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THE USE OF PINE FRUIT WASTE AN ALTERNATIVE ENERGY SOURCE BASED ON GRANULE VARIATION

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Abstract
The use of Pine Fruit Waste as Alternative Energy Source in the form of charcoal briquettes was motivated by the great availability of pine fruits in North Toraja which is not utilized properly, only left as useless garbage.

This study aims (1) to determine the calorific value of pine fruit charcoal briquettes in terms of granular variation (2) to determine the value of thermal efficiency in pine fruit charcoal briquettes in terms of grain variations.

The used research method was experimental method by using pine waste as fuel for stove to boil water.The results of calorific test results obtained that briquette 1 was 5721 cal/gr, briquette 2 of 5340 cal/gr and briquette 3 of 5686 cal/gr. Burning test results showed that briquette 3 is the most superior in terms of boiling water as much as 3 (three) times and the burning efficiency of 43.58% followed by briquette 2 of 33.18% and briquette 1 of 32.17%.
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Introduction
By the development of this increasingly advanced era, fuel energy consumption is increasing and focusing only on the use of limited fuel oil and increasing prices. So, it is necessary to do various breakthroughs to get alternative energy sources, in addition to the use of fuel oil and gas.

In addition to petroleum, there are three kinds of hydrocarbon sources namely coal, natural gas and biomass. Out of the three sources of energy, only biomass can be categorized as renewable energy source. Biomass is generally known as the dry composition of organic material or the material remaining after a plant or organic material is dried. Biomass is very easy to find from agriculture, plantation, livestock, fishery and other wastes.Biomass waste becomes one of alternative energy sources. An example of the use of biomass energy derived from forestry waste is pine waste. It is a part of pine trees that grow well in areas of South Sulawesi, especially North Toraja. According to data from the North Toraja Forestry and Plantation Office, the area of pine trees in North Toraja District 2016 are Nanggala 560 ha, Buntao300 ha, Sadan 300 ha, Sanggalagi 200 ha, Rantebua 1350 ha, Rindingallo150 ha , and KapalaPitu 150 ha. Then, the total number of 7 areas is 3011 ha. If 1 ha of land is planted with 1666 pine trees, spacing 2 x 3 meters, and normal production of pine fruit in 1 tree ranges from 70-80 kg or average 75 kg, so in 1 year the pine tree bears fruit twice that of April - July and November - December. From the total land area multiplied by the number of trees/ha, then the number of pine trees that is about 5.016.326 trees. So, the pine fruits produced in a year are: 5,016,326 trees x 75 kg = 376.224.450 kg x 2 times fertilization = 752.448.900 kg or 752.449 tons/year. Then this potential is large enough to serve as biomass fuel as one of alternative fuel.

Review of Literature

Pine Tree

Definition of Pine
Merkusii Pine is one of monocotyl plants that have characteristic with its leaves are flattened like needles and in groups or in the form of scales. Pine has a male strobilus and a female strobilus in one tree. Male strobilus size is

smaller than female strobilus (woody), located axillary. Woody trees (woods), strobilus konus form. Morphologically, merkusii pine has seven parts, namely roots, stems, stalks, leaves, flowers, fruits and seeds that each have distinctive characteristics and have different functions in one plant.

Classification of Pinus Merkusii

In Indonesia, pine has another name that is tusam. This species is naturally dispersed from the East Longitude 95 ° 30 'to 121 ° 30' and the North Latitude 22 ° to the 2 ° South Latitude. Based on the classification of plants, merkusii pineis included in the family Pinaceae; it is the only pine that its natural spread to the south of the equator. Merkusii pineis included in the family Pinaceae. In Java and South Sulawesi, it is spread as a result of planting. It grows at an altitude of 30-1,800 meters above sea level on various soil types and climates. Average annual rainfall is approximately 3,800 mm in the Philippines and 1,000 to 1,200 mm in Thailand and Myanmar. In Sumatra's natural stands (Aceh, Tapanuli and Kerinci), not a single month of rainfall is less than 50 mm, means that there is no dry month. The average annual temperature is 19-28 ° C. The classification starts from kingdom to species, namely:

