Biomass Power Plant Prototype (Pltbm) Based On Rice Husk Agricultural Waste Using Downdraft Gasification Technology

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ABSTRACT

Almost all power plants in Indonesia still use non-renewable energy sources which will run out if used continuously. One of the renewable energies that can be utilized is biomass which can be converted into electrical energy by utilizing the gasification process to produce syngas which is burned and drives the stirling engine, then the stirling engine will drive the generator, and the generator converts kinetic energy into electrical energy. This research design uses rice husk as fuel in the gasification process to produce syngas and a stringing machine as a generator of kinetic motion which will be converted into electrical energy using a generator and will be connected to a monitoring system to display voltage and current results on the LCD. The monitoring system uses current and voltage sensors, an Arduino Nano microcontroller and a data logger shield to store data history. There are results from research testing that has been carried out. The first result is the effective flame of the gasification reactor using 1 kg of fuel with drying time for 9 minutes and without drying for 4 minutes and the process of the reactor in producing gas with drying for 10 minutes and without drying for 13 minutes. The second result is the voltage and current values generated every 5 seconds until the 25th second are 2.52V, 2.47V, 2.52V, 2.75V, 2.76 V and 1.45mA, 1.56mA, 1.87mA, 3.11mA, 2.70mA.

Keywords: *Power Generation, Biomass, Gasification, Stirling Engine, Arduino Nano, Data Logger Shield*

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INTRODUCTION

Along with the rapid development of technology and the economy today, the need for energy is also increasing because of the attachment to one another. However, most of the energy consumed today, especially fossil fuels such as coal and oil, is categorized as non-renewable energy. Non-renewable energy sources are limited energy sources created from the remains of animals that became extinct millions of years ago and will run out if used continuously. On the other hand, the use of non-renewable energy such as fossil energy also has a negative impact on the environment because of the pollution it produces. Electricity production still relies heavily on fossil fuels as its main energy source. To break away from dependence on fossil energy, it is very important to develop long-term alternative energy sources that can be used sustainably.

Renewable energy is defined by the International Energy Agency (IEA) as sustainable renewable energy obtained from natural processes. The IEA has categorized renewable energy into solar, biomass, water, wind/wind, geothermal, marine, biofuels and hydrogen. The term biomass itself is used to describe all organic matter obtained from cultivated plants, algae, and organic waste that can be used as a renewable alternative energy source.

In the context of increasingly limited fossil energy, increasingly serious environmental pollution and increasing energy needs, the use of biomass is starting to gain interest because it can be a solution to reduce energy costs and become a source of electrical energy, one of which is the use of agricultural waste. Palm shells, rice husks, corn cobs, bagasse and sawdust are examples of agricultural wastes that can be used as fuel for electricity production.

Several studies have been carried out, such as the management of organic waste from biomass and manure into electricity, because most of it is only used as fertilizer and very rarely used for electricity generation. The biomass is processed using a digester for 28 days to produce methane. The gas released from the digester is channeled into the combustion chamber of the internal combustion engine generator. The results showed that 105 kg of organic waste and livestock manure biomass can produce 25 kg of methane which can produce an electric voltage of 228 Volts with a load of 150 Watts (Fachrudin, Setiawidayat, 2019).

Research on the design of biomass gasification equipment has also been carried out because many Indonesian people do not have access to fuel and use traditional stoves for cooking. Indonesia actually has a lot of potential for clean and renewable energy, as we all know. The idea to make a biomass gasification tool that can be used in places that still lack access to energy arose when it was observed that Indonesia's achievements in the use of clean energy and renewable energy were still low, even though the potential for renewable energy was quite high and widespread. This study succeeded in showing that a gasifier built with beach sand and rice husk fuel can produce flammable gas that can be used by the community, especially in coastal areas (Umar, Mulyawan, 2021).

