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Steam Power Plant Powered by Wood Sawdust Waste: A Prototype of Energy Crisis Solution

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ABSTRACT

The used of electricity from year to year is increasing. One of the alternative to power plants with abundant availability is wood waste. The aims of this study is to: (1) design a wood waste PLTU prototype as an alternative biomass-based energy resource and an effort to reduce wood waste, (2) describe the calorific value, the resulting electrical voltage, and the duration of the lamp flame generated from wood waste fuel. Teak (*Tectona grandis*), surian wood waste (*Toona sureni*), and a mixture of both. This descriptive research includes 3 stages, which is analysis, design, and testing. Through this research, a prototype of a wood waste steam power plant was successfully designed by utilizing biomass waste fuel. The results showed that the calorific value, the resulting electrical voltage, and the resistance time of the lamp varied in the wood samples used. This indicates that the wood samples used have the potential to be used as an alternative to biomass-based energy resources.

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1. INTRODUCTION

Since ancient times humans have had a very close dependence on fossils (Nematollahi *et al*., 2016; Natar, 2019). Almost all industries and daily activities cannot be separated from dependence on non-renewable energy. Human dependence on fossil energy such as for electricity generation is inseparable in an effort to meet needs. The data obtained from the Directorate General of Oil and Gas Republic of Indonesia, oil and gas production in Indonesia in recent years has decreased significantly. In 2012, the amount of oil production was half of the previous year's production, namely in 2011 amounting to 329,249 thousand barrels per day. 163,633 thousand barrels per day. Oil reserves in Indonesia also experienced a decline, namely in early 2012 it reached 3,742 billion metric barrels of oil (MMBO).

The existence of electrical energy in people's lives is an important factor that supports the rapid development of life today (Fitriani *et al.*, 2019). Based on World Bank data, in 2014, the average Indonesian population used 800 kWh of electrical energy per year (IEA Statistics, 2014). Higher than the Philippines, Cambodia and Myanmar. The use of electricity that is not wise will certainly have an impact on Step of the Research, which will also have an impact on the depletion of energy supplies (Fitriani *et al.*, 2019; Sakah, 2019).

Steam Power Plant is defined as a power plant which can generate electricity if there is steam kinetic energy (Ahmadi *et al*., 2016 ; Jayusman, 2018; Koroglu , 2018 ; Lewerissa , 2018). The working principle of this tool is a Steam Power Plant (PLTU) that dminates the total capacity of power plants in Indonesia.

According to the statistics of PT. Perusahaan Listrik Negara (PLN), the power capacity of steam power plant of December 2015 reached 21 thousand GW or equivalent to 40% of the total installed generating capacity of 52.9 GW. During 2015, the amount of electricity produced by itself (including rent) amounted to 176 ,472 GWh , an increase of 0.67 % compared to the previous year . 61.55 % were produced by PLN Holding , and 38.45 % produced by subsidiaries , namely PT Indonesia Power , PT PJB, PT PLN Batam and PT PLN Tarakan (PLN, 2016 , see https://databoks.katadata.co.id/datapublish/2016/09/22/pltu-dominasi-pembangkit-listrik-di-indonesia#:~:text=Menurut%20statistik%20PT%20Perusahaan%20Listrik,terpasang%20sebesar%2052%2C9%20GW).

Wood sawdust is waste obtained from sawing wood using machines or manually. From the data on wood waste produced by the sawmill industry process is 57,380 kg-per day (Jayusman, 2018; Muhammad *et al.*, 2018; Varma *et al*., 2019).

This purpose in this study those to (1) design a wood waste PLTU prototype as an alternative biomass -based energy resource and an effort to reduce wood waste (2) describe the calorific value , the resulting electrical voltage , and the duration of the lamp flame generated from wood waste fuel. Seeing this condition , we took the initiative to make a Steam Power Plant from wood sawdust waste because in line with the large demand for wood, there is also a lot of waste generated, wood sawdust can also be a fuel which means it contains heat and with this innovation, this wood sawdust can be utilized to reduce wood sawdust waste.

2. METHOD

Descriptive research is a research conducted by collecting data related to the problem under study, then the data is processed, interpreted and analyzed so that it can provide an overview of something (Nugroho, 2016). This research includes three stages, which is analysis, design, and testing (**Figure 1**).

