Comparative Analysis of the Quality and Electrical Energy of Wood Waste Briquettes with Natural (Starch) and Synthetic Adhesives (Synthetic Rubber Adhesive)

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***Abstract* – On average, small and medium-scale wood processing industries produced at least 2 to 4 cubic meters of wood a day, this production produced 0.25 to 2 m^3 of wood waste a day. In fact, this waste can be used as a renewable energy source by processing it into briquettes. This research will produce wood waste briquettes using the pyrolysis method from two types of adhesive, namely starch and synthetic rubber adhesive with a composition ratio of 3:1. Apart from that, the resulting briquettes were tested using a bomb calorimeter to obtain the calorific value, water content, ash content, and volatile matter content, and then compared with the SNI 01-6235-2000 standard. The resulting briquettes were then calculated using mathematical calculations for the potential electrical energy they could generate. From laboratory tests, the calorific value, water content, ash content, and volatile matter content of natural adhesive briquettes were obtained at 5194.44 cal/g, 11.3%, 1.36%, and 40.8%, while synthetic adhesive briquettes respectively had values of 6369.46 cal/g, 4.33%, 2.74%, and 25.54%. From these results, synthetic adhesive briquettes had better calorific value, water content, and volatile matter content compared to natural adhesive briquettes. Apart from that, synthetic adhesive briquettes also had greater energy potential with an energy potential of 7,407 kWh/kg compared to briquettes with natural adhesives which only had a value of 6,041 kWh/kg. Thus it can be concluded that synthetic adhesive briquettes are better quality compared to natural adhesive briquettes because they can generate greater energy, and meet 3 of the 4 test parameters based on SNI while natural adhesive briquettes only meet 2 of the same 4 test parameters**

Keywords: Wood waste, Bricket, Natural, Synthetic.

I. INTRODUCTION

The wood processing industry is one of the sources of livelihood for the Indonesian people [1]. This industry continues to grow rapidly because many people's needs use wood as the main raw material such as doors, tables, chairs, cupboards, and so on [2]. The increase in Indonesia's processed wood production will continue an increase until 2021. Starting from 2017, processed wood production reached 38.86 million m^3 which then increased to 40.02 million m^3 and 40.08 million m^3 in 2018 and 2019 [3]. Then from 2020 to 2021, there was another increase of 46.47 million m^3 and 48.03 million m^3 [3]. The production volume of processed wood certified for wood legality has also increased, previously only 45 million m3 in 2020, increasing to 135 m^3 in 2022 [4]. This increase in the production volume of legally certified processed wood also has an impact on increasing the export volume of forest industry products, which was previously only 15 million tons in 2020, rising to 46.5 million tons in 2022 [4].

Based on the results of a direct interview with one of the wood MSME owners every day, the wood industry in that place is capable of producing 2 to 4 cubic meters of wood a day with the types of kuing, meranti, and kulim wood. The processing process produces wood waste in the form of pieces, shavings, and sawdust amounting to 0.25 to 2 cubic meters a day. The waste produced has not been utilized optimally, this waste is only sold at a very cheap price of IDR 5,000 (on 50 kg sack) to become a mushroom growing medium, livestock medium, and chicken feed. Most of this waste is simply left to pile up and burn [5][6][7]. This wood waste can be processed into goods that have higher economic value than just being left to pile up and become a place for the growth of microbes and fungi which can cause a bad smell and be a source of disease [8]. Apart from that, other impacts if the waste is burned directly will produce air pollution which can hurt personal health and the environment [9][10].

Regarding the problem of wood waste, there have been several previous studies that have examined the use of wood waste in briquettes, such as research conducted in [11] examining the use of sawn waste from the wood industry as raw material for making briquettes using the carbonization method. Research [12] studied the characteristics of briquettes from wood dust using the pyrolysis method. From the research related above, the best results were obtained for utilizing wood waste in briquettes, namely by using the pyrolysis method. From the results obtained, it can be concluded that the quality of charcoal briquettes produced using the pyrolysis method was by the Indonesian National Standard for briquettes from wood dust.