- Kingdom: Plantae (Plants)
- Subkingdom: Tracheobionta (Vascular Plant)
- Division: Spermatophyta (Produce seed)
- Subdivision: Gymnospermae
- Class: Coniferinae
- Subclass: Dillenidae
- Order: Coniferales
- Family: Pinaceae
- Genus: Pine
- Species: PinusmerkusiiJungh and De Vr

Benefits of Merkusii Pine

Pine trees have a wide range of benefits, both wood and non-timber products. Pinewood is used for various purposes such as light construction, furniture, pulp, matches and chopsticks non-timber products of resin that produce high-value gondorukem and turpentine products. Turpentine oil containing terpene compounds is usually used as a solvent for diluting oil paints, varnish blends, perfume ingredients, oils, aromatherapy massage oils and additives to chewing gum so that it becomes elastic and warped.

Processed products from sap or other pine resin are gondorukem. Gondorukem is the sap of Pinusmerkusii tree which is then processed into gondorukem. The use of gondorukem is for the raw materials of paper, ceramic, plastic, paint, batik, soap, printing ink, polish furniture (varnish), pharmaceutical, cosmetic and so on.

Making Charcoal Briquettes

Briquettes are solid fuels that can be used as alternative energy sources that have a particular shape. The content of water on the briquetting is between 10 - 20%. The size of the briquettes varies from 20 - 100 grams. The selection of the bourgeoning process must necessarily refer to the market segment in order to achieve theoptimal economic, technical and environmental values. It aims to obtain quality fuel that can be used as an alternative energy source.

Some common types of briquettes are: oval, honey comb, cylinder, etc. The advantages of briquette shape are as follows:

1. The size is flexible (it can be conditioned on the needs)
2. Porosity can be set up to facilitate burning
3. Easy to be used as fuel.

In general some specifications of briquettes required by consumers are as follows:

1. Sustainability of briquettes
2. Suitable size and shape on its use
3. Clean (not smoky), especially for the household use
4. Free of harmful gases
5. Proper burning characteristics (ease of burning, energy efficiency, stable burning).

There are some factors that need to be considered in making briquettes include:

1. Raw Materials
   Briquettes can be made from a variety of raw materials, such as bagasse, rice husk, sawdust, and so on. The main composition that must be contained in the raw material is cellulose. The higher the cellulose content the better the quality of the briquette. The briquettes that contain substances that fly too high tend to smoke and smell bad.
2. Binder Material
   To attach the particles of substances in raw materials to the process of making briquettes, it needs a binding agent to produce a compact briquette.

Generally, the process of making briquettes is through the step of grinding, mixing, printing, drying and packing.

1. Scouring is crushing raw material of briquettes to obtain a specific grain size. The tool used in this step is crusher.
2. Mixing is mixing raw material of briquettes at certain composition to get homogeneous dough. The tool used for mixing is mixer or combining blender.
3. Printing is to print briquette dough to get a certain shape as desired. The tool used the step of printing is Briquetting Machine.
4. Drying is the process of drying the briquettes by using hot air at a certain temperature to decrease the water contained in the briquette.
5. Packaging is packaging of briquette products in accordance with the specified quality and quantity specifications.

Parameters used as standard of charcoal briquettes include: *Heating value* is an important parameter of a thermal coal. *Gross calorific value* is obtained by burning a sample of briquettes in the calorimeter bomb by returning the system to ambient temperature. *Net calorific value* is usually between 93-97% of the gross value and depends on the inherent moisture content and the hydrogen content in the briquette.

From the several parameters that affect the quality of briquettes, the value of heat is very important to be discussed further in this study by ignoring other parameters that may affect the quality of briquettes namely; water content, ash content, volatile matter and carbon content.

Cricket Technology

The process of briquetting is the processing process which undergoes the treatment of grinding, mixing of raw materials, printing and drying under certain conditions, in order to obtain briquettes that have the shape, physical size, and certain chemical properties. The purpose of briquetting is to improve the quality of materials as fuel, facilitate handling and transport, and reduce material loss in the form of dust on the transport process.