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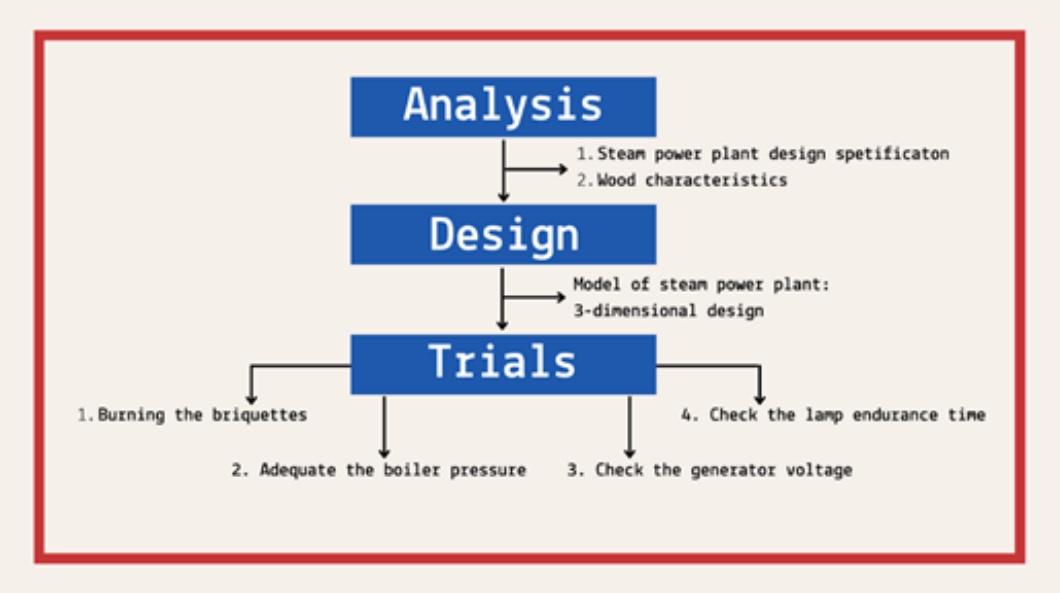

Figure 1. Steps of the research.

2.1. Analysis

At this step, we analyze the working principle and the function from the component of the steam power plant (**Figure 2).** The purpose is for us to understand the component and the equipment that we are going to use to make the steam power plant.

2.2. Model Design

To simplify the process of making a prototype, our group created a 3-dimensional design in order to design the final shape of the steam power plant prototype. This 3D design was created using a blender software.

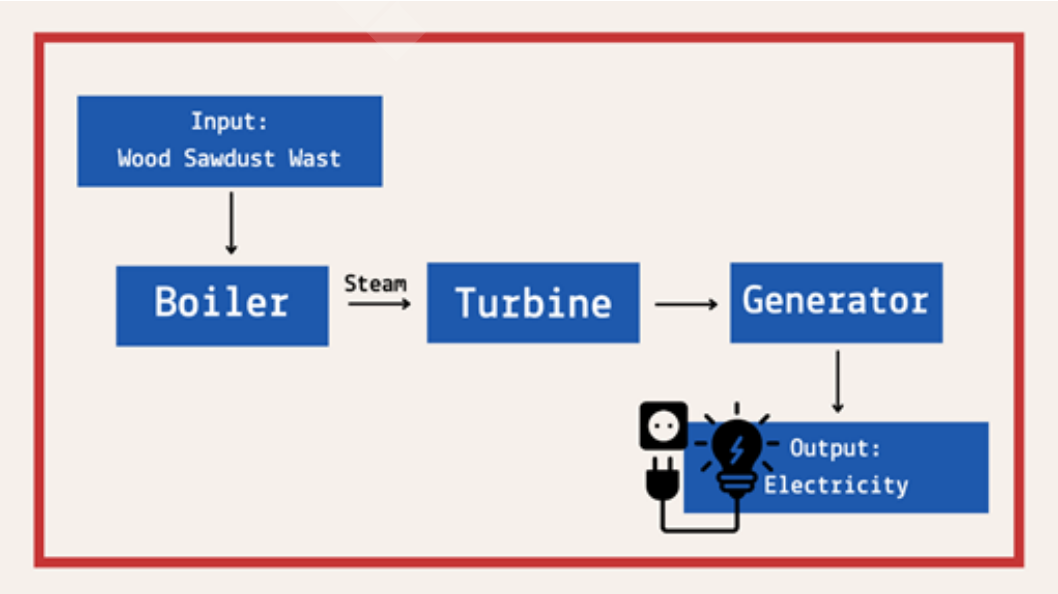

Figure 2. Block diagram of the system.

