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Gasification of *Artocarpus Heterophyllus* to Produce Syngas

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ABSTRACT

Indonesia, known for its abundant plant commodities, utilizes various agricultural resources for multiple industries. Among these resources is jackfruit wood (Artocarpus heterophyllus), commonly used in furniture manufacturing. The powdered wood waste generated from this industry presents a viable biomass source for syngas production through gasification. This study investigates the gasification process using a gasifier, focusing on the impact of varying wood powder mass on syngas output. Key dependent variables measured include syngas yield, production time, and gas composition. Findings reveal that increasing powdered wood's mass enhances syngas production and prolongs the duration of gasification. Analysis of the syngas composition indicates the presence of 10.362% CO and 0.862% CH_4. These results demonstrate that jackfruit wood powder is an effective biomass material for gasification, contributing to sustainable energy solutions, particularly in gas fuel applications.

1. Introduction

Artocarpus heterophyllus, commonly known as jackfruit, has been identified as a significant biomass resource with potential for gasification processes. Studies have shown that this species contains substantial biomass, making it a valuable feedstock for gasification [1], [2]. The high biomass content of artocarpus heterophyllus makes it a favorable choice for gasification, as biomass-rich feedstocks are known to enhance gasification efficiency [3], [4].

Furthermore, artocarpus heterophyllus has been recognized for its nutritional value, being rich in carbohydrates, minerals, dietary fiber, and vitamins [5]. This nutritional richness can translate into a high energy content when used as a feed for gasification processes [6]. Gasification can convert various biomass like bagasse [7], sengon [8], mahogany [9], tamarind [10], coconut wood [11], and oil palm shells and empty fruit bunches [12]. Additionally, the use of artocarpus heterophyllus in traditional medicine, such as its diuretic and anti-diabetic properties, highlights its diverse applications beyond just being a biomass feedstock [13], [14].

Gasification of biomass, including species like artocarpus heterophyllus, has been extensively studied for hydrogen and syngas production. Research has shown that gasification of biomass can yield significant amounts of hydrogen and ethanol, indicating the potential for biofuel production [15]. Moreover, the use of biomass in gasification processes has been explored in various reactor configurations, such as entrained flow gasification and catalytic gasification, to optimize gas production and minimize tar formation.

Biomass gasification is a thermochemical process that has gained significant attention due to its potential to convert biomass into valuable products with various applications. This process involves the partial oxidation of solid carbon-based feedstock, resulting in the production of a gaseous mixture known as syngas, which typically consists of hydrogen, carbon monoxide, carbon dioxide, methane, light hydrocarbons, tar, char, ash, and minor contaminants [16]. The introduction of steam during biomass gasification has been shown to enhance the quality of the produced gas by promoting the production of low-molecular-weight gases through steam-reforming reactions of volatiles and nascent char [17]. Additionally, the use of steam has been reported to improve gas quality by increasing the hydrogen yield through tar and higher hydrocarbon reforming, as well as the water gas shift reaction [18].

Moreover, the addition of a catalyst in biomass gasification can further enhance the hydrogen content in the synthesis gas, reduce biomass tar content during pyrolysis, and improve energy utilization efficiency [19]. Studies have also indicated that the introduction of biomass during co-gasification with low-level coal or the addition of biomass ash can significantly impact gasification reactions, with alkali and alkaline earth metals in ash promoting these reactions [20]. Furthermore, the use of CO_2 as a reacting gas in biomass gasification has been explored, highlighting the versatility and potential for different gasification conditions [21].

This research will conduct the gasification of Artocarpus heterophyllus biomass to produce syngas, which presents a promising feedstock for gasification processes in Indonesia due to its high biomass content, nutritional value, and potential for biofuel production. Developing this biomass resource for gasification can contribute to sustainable energy production and biofuel generation.

2. Research Methodology

2.1. Materials

The material used in this study is an *Artocarpus Heterophyllus* sawdust. The powder was obtained from one of the furniture craftsmen who produced doors, windows, and other materials located in the Kalasan district of Sleman Yogyakarta, which is a waste from the manufacture of furniture itself.