In the process of making wood briquettes, a substance is needed to stick together the fine charcoal particles to become a solid briquette product. Research [13] examined briquettes from wood dust waste using a natural adhesive, namely starch. Research [14] studied the characteristics of briquettes from the leaves and stems of pineapple plants with natural latex adhesive. Research [15] investigated the comparison of the quality of briquettes from coconut shells using natural adhesives of wood sap and starch. Research [16] compared the production of briquettes from sugarcane bagasse using natural adhesives LNFC, NFC, and lignin. From several studies above, it was found that natural starch adhesive is better than other adhesives because briquettes using starch adhesive have a calorific value that follows SNI, namely 5181 cal/g.

Apart from using natural adhesives, to glue charcoal particles into dense briquettes you can also use synthetic or non-natural adhesives. Research [17] examined the use of synthetic adhesives in the form of maltodextrin to produce briquettes from dry waste leaves. Research [18] examined the use of epoxy wood glue as an adhesive for biobriquettes made from water hyacinth. Research [19] examined the manufacture of rice husk biobriquettes using the pyrolysis method using wood glue adhesive. Research [20] examined the manufacture of briquettes from acacia wood dust and coconut shells using a carbonization process using rubber gum adhesive (Rubber Gum Adhesive). From several studies above, it was found that the use of synthetic adhesive in the form of epoxy wood glue is better than other synthetic adhesives because it has a higher calorific value compared to other synthetic adhesives whereas by using epoxy wood glue, the resulting briquettes have a calorific value of 5312 cal/g. In this research, a new type of adhesive was used to improve the quality of briquettes with synthetic adhesive. One of them is the Synthetic Rubber Adhesive type of adhesive. This type of adhesive is classified as an adhesive that has high adhesion compared to other types of synthetic adhesives because this type of adhesive has a viscosity level of 3500 Pa.s [21].

Apart from raw materials, methods, and types of adhesive. Another parameter that influences the quality of the briquettes produced is the composition ratio between the raw material and the adhesive. Research [22] studied the manufacture of briquettes from sawdust using paper pulp adhesive with variations in raw materials and adhesive of 1:1, 2:1, and 4:1. Research [23] examined the effect of tapioca flour adhesive concentration on charcoal briquettes from sugar palm fronds with raw material and adhesive compositions of 9:1, 8:2 and 7:3. Research [24] examined the use of corn cob waste charcoal briquettes with raw material and adhesive compositions of 3:1, 3:2, 4:1, and 5:2. Research [25] examined the use of oyster mushroom waste as raw material for making briquettes with a raw material composition and adhesive content of 3:1. From the research that has been carried out by testing the calorific value parameters of various existing raw materials and adhesives, it was found that the most optimal composition of the raw material and adhesive mixture with the best calorific value is with a ratio of raw materials and adhesive of 3:1.

After the process of determining the raw materials, type of adhesive, and varying levels of adhesive. The quality of the briquettes produced needs to be tested. Research [26] examines the comparison of heating value tests using two methods, namely gasification stove experiments and bomb calorimeters. From the research conducted, it can be concluded that testing using a bomb calorimeter is better than using a gasification stove because testing using a gasification stove has an error of 8.36%. Apart from testing the quality of the briquettes, the heat energy from the briquettes can be converted into electrical energy. Research [27] examines the conversion of heat energy produced by briquettes into electrical energy using mathematical calculations. From this research, it was obtained that the highest heat energy that could be converted into electrical energy was 6,598 kWh/kg depending on the large number and high calorific value of the briquettes produced.