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2.3. Trials

In the trial phase, several studies were carried out on the prototype of a steam power plant from wood waste that we have made based on **Figure 3**. Among them there are studies that show the difference in final pressure and flame resistance for each wood sample.

3. RESULTS AND DISCUSSION

3.1. General Concept of Steam Power Plant Powered by Wood Sawdust Waste

In the process, the prototype of steam power plant was almost the same performance as the original Steam power, only in terms of size and different fuels. Because the purpose of making this prototype Steam power plant from Wood sawdust waste was made for training tools for school children and efforts to reduce sawdust waste from furniture craftsmen. Where the teak sawdust that has accumulated in the furniture craftsmen makes the scene uncomfortable . This also raises various alternatives that can answer the problem (Arini and Aminah, 2020). Therefore, our group made a prototype steam power plant.

3.2. Wood Characteristics

We are also looking for the characteristics from those 2 different woods. Teak wood was thermally modified at 160, 180 and 210 °C and thermal modification had negative influence on burning and ignition of teak wood (Gaff, 2019). With a higher MOE value and relatively the same side hardness, in general, surian wood can partially replace the role of teak (Rakhman, 2012, see https://repository.ipb.ac.id/handle/123456789/57714).

3.3. Model Design

3.3.1. Working principle

The equipment we make consists of a boiler, pipe, turbine, generator and lamp. The boiler is a place to boil water. So that when the water boils it will produce steam. Then the steam is going to the pipe. The pipe as the way out of steam from the boiler to the turbine. In order for the turbine to rotate, the pipe used must have the smallest diameter. Next, the turbine is a working tool that will be rotated by the steam. Turbine is connected to a generator so that when the turbine rotated it will produce energy to make the generator carry out Its duties. A generator is a device that is driven by a turbine so that it can convert motion energy into electrical energy. Lastly we have lamp as a tool we used to prove that a generator can convert motion energy into electrical energy. The following are the specifications of the tools used in the manufacture of the steam power plant **Table 1**.

Table 1. Specifications and experimental results.

Motor DC RF 300CA (3V-6V)	
Optimal Voltage	1.4v 5500 rpm
Diameter	24 mm
Height	13 mm
Diameter Shaft	2 mm
	Lamp
LED Lamp	1.5 Volt

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3.3.2. 3-Dimension

To simplify the process of making a prototype, our group created a 3-dimensional design in order to design the final shape of the steam power plant prototype. This 3D design was created using a blender software (see **Figure 4**).

3.3.3. The original design of steam power plant powered by wood sawdust waste

This is the design of our steam power plant prototype from wood sawdust waste that we have made (**Figure 5**, video available at http://bit.ly/SteamPowerPlant_MKKF14). This prototype can be used as one of the experiments in school (Setyanto, 2013). The desain was made by our group to show how the steam power plant works.

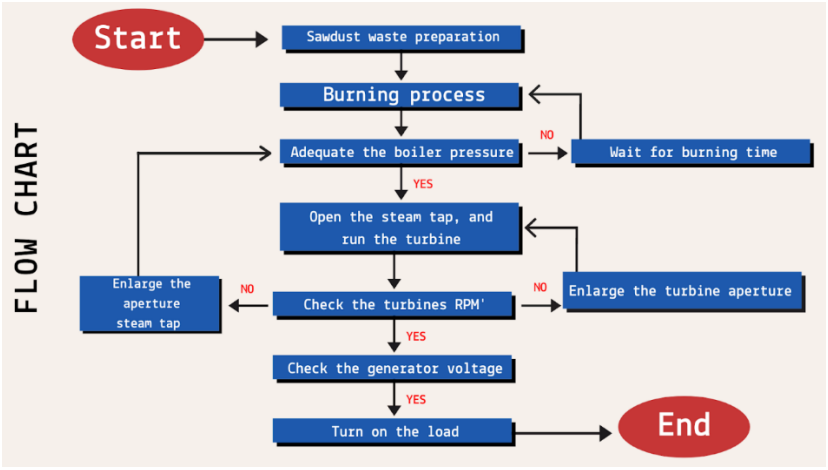

Figure 3. Flow chart.