Some of the factors that affect briquetting include:

1. Particle Size and Distribution
   Particle size affects the strength of the resulting briquettes due to smaller size will produce a smaller cavity as well so that the strength of briquette press will be greater. Meanwhile, the size of distribution will determine the possibility of the preparation (packing) better.

Table 2.1. Particle dimension particle size

U.S. Mesh	Microne	Inches	millimeter
20	840	-331	-84
25	710	-28	-71
30	590	-232	-59
40	420	-165	-42
50	297	-117	-297
60	250	-98	-25
70	210	-83	-21
80	177	-7	-177
100	149	-59	-149

Material Violence
The strength of the briquette obtained will be inversely proportional to the hardness of the constituent material.

Research Method
The research method used in this study is experimental method that is by making charcoal briquettes of pine fruit in the form of hollow cylinders (honeycomb) in terms of grain variations, know the calorific value (HHV) fruit charcoal briquettes, testing the burning of charcoal pine briquettes on the briquette stove, and know the efficiency thermal (ɳth). The composition of briquettes in terms of granular variations can be seen in table 3.1.

Table 3.1. The composition of briquettes is evaluated from granular variations

Variation of Granules	Composition					
	Pineapple Charcoal (gram) Mesh 20 and 40	Pineapple Charcoal (gram) Mesh 30 and 50	Pineapple Charcoal (gram) Mesh 40 dan 60	Clay (gram)	Tapioca Flour (gram)	Water (ml)
Briquette1	800	-	-	100	100	800
Briquette 2	-	800	-	100	100	800
Briquette3	-	-	800	100	100	800

Time and Place of Study
This research was conducted in July 2017. The research sites used during the research process are:

1. Machine Laboratory Faculty of Engineering Christian University of Indonesia Toraja, for the manufacture of pine fruit charcoal briquettes, testing of briquette burning on stove briquettes
2. Laboratory of Animal Feed and Chemistry Faculty of Husbandry of Hasanuddin University of Makassar, for heating value test (HHV).

Materials and Equipment
Materials and equipment used are:

1. Material:
    a. Pine Fruit
    b. Tapioca flour
    c. Clay
    d. Water

2. Equipment:
   a. Drum carbonization as a place of burning pine fruit to charcoal
   b. The briquette printing tool for printing the pine charcoal powder into briquettes
   c. The briquette stove serves as a burning briquette
   d. Analogue scale as a briquette material weight gauge
   e. Aluminum pot serves to boil water
   f. Water kettle as water heater
   g. Timekeeper/Stopwatch to measure the needed time for boiling water
   h. Thermocouple to measure the temperature of hotspots and boiling points of water at burning testing
   i. Measuring cups as a measuring instrument to measure the weight of water
   j. 20 and 40 mesh sieves, mesh 30 and 50, and mesh 40 and 60 as a means of separating charcoal smooth with coarse grind after being grounded or manually pounded.

Research procedure

1. The Making of Charcoal of Pine Charcoal
2. Heat Value Test (HHV) Briquette of Pine Charcoal Fruit
   a. The process of making pine fruit charcoal briquettes
   b. The process of printing charcoal pine fruit charcoal
3. Physical Characteristic Test of Briquette of Pine Charcoal
4. Burning Test of Charcoal Briquette of Pine Fruit on the Briquette Stove
5. Thermal Efficiency Test (ηth) Burning Briquettes of Pine Charcoal Briquettes

This method is done by heating some water to boil on the stove by using briquetted shell as the fuel. The volume of water measured and the fuel mass of the briquettes used is calculated, so thermal efficiency can be calculated by the following formula:

$$\eta_{th} = \frac{(Ma\ x\ Cp_{air}\ x\ (T_a - T_b)) + (M_p x Cp_{al} x (T_c - T_b)) + (Mu\ x\ Hl)}{LHV\ x\ Mbb} \ldots(2)$$