Gasification is one technique that can be used to convert biomass into usable energy. The goals of this research included developing a gasification furnace design and figuring out how to light it, how hot the flame should be, and how many calories it could produce. The downdraft type gasification reactor used in this study produces gasification products of gas and air in the same direction, namely downward. The results showed the ability of the downdraft gasifier or continuous downdraft gasifier to ignite within 10 minutes with a maximum temperature of 5730C, flame duration of 36 minutes, and boiling point of water 2626.7 kJ. Meanwhile, it can ignite within 6 minutes, reaches a maximum temperature of 5730C, burns for 62 minutes, and has a heating value of 4369.2 kJ (Khoiri, 2016).

By studying some of the studies that have been carried out above, this research was conducted to develop and innovate the utilization of organic biomass waste, especially in terms of converting energy into electrical energy. The process used in this study is the gasification process using rice husk fuel with the aim of producing syngas which will be burned. The syngas combustion results are used to drive the Stirling engine and then drive the generator. After that the generator converts kinetic energy into electrical energy which is connected to a monitoring system to display the results of voltage and current on the LCD.

METHODS

One model strategy for research and development is the 4D model approach. The four main steps of a 4D model are definition, design, development and deployment, as the name suggests. The following is the process of making 4D model learning tools:

1. Define Stage
In the definition stage, the authors analyze and collect information on how far development needs to be carried out on a prototype power generator of rice husk agricultural waste biomass using downdraft gasification technology. This can be done through an analysis of previous research and literature studies.
2. Design Stage (Design)
At the design stage the authors design tools that will be used to test gasification reactors and monitor voltage currents in the monitoring system.
3. Stage Develop (Development)
At the development stage, the writer will develop the product through research and test the product to find out the lack of tools for tool repair. Validation is needed to test the feasibility of the product that has been developed.
4. Disseminate Stage
At the dissemination stage the author will only create a product that will later be used as a learning medium on campus.

How the Tool Works

The biomass energy source used is rice husk agricultural waste which will later be put into a downdraft gasifier type gasification reactor. Before being added, rice husks must first be dried in the sun so that the gasification process can run optimally. Then do the weighing of the amount of rice husk to be used. After that, the rice husk is put into a gasification reactor and burned with limited air, so that most of the gas produced contains hydrogen, carbon monoxide and methane. These gases are then reacted with oxygen (obtained from the air) to produce hot combustion gas known as syngas. The syngas is then burned to produce fire which is used to drive the stirling engine and activate a generator which functions as a converter of mechanical energy into electrical energy. The resulting voltage range is 3V and 4mA current. After the generator produces electrical energy, current and voltage sensors will be active to calculate the resulting voltage and current which will be read by the microcontroller and the data will be displayed on the LCD and data recording will be automatically stored on the SD Card via a data logger sheet.

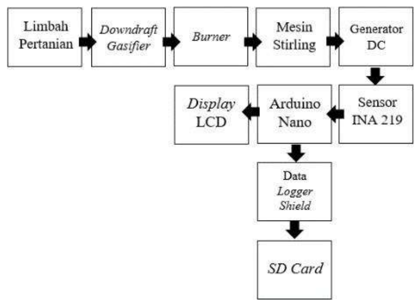

Figure 1 Tool Design

Hardware Components

1. Downdraft Gasifier
Downdraft Gasifier is a type of reactor for gasification that circulates biomass (agricultural waste) and air from top to bottom to the zone in the hot gasification reactor, this allows ash or tar in the smoke to burn to produce cleaner syngas.

2. Stirling engine
Stirling engine is another alternative for the production of electrical energy from biomass. The Stirling engine has in common with an internal combustion engine, namely a device or converter that produces mechanical energy, which is then converted into electricity by a generator. The difference is that the Stirling engine is a heat engine that converts heat into mechanical energy. Meanwhile, heat generation occurs outside the device, so the Stirling engine can also be used as an external combustion engine if the heat source comes from combustion outside the unit. In this case, gasification can also be used, but it is positioned as a heater or heat generator used by the stirling engine.

3. Generators
A device used to generate electrical energy. In the process of designing this PLTBm it becomes a component that generates electrical energy from the kinetic energy of the Stirling engine.

4. Sensor Circuit
Here the author uses current, voltage and power sensors which function to monitor the output current, voltage and power generated from the generator. The author uses current, voltage, and power sensors which will detect the output current and voltage generated by the generator which then the sensor will read by the microcontroller.