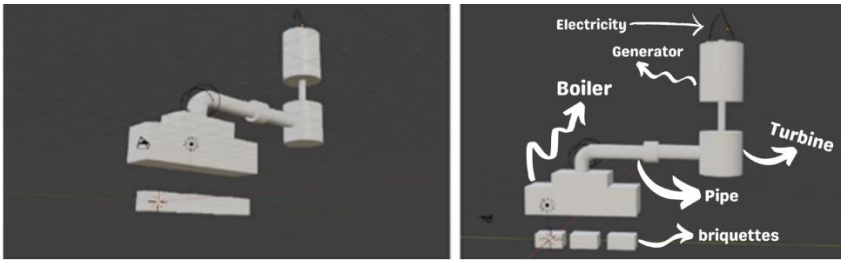

Figure 4. 3-Dimesional of steam power plant powered by wood sawdust waste.

Figure 5. The original design of steam power plant powered by wood sawdust waste.

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Here are some of the functions of each part in the Steam Power Plant Powered by Wood Sawdust Waste design in **Figure 5**.

3.4. Trial Result

3.4.1. Burning the briquetes

At this stage, we burn-out three types of the woods. Type of the woods that we burnt is teak wood, surian wood and the combination between both of them. In previous research, the sample that was used for the trials just teak wood.

3.4.2. Adequate the boiler pressure

At this stage, we are checking the steam pressure that the boiler produced. When the steam that comes out is in a low pressure, we will repeat the burning process.

3.4.3. The calorific value

From some of the research journal we got the **Table 2** of the heat. This teak calorific value data is obtained from a journal with the author Nabawiyah and Abtokhi, 2010. Furthermore, the calorific value data of surian wood is obtained from a journal with the author Nurhayati *et al*., 1997.

3.4.4. Electrical voltage checking

From the trials we got the data bellow **Table 3** in electrical voltage checking teak wood sawdust has the highest voltage , which is 1.8 – 2.0 v. In the second place the mixture of teak and surian wood sawdust with the voltage of 1.4 – 1.5 v. Lastly the surian wood sawdust with 1 .3 – 1.4 v.

3.4.5. Lamp endurance time

From the trials we got the data bellow **Table 4** in the trials, teak wood sawdust has the highest lamp endurance time, which is 15 minutes. In the second place the mixture of teak and surian wood sawdust with the lamp endurance time of 12.5 minutes . Lastly the surian wood sawdust with 10 minutes.

Table 2. The calorific value of wood

Sample	The Calorific Value ($^{cal}/_{gr}$)
Teak wood (*Tectona grandis)*	4765,78 cal/gram
Surian wood (*Toona sureni*)	5042,78 cal/gram

Table 3. Electrical voltage result

Sample	Electrical voltage (volt)
Teak wood sawdust(*Tectona grandis)*	1.8 – 2.0 Volt
Surian wood sawdust(*Toona sureni*)	1.3 – 1.4 Volt
Mixture of teak and surian sawdust	1.4 – 1.5 Volt

Table 4. Lamp endurance time

Sample	Lamp endurance time
Teak wood sawdust(*Tectona grandis)*	15 minutes
Surian wood sawdust(*Toona sureni*)	10 minutes
Mixture of teak and surian sawdust	12.5 minute

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4. CONCLUSION

The conclusion of our experiment on a Steam Power Plant (PLTU) Prototype is that it is possible if the PLTU is made with briquettes from sawdust waste as fuel, it just needs to be reheated the heat contained in the briquettes so that the heat generated as initial energy is even greater so that can be converted even more to its electric power. Further research is needed regarding this renewable energy.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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