Some of these studies still focus on discussions regarding the types of raw materials, adhesive materials, and variations in the ratio of adhesive levels for processing briquettes. This research further aims to examine the use of wood waste in briquettes using the pyrolysis method. This method was chosen because it has several advantages, including producing a high calorific value from the briquette products produced and in the process producing less carbon content that is wasted into the air thus it is more environmentally friendly. environment [12]. This research also compares the quality of briquettes produced from two different types of adhesives, namely natural and synthetic adhesives. Natural adhesives in the form of starch were chosen because briquettes using starch adhesive have a calorific value that complies with SNI and has a strong resistance level of 0.53-0. .66 grams/cm^3, apart from that, the starch adhesive has a good heat-holding ability thus that the resulting briquettes do not break easily [13]. Meanwhile, the choice of synthetic adhesive in the form of Synthetic Rubber Adhesive was chosen because this type of adhesive has a viscosity level of 3500 Pa.s [21]. Apart from the type of adhesive, another parameter used is the variation between carbon charcoal and the adhesive content used of 3:1. The choice of variation between carbon charcoal and adhesive content is because the 3:1 variation produces a high heating value and is by SNI. This high heating value is influenced by the large composition of carbon charcoal used [24]. The resulting briquette product was then tested using a bomb calorimeter. The bomb calorimeter tool was chosen because it has a lower error value than other testing tools [26]. The briquette quality parameters tested using a bomb calorimeter are heating value, water content, ash content, and volatile matter content. Apart from that, this research also aims to obtain the value of electrical energy that can be generated by briquettes produced from wood waste using natural or synthetic adhesives using mathematical calculations.

II. METHOD

The object of this research was wood waste obtained from the remaining production of wood processing MSMEs. The wood waste that was processed into briquettes such leftover wood in various forms such as pieces, shavings, and sawdust. The processed wood waste is 2 kg or the equivalent of 0.002 m^3 which was process used the pyrolysis method with the ultimate that was aimed of obtaining briquettes of the best quality with several existing test parameters including heating value, water content, ash content, and volatile matter content. This research was carried out to compare the quality of briquettes produced from two types of adhesive materials, namely natural and synthetic, the main raw material of which comes from processed wood waste. The processing of processed wood waste into briquettes in this research was processed used the pyrolysis method using a piece of simple pyrolysis equipment. This research compares the quality of briquettes produced from two types of adhesive, namely natural in the form of starch and synthetic in the form of Synthetic Rubber Adhesive. Apart from that, this research tested the quality of the briquettes quantitatively with the test variable, namely a mixture of carbon charcoal and adhesive of 3:1. the quality of the briquettes produced will be tested using a bomb calorimeter with test parameters in the form of heating value, water content, ash content, and volatile matter content. The briquettes produced from this research were intended as a new energy source to replace fossil fuels, Inded this research also calculates the value of electrical energy that can be generated from processed wood waste briquettes. The data and test parameters used in this research come from primary data and secondary data. The primary data used comes from interviews with one of the wood processing industries in Kampar Regency, Riau Province, while secondary data such as test parameters and briquette quality standards as well as comparison variables for the composition of natural or synthetic adhesive mixtures come from related journal references.

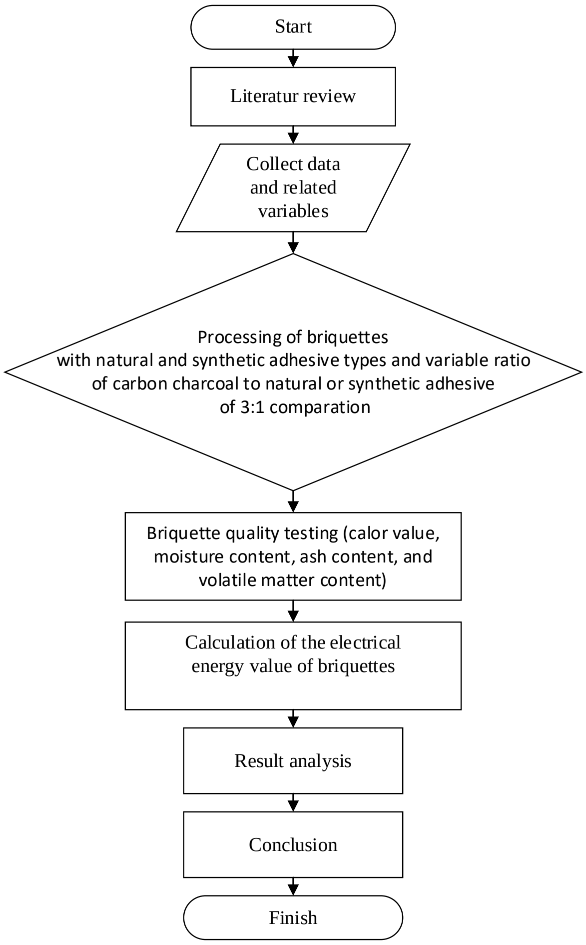

Figure 1. Research Flowchart

A. Wood Waste

Based on the results of interviews conducted with several sources from owners of small and medium-scale processed wood waste industries in Kampar Regency, primary data was obtained in the form of potential waste produced from 1 MSME in the processed wood industry, an average of 0.25 to 2 m^3 a day with varying types of waste. including in the form of pieces, shavings, or sawdust. The data on waste produced based on the volume of wood produced is as in Table 1.