5.Arduino
Components that function as data centers to control electronic components with programs.

6.LCD
Direct monitoring system for current and voltage sensors generated by the generator.

7. Data Logger Shield
A component that functions as a link between the Arduino Nano microcontroller and the SD card, where the data logger shield has an SD card slot and RTC (Real Time Clock).

8. SD Card
Media as data storage of current, voltage, and power sensor results that have been forwarded by the data logger shield from the microcontroller.

Software Components

Arduino Software Programs
The programming language used by Arduino is the C programming language. The C programming language is a high-level programming language because C language can be understood and learned easily because of its proximity to human language. The C programming language is generally used as an operating system and language compiler. In this case the author uses Arduino Nano as a device that will be connected to this Arduino software.

RESULTS AND DISCUSSION

The downdraft gasification reactor is made of iron plates and pipes with a thickness of approximately 2 mm to withstand heat during the gasification process. The reactor is designed in such a way as to get the best results during the rice husk gasification process experiment. The size of the iron plate and pipe used varies according to a predetermined design. Additional components as a complement to this gasification reactor are a 2” size blower as the main air supplier and plastic pipes as a medium for air distribution from the blower to the gasification reactor.

The voltage and current monitoring system is made using a series of several electronic components. The main components are the INA219 sensor, arduino nano, data logger shield, and LCD. The way it works is that the voltage and current from the generator which has produced electrical energy will be read by the INA219 sensor which is then processed by Arduino Nano and displayed on the LCD. The history of the results of the voltage and current data will be stored on the SD Card via the data logger shield.

In this study, there are two things that must be tested, namely testing of the gasification reactor and monitoring system. The stages of testing the gasification reactor were carried out, namely the length of time for releasing methane gas and the flame produced in the downdraft gasification process and the monitoring system testing stages carried out, namely the current and output voltage results from the stirling engine generator displayed on the LCD. Testing of the downdraft gasification reactor was carried out by calculating the length of time needed for the reactor to remove methane gas from the start of combustion and the length of time the effective flame was removed.

Figure 2 Gasification Reactor Testing

The following is the test results data from the downdraft gasification reactor:

Keterangan	Jumlah Bahan Bakar	Waktu	
		Penjemuran	Tanpa Penjemuran
Proses reaktor menghasilkan gas	1 Kg	10 Menit	13 Menit
Nyala api efektif		9 Menit	4 Menit

Figure 3 Gasification Reactor Test Results

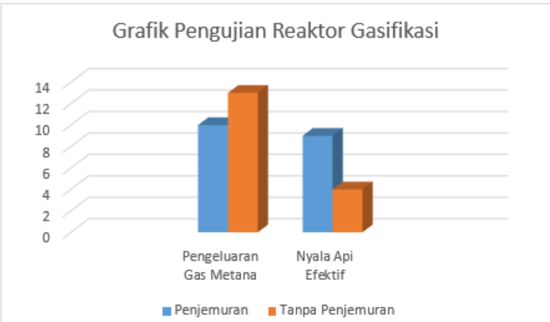

Figure 4 Gasification Reactor Testing Chart Based on the test results above, it can be explained that the test was carried out with 2 different processes, namely using rice husks that had been dried in the sun and rice husks without drying in the same amount of 1 kg. Rice husk that has been dried takes 10 minutes to produce syngas and 9 minutes for an effective flame. While the processing time for rice husk without drying in the sun to produce syngas is 13 minutes and the effective flame is 4 minutes.

Based on these tests, it can be concluded that testing the gasification reactor using rice husk which has been dried in the sun produces syngas with a faster time and longer effective flame than the process using rice husk without drying. So, the gasification reactor process in producing syngas and effective flame itself depends on the water content contained in the rice husk.

The voltage and current monitoring system is a system used to monitor the voltage and current generated by the generator which is then displayed on the LCD and the data history will be stored on the SD Card via a data logger shield.

