Utilization of wood biomass as a renewable energy source using gasification technology

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Abstract. One of the potential uses of biomass is gasification. Therefore, various breakthroughs need to utilizing biomass. One of the possible services of biomass is gasification. The best method for producing woody biomass is gasification conversion technology. The principle of biomass gasification uses incomplete combustion in a room withstand high temperatures called a gasifier. Burning order imperfect can occur, then the air with a small amount of stochiometric needs of explosion flowed into the reactor to supply oxygen needs using a fan/blower. The combustion process that occurs causes a thermo-chemical reaction that produces CO, H2, and methane gas (CH4). The Downdraft gasifier, where the combustible gas had passed to the oxidation part of the combustion by being pulled down so that the resulting gas will be cleaner because the oil will burn when it passes through the oxidation part of the explosion. Gasification of wood sawdust can produce gas fuel. Where more biomass is classified, it will increase the amount of gas delivered to become fuel.

1. Introduction

The depletion of fossil fuel reserves and the increasing human population are very contradictory to the energy requirements for human survival and economic and social activities. In the last five years, Indonesia has experienced a decline in national oil production due to the natural decline in oil reserves during the whole production period. Whereas with the increase in population, the need for transportation facilities and industrial activities also increases the demand and consumption of power oil. To meet the needs of these fuels, the government imports some of the power. Seeing these conditions, the government has issued Presidential Regulation No. 5 of 2006 concerning the National Energy Policy to develop alternative energy sources as a substitute for fuel. Although the policy emphasizes coal and gas as a substitute for BBM, it also stipulates renewable resources such as biofuels as alternatives to power. The government has also given serious attention to biofuel development by issuing Presidential Instruction No. 1 of 2006 dated January 25, 2006, concerning the Provision and Utilization of Biofuel as another fuel [1]. Therefore, exploration and exploitation of alternative sources is now a necessity. Through the Ministry of Energy and Mineral Resources, the government is intensely promoting the use of biofuels for energy-saving and saving the environment.

Biomass is organic material produced through photosynthetic processes, both in the form of products and waste. Examples of biomass include plants, trees, grass, yams, agricultural waste, forest waste, feces, and livestock manure. Besides being used for primary purposes of fiber, foodstuffs, animal feed, vegetable oil, building materials, and so on, biomass has operated as an energy source (fuel). In general, what is used as fuel is biomass, which has low economic value or waste after the primary product had
taken. In Indonesia, wood is a biomass that has long been known by the community and is a renewable energy source. Wood-derived biomass's potential includes sawn waste, plywood waste, and logging waste. In addition to its availability in Indonesia, wood biomass also tends not to impact the environment negatively [2].

Biomass energy can be an alternative energy source as a substitute for fossil fuels (petroleum) because of some beneficial properties that can utilize sustainably. It does not contain sulfur, does not cause air pollution, and increases forest and agricultural resources' efficiency.

Some biomass that has considerable potential is wood waste, rice husks, straw, bagasse, coconut shells, palm shells, livestock manure, and municipal waste. Biomass energy using the briquette method is to convert solid raw materials into a compacting form that is easier to use.

Wood biomass has some advantages, such as an energy source that can provide renewable to provide sustainable energy (sustainable) as fuel. Biomass needs to biomass conversion. Biomass conversion technology, of course, requires differences in the tools used to convert biomass and produce fuel differences. One of the potential uses of biomass is gasification. Therefore, various breakthroughs need to utilizing biomass. One of the possible services of biomass is gasification. The best method to produce wood biomass is gasification conversion technology, which affects charcoal briquettes' characteristics, namely density or density of charcoal powder, powder fineness, carbonization temperature, and briquette raw material [3].

2. Biomass in Energy Source
Before knowing fossil fuels, humans had used biomass as an energy source, for example, by using wood to light a campfire. Since humans turn to oil, natural gas, or coal to produce energy, biomass has displaced from human life. But the massive use of energy has made humans experience an energy crisis—this due to the high dependence on fossil fuels such as petroleum and natural gas. Fossils are non-renewable natural resources, so several alternative energy sources need to develop, so overcoming the future binding energy is biomass energy.