Table 1. Processed Wood Waste from the Wood Industry

No	Processed Wood Volume (m^3)	Waste Type	Amount of Waste (m^3)	Percentage (%)
1	1	Chunks, shavings and sawdust	0,27	27
2	1		0,25	25
3	6,6		2	30
Average Amount of Waste			0,84	25-30

B. Briquette production

Biobriquettes are a solid form of fuel that is used as a new, environmentally friendly energy source to replace fossil energy [28]. Pyrolysis is a process of decomposing a material which is carried out at high temperatures with no or little air. This pyrolysis process produces products in the form of solid fuel, namely carbon, a mixture of tar, and other substances. Generally, pyrolysis is carried out with a combustion time of 5 to 6 hours [29]. Several stages need to be done in making briquettes, namely:

a. Collection of Tools and Materials

The tools used in this research were a simple pyrolysis tool, briquette mold, 60 mesh sieve, wooden grinder, scales, bowls, spoons, stove, pan, stopwatch, lighter, and saucepan. The raw materials used in the briquette-making process come from wood processing industry waste where the waste is in the form of pieces, shavings, and wood powder. The wood waste used was 2 kg.

b. Making Charcoal by Pyrolysis

In making charcoal for briquettes, the pyrolysis combustion method is used. This burning process lasts for 6 hours. After the combustion process is complete, the charcoal resulting from the combustion process is cooled for 4 hours and then weighed. From the combustion process using 2 kg of raw materials, a charcoal mass of 600 grams is obtained.

c. Coal Refinement and Screening

After the charcoal-making process is complete, the charcoal is ground by pounding it until it is completely smooth and there is no longer any coarse charcoal left, after that the charcoal is filtered using a 60 mesh sieve to separate the charcoal particles from coarse to fine charcoal thus the size of the charcoal which have been made the same.

d. Mixing Charcoal with Adhesive

After the grinding and filtering process is complete, the carbon charcoal is then separated into 2 bowls with a weight of 300 grams of carbon charcoal on bowl, then natural adhesive in the form of starch and synthetic adhesive in the form of Synthetic Rubber Adhesive are mixed into each bowl with a composition ratio of carbon charcoal and 3:1 adhesive.

It is. Briquette Printing and Briquette Drying

Briquette printing is carried out using a molding iron with a diameter of 7 cm with the target of printing briquettes of the same size as the weight of the briquettes produced weighing 100 grams. After the briquettes are printed with the same size and weight, the final step in the briquette making process is to dry the briquettes in the sun for 4 days thus the briquettes dry perfectly and to reduce the water content in the briquettes.

C. Briquette Quality Testing

In determining the quality of briquettes, there needs to be standardization to determine whether the quality of the briquettes produced is good or not. For this reason, secondary data is needed in the form of standardized briquettes taken from the SNI for wood charcoal briquettes as in Table 2.

Table 2. Indonesian National Standard (SNI 01-6235-2000) Wood Charcoal Briquettes

No	Characteristics	Unit	Stop
1	Calorific Value	Kal/g	≥ 5000
2	Water Rate	%	≤ 8
3	Ash Rate	%	≤ 8
4	Volatile Matter Rate	%	≤ 15

a. Calorific Value

Calorific value is the number of calories produced in the combustion process of a certain amount of fuel with air. Combustion value is a value obtained from the complete combustion process. In principle, calculating the heating value using a calorimeter is a process where heat is not influenced from outside. To measure heat, you can use a bomb calorimeter [31][32].

b. Moisture Content

The water content in briquettes affects the calorific value, where the lower the water content, the higher the calorific value. [32].

c. Ash Content

Basically, the ash content can affect the amount of heat contained in the briquette, thus the lower the ash content in the briquette, the higher the calorific value of a briquette. [31] [32].

d. Volatile Matter Rate

The volatile matter content greatly determines the burning properties of the briquettes. The higher the volatile matter content, the easier it is for the briquette to ignite and the faster the combustion rate. [31][32].