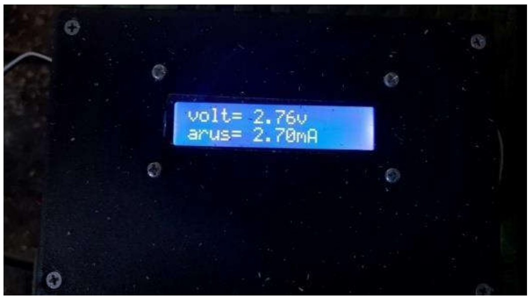

Figure 5 Monitoring System Testing

The following is the test result data from the voltage and current monitoring system:

Penyalaan Api Terhadap Gas Metana	Tegangan pada Tampilan LCD	Arus pada Tampilan LCD
5 detik	2,52 V	1,45 mA
10 detik	2,47 V	1,56 mA
15 detik	2,52 V	1,87 mA
20 detik	2,75 V	3,11 mA
25 detik	2,76 V	2,70 mA

Figure 6 Monitoring System Test Results

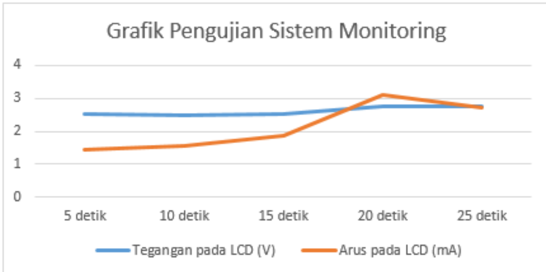

Figure 7 Graph of Monitoring System Testing Based on the test results above, it can be concluded that the prototype of a biomass power plant with rice husk agricultural waste can generate voltage and electric current as in the table above. The results of the voltage and current tests in the table above are written every 5 seconds to the 25th second and are influenced by the stirling engine speed, load, and stability of the gasification reactor flame.

CONCLUSION

Conclusion

Based on the results of the tests that have been carried out, conclusions can be drawn which will be explained as follows:

1. The design of a prototype biomass power plant consists of 2 parts, namely the place where the gasification process occurs and the resulting current voltage monitoring system. The place where the gasification process takes place is called the gasification reactor, which is a furnace made entirely of iron with a thickness of approximately 2 mm to retain heat when the gasification process occurs. The monitoring system consists of a series of several

electronic components such as the INA219 sensor, Arduino Nano, data logger shield, and LCD to determine digitally generated voltage and current values.

2. Testing of the prototype of the biomass power plant is carried out in two parts, namely testing of the gasification reactor and monitoring system. The stages of testing the gasification reactor were carried out to determine the length of time for releasing methane gas and the flame produced in the downdraft gasification process and the monitoring system testing stages were carried out to determine the success of the design of the tool that had been made with the current and voltage results displayed on the LCD.

3. The test results on the gasification reactor are the effective flame of the gasification reactor using the amount of fuel 1 kg by drying in the sun, it takes 9 minutes and without drying, it takes 4 minutes and the reactor process in producing gas uses the same amount of fuel 1 kg by drying it, it takes 10 minutes and without drying, it takes 13 minutes. The results of testing the monitoring system, namely the voltage and current values generated every 5 seconds to the 25th second are 2.52V, 2.47V, 2.52V, 2.75V, 2.76 V and 1.45mA, 1.56mA, 1 .87mA, 3.11mA, 2.70mA.

Advice

Realizing that this research entitled "Prototype of Biomass Power Plant (PLTBm) Based on Rice Husk Agricultural Waste Using Downdraft Gasification Technology" still has many shortcomings, therefore some suggestions are needed to develop and improve the design of the tool that has been made, including:

1. Refine the design of the gasification reactor design and dry the rice husks for at least half a day in order to maximize the gasification process for the length of time and stability of the methane gas produced.
2. Using more than 1.5 kg of rice husk to anticipate the reduced amount of rice husk during the initial combustion of the gasification process before producing methane gas.
3. Using other types of agricultural waste such as palm shells, rice husks, corn cobs, bagasse, and wood powder as raw materials in the biomass process.
4. Using air supply components that are not sourced from AC power.

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