is carried out in sample earrings[8]

Raw Material Characteristics

Coal and bagasse are the basic materials that were analyzed both proximally and ultimately to ascertain their qualities. 7. In addition, tests are conducted to ascertain each raw material's calorific value in the Sriwijaya State Polytechnic's chemical engineering laboratory.

Gasification Procedure

Each sample was put through a gasification process in a gasifier, weighing 5.0 kg of coal and bagasse respectively. The agent gas is introduced into the gasification process. In this study, oxygen serves as the agent gas. After that, ignition is carried out, and the purified gas from the flare stack is ignited with a flame to create a steady flame. This gasification process is continued until the reactor exhausts its flame and the temperature drops. [11]

Sampling

Using a gas detector, the extracted syngas product is examined to ascertain the composition of the gas generated during the gasification process.

3. Results And Discussion

3.1 Raw Material Characteristics

Table 1. Presents data for analysis of ultimate, proximate and calorific value of raw materials.[8]

Table 1. Analysis of Proximate, Ultimate and Calorific Value of Coal and Bagasse

Content	Unit	Method	Analisys			
			Coal A	Coal B	Coal C	Bagasse
Proximate Analysis						
Moisture	%	ASTM D 3173-17a	9,08	9,23	9,25	6,90
Ash Content	%	ASTM D 3174-12	7,46	7,37	7,35	1,89
Volatile Matter	%	ASTM D 3175-18	43,85	43,57	44,64	76,00
Fixed Carbon	%	ASTM D 3172-13	39,61	39,83	38,76	15,21
Nilai Caloric Cal/gram			3,843	4.502	5,911	2,651
ltimate Analysis						
Carbon (C)	%	ASTM D 5373-21	45,56	53,89	57,96	41,72
ydrogen (H)	%	ASTM D 5373-21	5,00	7,46	5,95	6,32
Nitrogen (N)	%	ASTM D 5373-21	0,50	1,04	0,83	0,32

Sulfur (S)	%	ASTM D 4239-18e1	0,21	0,23	0,35	0,22
Oxygen (O)	%	ASTM D 3176-15	30,93	22,01	18,04	43,84

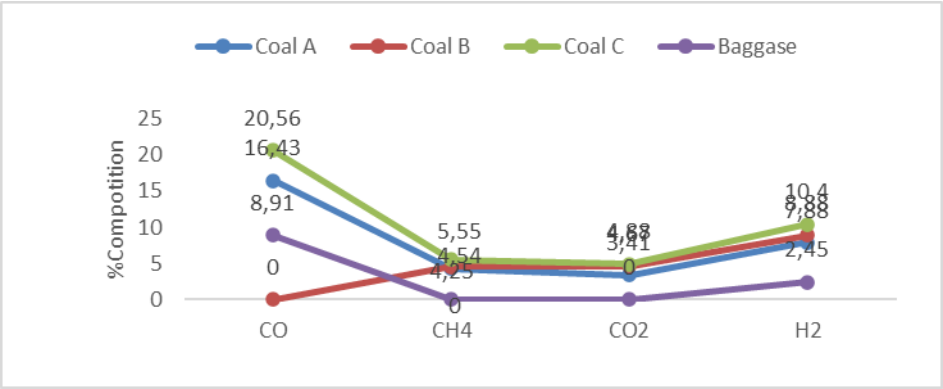

Figure 1. Graph of syngas composition from coal and bagasse

As observed in the accompanying graph, the primary constituents of syngas generated from coal and bagasse are CH4, H2O, and CO, with CO making up 16.43% of coal A, 18.83% of coal B, 20.56% of coal C, and 8.91% of bagasse. The calorific value of bagasse and the calorific value of coal for every sample are linear in this value. Corresponding to the calorific value of coal and sugar cane bagasse, the composition of H¬2 in coal A is 7.88%, in coal B it is 8.88%, in coal C it is 10.20%, and in bagasse it is 2.45%. The percentage of CH¬4 in coal A is 4.25%, in coal B it is 4.54%, in coal C it is 5.55%, and in bagasse it is 1.55%. This percentage is also strongly related to the calorific value of coal and the leftover sugarcane dregs. In the meantime, the composition of CO2 in coal A is 3.41%, in coal B it is 4.67%, in coal C it is 4.88%, and in bagasse it is 8.88%. This value indicates that bagasse generates the highest CO2 value, indicating that the gasification process of bagasse is more likely to occur in a complete combustion process, which is caused by the bagasse's relatively large oxygen content.[14]

4. Conclusion

The composition of Syngas resulting from the gasification process is influenced by the calorific value of coal and bagasse. The results of the analysis of the composition of CO gas in syngas are directly proportional to the calorific value of coal and bagasse where bagasse with a calorific value of 2,651 cal/gr has the lowest CO composition, namely 8.91%. Coal C with a calorific value of 5,191 cal/gr has the lowest CO composition. high, namely 20.56%, as well as for other gas compositions, namely the

composition of H_2 and CH_4, which is also directly proportional to the calorific value of coal and bagasse. [5]

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