D. Calculation of the Electrical Energy Value of Briquettes

To obtain the potential value of electrical energy that can be generated from the briquettes produced, a conversion method using mathematical calculations can be used. The value of 1 kWh of energy is equivalent to 859.9-kilo calories (kcal) [27], thus the heat value produced by briquettes can be changed or converted into electrical energy whereas for mathematical calculations you can use the formula:

$$Electrical\ Energy\ Briquettes = \frac{Calorific\ Value\ of\ Briquettes}{859.9\ kcal} \tag{1}$$

With :

Energy from Briquettes = Energy produced from the conversion of heat energy to electricity (kWh/kg)

Briquette Calorific Value = Heat value produced from briquettes (cal/g) or (kilocalories)

859.9 kcal (kilo calories) = Value of 1 kWh

III. Results and Discussion

A. Wood Waste Briquettes

Figure 2 as seen in the figure above is the wood waste raw material used as the main ingredient in briquette processing in this research. The wood waste was collected from one of the MSMEs in the wood processing industry in Kampar Regency. The wood waste that was collected and then used as raw material for processing briquettes in this research was 2 kg or the equivalent of 0.002 m^3.

Figure 2. Raw material for briquettes from processed wood waste

Figure 3 as shown in the figure above is a briquette product made from wood waste using natural starch adhesives. Wood briquettes with starch adhesive have different characteristics from synthetic adhesives, including denser and paler in color compared to synthetic adhesives.

Figure 3. Processed Wood Waste Briquettes with Natural Adhesive (Starch)

Figure 4 as shown in the figure above is a briquette product made from wood waste using Synthetic Rubber Adhesive. The synthetic adhesive wood briquettes are not denser than the natural adhesive briquettes, but have a darker color when compared to the natural adhesive.

Figure 4. Processed Wood Waste Briquettes with Synthetic Rubber Adhesive

Table 3. Comparison of Raw Materials and Briquettes Produced from Wood Waste

No	Variable	Briquettes	
		Natural Adhesive	Synthetic Adhesive
1	Wood waste raw materials (kg)	2	2
2	Carbon charcoal produced (g)	600	600
3	Carbon charcoal used (g)	300	300
4	Briquettes produced (100 g/piece)	12	9

Based on Table 3 above, from 2 kg of wood waste which is processed into briquettes using the pyrolysis method, 600 grams of carbon charcoal is obtained. This means that the pyrolysis process reduces the processed wood waste raw materials by 1.4 kg or the equivalent of 70% of the total reduced raw materials. From the 600 grams of carbon charcoal formed or equivalent to 30% of the total weight of the raw material processed, the carbon charcoal is then divided into 2 with a weight of 300 grams each for natural adhesives and 300 grams for synthetic adhesives. After processing, 12 briquettes with natural adhesive, each weighing 100 grams, can be produced, and 9 briquettes with synthetic adhesive with the same weight, each with a ratio of raw materials to adhesive of 3:1.

B. Briquette Quality Test Results

The resulting briquettes were then tested using a bomb calorimeter, Minimum Free Space oven or MFS oven, Ash Content Test Oven, and Volatile Matter Furnace at the UPT Testing Laboratory of the Riau Province Energy and Mineral Resources Service. From the laboratory tests carried out, the results obtained for each parameter are as follows:

a. Calorific Value

Table 4. Calorific Value of Briquettes

No	Types of Briquettes	Calorific Value (Cal/g)	Standard Value (Cal/g)	Reference	Is
1	Natural Adhesive	5194, 44	≥ 5000	SNI	Standard Compliant
2	Synthetic Adhesive	6369, 46	≥ 5000	SNI	Standard Compliant