In general, biomass raw materials into two main types, such as woody trees and herbaceous. At present, woody material has estimated to represent 50% of the total bioenergy potential, while the other 20% is straw obtained from agricultural by-products [4]. Logs are an example of the first known application of biomass for energy. However, the use of wood bars for energy purposes currently competes with the help of non-energy. It has more value, such as for pulp production and the furniture industry. It causes high raw materials prices for processing biomass into derivatives from gas synthesis (Biomass to liquid) and increased trees' consumption. Woody's raw material in question is woody material resulting from the processing of paper, furniture, and others.

As a fuel, biomass needs to be processed first to be easily used, known as biomass conversion. Biomass conversion technology, of course, requires differences in the tools used to convert biomass and produce fuel differences produced. In general, biomass to fuel conversion technology has been divide into direct combustion, thermochemical conversion, and biochemical conversion. Direct discharge is the most straightforward technology because, in general, biomass can directly burn [5].

2.1. Biomass conversion
Now the combustion heat will be converted into electrical energy through turbines and generators. The heat from the biomass discharge will produce steam in the boiler; then, the vapor will be transferred into the turbine to make the rotation and move the generator. Rotation of the turbine is converted into electrical energy through a magnet in the generator. Direct combustion of biomass has weaknesses so that in the current application, it has begun to apply several technologies to increase the benefits of biomass as fuel. Some applications of conversion technology are:
• **Bio briquette:** Briquette is one method used to convert biomass energy sources into other biomass forms by compressing them to become more organized. The famous briquettes are coal briquettes, but it is not only coal briquettes, other biomass such as sawdust, sawdust, and other biomass wastes.

• **Gasification:** According to Sulaiman [1] gasification is an alternative in the framework of energy-saving and diversification programs. Besides, gasification will help overcome the problem of handling and utilizing waste from wood products. The gasification process for woody material is not possible because the particle size is too large or too different, the water content and the content of impurities. Therefore woody biomass requires preliminary treatment and transformation into an appropriate raw material for the gasification process and other processes. The raw material is usually in the form of wood chips, sawdust, or pellets. The advantage of gasification is that gas is more comfortable to ignite, causes fewer emissions, lights more easily controlled, and is for heat and power needs [6].

• **Pyrolysis:** Pyrolysis or commonly called thermolysis, is a chemical decomposition process using heating without oxygen. This process is part of the carbonization process, which is a process for obtaining carbon or charcoal. Some of the pyrolysis processes are high-temperature carbonization (HTC), more than 500°C [11]. The pyrolysis process produces a product in solid fuel, namely carbon, a liquid in a mixture of tar, and several other substances. Other products are gases such as carbon dioxide (CO2), methane (CH4), etc.

• **Liquification:** Liquification is the process of changing form from gas to a liquid by condensation, usually through cooling, or changing from solid to drinks by melting, heating, or grinding and mixing with other juices to break bonds. In energy, liquefaction occurs in coal and gas into liquid forms to save transportation and facilitate utilization [7].

• **Biochemistry:** Another use of biomass energy is through biochemical processes. Examples of functions included in biochemical processes are hydraulic, fermentation, and anaerobic digestion. Anaerobic digestion is the breakdown of organic material or cellulose into CH4 and other gases through biochemical processes. In addition to anaerobic digestion, the process of making ethanol from biomass belongs to biochemical conversion. Biomass rich in carbohydrates or glucose can be fermented so that it breaks down into ethanol and CO2. However, carbohydrates must first decompose (hydrolyze) into glucose. Fermented ethanol generally has high moisture content and is not suitable for its use as a substitute fuel for gasoline. This ethanol must distill in such a way as to reach ethanol levels above 99.5% [7].

• **Carbonization:** Carbonization is a process to convert organic material into charcoal. The carbonization process will release flammable substances such as CO, CH4, H2, formaldehyde, methane, formic, and acetic acid as well as non-combustible substances such as CO2, H2O, and liquid tar. The gases released in this process have a high heating value and can be used to meet the carbonization process [8].