This study used a gasification unit (including a reactor, blower, filter, temperature logger, and gas analyzer), bucket, weight scale, and syringe.

2.2. Procedures

The research begins by weighing *Artocarpus Heterophyllus* sawdust according to variables of 500, 1000, 1500, 2000, and 2500 grams. The *Artocarpus Heterophyllus* sawdust is weighed and put into the gasification reactor. The *Artocarpus Heterophyllus* sawdust inside the gasification reactor is heated with the help of a little coal, where the blower assists the airflow. Once the *Artocarpus Heterophyllus* sawdust starts to burn, the reactor is closed so that enough fluid flows from the air inlet to the outlet that the filter misses. During the combustion process, tar, a by-product of combustion, is removed at certain times so as not to interfere with the emission of gases. The tar that has been released is measured in volume and then density in the lab. After the combustion process is completed, ashes or residues are weighed. It should be noted that the *Artocarpus Heterophyllus* sawdust must be properly dry to facilitate the burning process.

The data taken during the test was the temperature inside the reactor (upper and lower temperatures) with a 10-minute interval. The sampling is done using an injection and then inserted into a vacuum tube for testing in the laboratory. This test aims to find out the composition of the resulting syngas.

3. Results and Discussion

The data taken during the test was the temperature inside the reactor (upper and lower temperatures) with a 10-minute interval. Syngas are injected and inserted into a vacuum tube to be tested in the laboratory. This test aims to find out the composition of the resulting syngas. From the syngas data, we will know the influence of the weight of the feed on the syngas, the effect of the weights on the time of production of the syngas, and the composition of the syngas.

3.1. The Influence of The Weight of The Feed on The Syngas

To figure out how much syngas is produced, some data is needed from the research, namely the remaining combustion ash weight and tar weight. From both of these data will be obtained data on the influence of feed weight on the Syngas produced. Below is the data on the weight influence of cane powder on Syngas weight presented in Fig. 1.

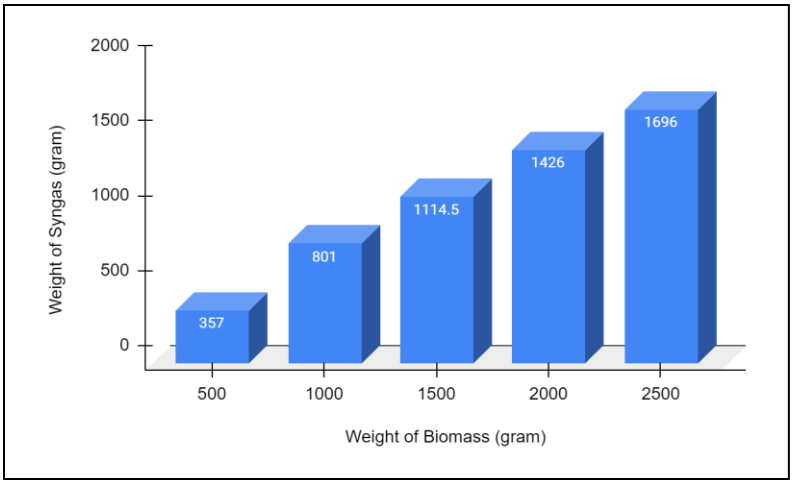

Fig. 1. Correlation of weight of biomass and weight of syngas

Fig. 1 shows a clear relationship between the weight of the raw wood dust material and the produced syngas mass. As the weight of the wood dust increases, there is a corresponding increase in the mass of the resulting syngas. Fig. 1. Describes a positive correlation between the weight of the raw wood dust material and the produced syngas mass. Trendline indicates that with the increasing weight of wood dust, the weight of syngas also increases proportionately. This observed relationship aligns with expectations, as larger amounts of raw wood dust materials provide more gasification material, resulting in increased syngas production. Furthermore, the findings are consistent with previous studies on biomass gasification [22]. In conclusion, the results show that the weight of raw wood materials, sawdust, significantly affects syngas production. Understanding this relationship is crucial to optimizing the gasification process and maximizing synergy outputs in biomass conversion applications [23].