Table 4 above is the results of laboratory tests for two types of briquettes made from processed wood waste with a ratio of 3:1 between the raw materials and adhesive used for each. The heat test was carried out at the UPT Testing Laboratory of the Riau Province Energy and Mineral Resources Service. The heat test was carried out using a bomb calorimeter which was carried out in the period 13 October – 19 October 2023. From the laboratory tests carried out, the respective heating value of the type of adhesive used was 5194.44 cal/g for briquettes with natural adhesive and 6369. 46 cal/g for briquettes with synthetic adhesive. From these two types of briquettes, the calorific value produced is more than 5000 cal/g thus it can be said that both types of briquettes have a calorific value that is by the Indonesian National Standard. Briquettes with synthetic adhesives have a calorific value of 6369.46 cal/g or 1175.02 cal/g higher when compared to the calorific value of briquettes with natural adhesives. With the calorific value of synthetic adhesive briquettes being higher than natural adhesives, it can be concluded that briquettes with synthetic adhesives are capable of generating greater energy than natural adhesive briquettes because the calorific value produced will influence the energy that can be formed from the briquettes. The greater the calorific value of a substance, the greater the energy value that can be generated from that substance [27].

b. Moisture Content

Table 5. Briquette Water Content Values

No	Types of Briquettes	Water Level Value (%)	Standard Value (%)	Reference	Information
1	Natural Adhesive	11,3	≤ 8	SNI	Not Compliant with Standards
2	Synthetic Adhesive	4,33	≤ 8	SNI	Standard Compliant

Table 5 above shows the results of lab tests for the content values of two types of briquettes with natural and synthetic adhesives. To measure the water content value, a Minimum Free Space oven or MFS oven is used to produce the percentage of water still contained in the two types of briquettes tested. Based on SNI, the maximum water content that is allowed to be contained in a briquette is less than or equal to 8%. From the lab tests carried out for the two types of briquettes tested, natural adhesive briquettes had a water content of 11.3% or higher than the maximum permitted limit of 8%, thus natural adhesive briquettes did not meet the standards for water content test parameters. On the other hand, synthetic adhesive briquettes have a much lower water content, even 50% less than the maximum permitted limit with a water content of 4.33%. This value shows that the synthetic adhesive meets SNI standards for water content test parameters. This low water content has an impact on the quality of the briquettes produclled. The lower the water content of a briquette causes the briquette to burn easily with a higher heating value, thus briquettes with synthetic adhesives have a better heating value than briquettes with natural adhesives [12].

c. Ash Content

Table 6. Briquette Ash Content Values

No	Types of Briquettes	Value of Ash Rate (%)	Standard Value (%)	Reference	Information
1	Natural Adhesive	1,36	≤ 8	SNI	Standard Compliant
2	Synthetic Adhesive	2,74	≤ 8	SNI	Standard Compliant

Table 6 above shows the lab test results for the briquette ash content values of the two types of briquettes tested. The ash content value is measured using the Ash Content Test Oven. From tests carried out, the two types of briquettes had an ash content of 1.36% for natural adhesives and 2.74% for synthetic adhesives. If we refer to the SNI standard for ash content in briquettes, the two types of briquettes can be said to meet the standard because their respective ash content values are less than 8%, which is the maximum limit of ash content permitted in a briquette. However, if compared in more detail, briquettes with synthetic adhesives have an ash content that is 2 times higher compared to the ash content produced from briquettes with natural adhesives which have an ash content of 1.36%. A certain amount of ash content has a bad impact because the greater the ash produced, the more waste or residue will be produced. Apart from that, the ash content also affects the calorific value contained in the briquettes, thus the lower the ash content in the briquette, the higher the calorific value of a briquette [12]. thus it can be concluded that the ash content test parameters for natural adhesives are of better quality than synthetic adhesives. [12]. From the results of the research conducted, the ash content value resulting from this research has a lower value compared to the research [12].

d. Volatile Matter Rate

Table 7. Briquette Volatile Substance Content Values

No	Types of Briquettes	Volatile Matter Rate Value (%)	Standard Value (%)	Reference	Information
1	Natural Adhesive	40,8	≤ 15	SNI	Not Compliant with Standards
2	Synthetic Adhesive	25,54	≤ 15	SNI	Not Compliant with Standards