2.2. **Some Processing of Wood Biomass For Energy Sources**

Some examples of the results of processing biomass from wood that we often encounter include:

• **Biobriquette solid:** Biobriquette is a solid fuel containing carbon, has a high economic value, and can be ignited for a long time. This bio briquette is charcoal obtained by burning dry biomass without air and compressed with adhesives so that its shape becomes more organized. Using bio briquette as fuel, we can save the use of wood as the main product of the forest. By utilizing sawdust as a material for making biobriquette, it will utilize waste forest products while reducing air pollution, because so far, the existing wood sawdust is only burned just like that (wood) [9].
Prepare a gasifier unit equipped with a thermocouple and blower

Give water at the bottom of the gasifier as a seal

Inserting weighed sawdust into the gasifier

Run the blower to drain the combustion air into the gasifier

Light up biomass through the ignition hole

Measuring changes in gasification temperature using a thermocouple

Measuring the time of output of the gas produced by the burning gasification

Take a sample of gas from the gasification results and store it in a vacuum tube.

Weighing tar and ash produced from the gasification process

Figure 1. Flowchart of wood powder gasification research

- **Wood Briquettes**: Wood briquette is wood chips or sawdust that is changed in shape, size, and density by pressing a mixture of sawdust with an adhesive into a product that is more efficient in its use as fuel.

- **Wood Charcoal**: Wood charcoal is a porous solid material and is the result of combustion from woody material containing carbon (C). Most of the pores are still closed with hydrocarbons and other organic compounds. Its components consist of fixed carbon, ash, water, nitrogen, and sulfur. The shape is in the form of small lumps around 5-10 cm and has a deep black color [10].

3. Research Methodology
This study used equipment for the gasification process, which is equipped with a thermocouple to measure the temperature during the gasification process. The method used in this study is a batch feed system, which is a method by entering some biomass into the reactor and then ignited by fire. The raw material used in this study uses wood dust. In the initial process, the sawdust is dried in the sun for ±4 hours to reduce the water content. The experiment was conducted after all gasification equipment and measuring instruments used were confirmed to be functioning properly.
4. Results and Discussion
It can be known according to Kitani and Hall (1989) that the raw material for sawdust has a moisture content in the range of about 25-55%. The sawdust we use has a water content of approximately 29.6%. This indicates that mahogany wood powder can be used for biomass.

![Figure 1. Value graph of mahogany wood powder on syngas yield](image)

From Figure 1 about the effect of the value of mahogany sawdust on syngas yield with a variable weight of 1,500 grams; 2,000 grams; 2,500 grams; 3,000 grams; and 3,500 grams produce syngas value, 64.04%; 65.15%; 68.40%; 68.70%; and 70.71%. The graph shows that the more mahogany sawdust is fed, the more syngas is produced.

![Figure 2. Graph of the weight of mahogany wood powder on the time of syngas removal](image)

From Figure 2 about the effect of the weight of mahogany sawdust on the time of syngas removal with a variable weight of 1,500 grams; 2,000 grams; 2,500 grams; 3,000 grams; and 3,500 grams produce syngas with a long period of expenditure, namely 1,800 s; 5,400 s; 6,000 s; 10,800 s; and 18,000 s. The graph shows that the weight of 3,500 grams of mahogany sawdust produces syngas with the most extended expenditure of 18,000 s. At the same time the fastest time for syngas removal weighing 1,500 grams is during 1,800 s.
From Figure 3. The results of CH$_4$ analysis on the mass of material 1.5 kg, 2.5 kg, and 3.5 kg. From these data, the 1.5 kg sample has the smallest concentration of 0.666%, while the 3.5 kg sample has the highest concentration in the CH$_4$ analysis of 1.868%.

From Figure 4. Obtained the results of CO analysis on the mass of material 1.5 kg, 2.5 kg, and 3.5 kg. CO has the most prominent role in producing gas capable of burning or syngas. From these data, it can be seen that the 3.5 kg sample has the largest concentration of 15.902%, while the 2.5 kg sample which has the smallest concentration in the CO analysis of 8.090%.

From Figure 5, the results of H$_2$ analysis on the mass of material 1.5 kg, 2.5 kg and, 3.5 kg are obtained. From these data, the 2.5 kg sample has the largest concentration of 20.965%, while the 3.5 kg sample has the lowest concentration in the H$_2$ analysis of 3.948%. This indicates that the material used in the 3.5 kg sample has a relatively lower water content than the 1.5 kg and 2.5 kg samples.
5. Conclusions
The conclusion was obtained based on research that has been done that gasification of wood sawdust can delivered gas fuel. Where more biomass is classified, it will increase the amount of gas produced to become fuel. The average gas content of the gasification product was 1.41% CH₄, 10.72% CO and 12.68% H₂.

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