3.2. The Effect of The Weights on The Time of Production of The Syngas

In addition to the remaining combustion ash and tar weight, other data collected during this study were the time the combustion gas was capable of burning when triggered by fire. From this time, data will be known on the influence of wood powder feed on the time that indicates the presence of syngas in the gas resulting from combustion. The wood powder's weight influence data on the syngas' production time is presented in Fig. 2.

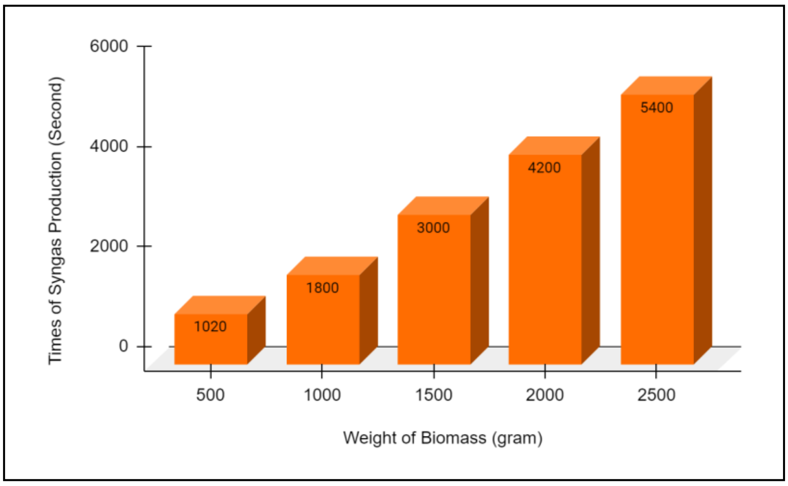

Fig. 2. Correlation of weight of biomass and times of syngas production

Fig. 2 shows the relationship between the raw material's weight and the syngas' combustion time. As the weight of the biomass increases, there is a corresponding increase in the syngas' burning time, indicating a longer burning duration. This trend is reflected in Fig. 2. Fig. 2. Visually represents a positive correlation between the weight of the raw wood dust material and the syngas' combustion time. The graph shows that as the weight of biomass increases, the combustion time of syngas also increases [24]. These findings suggest that the amount of biomass raw materials plays a significant role in the combustion characteristics of syngas. The higher weight of the syngas raw material results in longer burning times, potentially due to variations in gas composition and combustion kinetics [25]. Understanding the heavy influence of biomass raw materials at the time of combustion of syngas is essential to optimize the burning process and ensure efficient use of biomass resources [26].

3.3. Composition of Syngas

Gasification converts solid fuels through combustion with a limited air supply into combustible gases such as CO, CH_4, and H_2. To find the concentration of the compound in the Syngas from the gasification of the powder, sampling was performed into the vacuum tube 10 ml and gas chromatography analysis. Here are the results of Syngas's analysis on biomass gasification.

Table 1. Concentration of CO, CH_4, and H_2 in 10 ml of syngas

Component	Concentration (%)
CO	10.362
CH_4	0.862
H_2	0

From the data, it can be concluded that CO has the highest concentration in Syngas analysis, which is 10,362% [27]. It suggests that CO significantly contributes to the combustible gas or syngas. Meanwhile, the H_2 content in Syngas is 0%, indicating that H_2 is not present in significant amounts in the sample analyzed. On the other hand, the content of CH_4 in syngas is 0.862%, which indicates a small amount but still plays a role in the syngas constituent [22], [25].

4. Conclusion

From the research that we have done on the gasification of biomass of wood grinding powder with a free variable of feed weight, it can be concluded that wood grilling powder is one of the biomass that can be used as a raw material for gasification in meeting energy needs. It is indicated by the emergence of fire when the gas resulting from combustion is capable of burning when triggered by fire. The research results showed that the more inserts of wood grinding powder, the more Syngas are produced during the process of gasification, and the more inserts of the wood grilling powder are produced, the longer the Syngas production time. In these two bound variables, there is an alignment between the weight of the Syngas and the time of production, which increases in line with the addition of the number of powder feeds of the wood. The analysis of Syngas found that 10 ml of syngas contains CH_4 0.862%, H_2 0%, and CO 10.362%.

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