Table 7 above shows the lab test results for the briquette volatile matter content values of the two types of briquettes tested. The value of the volatile matter content was measured using a Volatile Matter Furnace. From laboratory tests carried out, the two types of briquettes tested had very high volatile matter content values, namely 40.8% for natural adhesives and 25.54% for synthetic adhesives, respectively. This value is much higher than the SNI standard that has been set, namely less than or equal to 15%, thus it can be concluded that the two types of briquettes tested do not meet the standards. However, if we examine in more detail, briquettes with synthetic adhesives have a smaller volatile matter content value than natural adhesive briquettes, thus it can be concluded that based on the parameters of volatile matter content values, synthetic adhesives have better quality compared to briquettes with natural adhesives. The higher the value of the volatile matter content, the faster the combustion rate, thus the higher the volatile matter content, the faster the heating, which has an impact on the combustion rate and the faster the briquettes burn out. With the volatile matter content of briquettes with synthetic adhesives having a lower value than natural adhesive briquettes, the impact is that synthetic adhesive briquettes tend to be more durable because briquettes with natural adhesives tend to heat up more quickly, which results in the fuel running out more quickly for briquettes with natural adhesives [12].

C. Electrical Energy Value of Briquettes

By using equation 1 as in the research methodology section, the value of the electrical energy contained in is as follows:

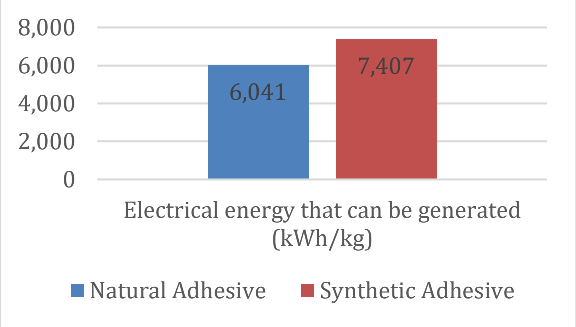

Figure 5. Electrical Energy Value of Briquettes

After carrying out mathematical calculations using equation 1 in the research methodology section and based on the calorific value obtained from the results of laboratory tests using a bomb calorimeter, the energy value produced from each type of briquette is shown in Figure 5. Briquettes with synthetic adhesives have an energy value. which can be raised higher when compared to briquettes with natural adhesives. The energy from synthetic adhesive briquettes is 1.36 kWh higher than natural adhesive briquettes which can only generate energy of 6.041 kWh/kg. The amount of energy value that can be generated from briquettes with synthetic adhesives cannot be separated from the influence of the calorific value of the briquettes, because the calorific value of briquettes with synthetic adhesives is higher than the calorific value of briquettes with natural adhesives. [27].

IV. Conclusion

Based on the research that has been carried out, it can be concluded that from a total of processed wood waste weighing 2 kg or the equivalent of 0.002 m^3, using the pyrolysis method, carbon charcoal weighing 600 grams can be obtained which can be used to make 12 briquettes with natural adhesive and 9 briquettes with adhesive. synthetic with each having a mixture of raw materials and adhesive of 3:1 with a weight of 100 grams on briquette. From the test results obtained, briquettes with synthetic adhesives meet 3 of the 4 test parameters based on SNI standards, while briquettes with natural adhesives only meet 2 of the 4 test parameters based on existing SNI standards.

Briquettes with synthetic adhesive each have a calorific value, water content, and volatile matter content of 6369.46 cal/g, 4.33%, and 25.54%, while briquettes with natural adhesive have a value of 5194.44 respectively. cal/g, 11.3% and 40.8%. The ash content value between these two types of briquettes both have values that are by SNI standards, where the ash content value of briquettes with natural adhesives is better than the ash content value of briquettes with synthetic adhesives, whereas the ash content value of briquettes with natural adhesives is 1. 36% while briquettes with synthetic adhesive have an ash content value of 2.74%. Briquettes with synthetic adhesives also have greater electrical energy potential compared to briquettes with natural adhesives. Briquettes with synthetic adhesives are capable of generating 7,407 kWh of energy of kg of briquettes, which is 1.36 kWh greater than the energy that can be generated from briquettes with natural adhesives which are only capable of generating 6,041 kWh of energy a kg.

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