Where:

ηth : thermal efficiency of briquette burning on briquette stove (%).
Ma : the initial water mass (kg),
Mbb : briquette masses that have been used inside boiling water (kg).
Mu : the mass of water vapor (kg).
HL : Latent heat of steam (kJ/kg).
Cpair : water specific caloric 4.1769 (kJ/kg 0C).
Cpal : specific heat of aluminum/pot material (kJ/kg 0C).
LHV : calorific value of bottom briquettes (kJ/kg).
Tb : ambient temperature of water
Ta water vapor temperature (100 0C)
Tc : pan temperature (0C)

Finding and Discussion

The results of this study include: the manufacture and specification of pine fruit charcoal briquettes, heating value test (HHV) pine fruit charcoal briquettes in terms of grain variations, testing of the physical characteristics of pine charcoal briquettes, testing of briquettes charcoal briquettes burning on briquette stoves, and thermal efficiency (ηth) burning of pine fruit charcoal briquettes in terms of granular variations.

Result of Preparation and Specification of Charcoal of Pine Charcoal

1. The Making of Pine Charcoal

Pine fruit charcoal briquettes are printed like a honeycomb form using briquette printing tools, and successfully printed as many as 18 briquettes.

2. Specification of Pine Charcoal Briquette

Specification of pine fruit charcoal briquettes produced consists of size, mass and volume of briquettes.

a. Briquette size

The resulting briquettes have average dimensions, namely; diameter (d) = 63 mm, height (l) of each resulting variation, briquette 1 (mesh 20 and 40) = 40 mm, briquette 2 (mesh 30 and 50) = 38 mm, briquette 3 (mesh 40 and 60) = 41 mm; diameter of the middle hole of the briquette (d) = 15 mm and the diameter of each of four perforated holes (d1) = 8 mm.

b. Mass and Brick Volume Charcoal

Charcoal briquettes before being burned on the briquette stove, the mass was weighed first by grouped based on the granular variation. Each granular variation consists of 3 briquettes which are weighed and the mass obtained is briquette 1 (mesh 20 and 40), briquette 2 (mesh 30 and 50), briquette 3 (mesh 40 and 60). The average weight of each briquette was 0.25 kg, so 3 briquettes = 83.333 grams/briquette.

Tailor Value Test Result (HHV) Briquette of Pine

Charcoal Heat value test was done at Laboratory of Animal Feed and Chemistry Department of Nutrition and Animal Feed Faculty of Animal Husbandry of HasanuddinUniversity of Makassar by the result that can be seen in Table 4.1.

Table 4. 1. Heat value test results (HHV)

Variation Granules	Heating value (cal/gram)
Briquette 1 (Mesh 20 and 40	5721
Briquette 2 (Mesh 30 and 50)	5340
Briquette 3 (Mesh 40 and 60)	5686

The Test Result of Burning Pine Charcoal Briquette on Briquette Stove

Burning test data of 3 types of briquettes based on the variation of granules on the briquette stove by the method of boiling water, can be seen in appendix 4 that is; briquettes 1 (mesh 20 and 40) in table 4.1, briquette 2 (mesh 30 and 50) in table 4.2, and briquette 3 (mesh 40 and 60) in table 4.3.

The results of briquette burning testing can be seen in table 4.5.

Table 4.2. Result of briquette burning test.

Variation Granules	Maximum Fire Temperature Beam (˚C)	Burning Time (Minute)	Water Weight (Kg)	Last Temperature of Water (˚C)	Boiling Water (Kali)
Briquette 1	430	155	1,1	86	2
Briquette 2	430	145	1,1	76	2
Briquette 3	432	135	1,1	21	3

The data of briquette burning and water boiling for 3 different briquette types in table 4.5 described the fire temperature of the briquette and water temperature, so briquette 3 (mesh 40 and 60) is better because it is boiling water for 3 times.

Results of Thermal Efficiency (ηth) Burning of Pine Charcoal Briquettes Based on Granules Variations

Thermal efficiency (ηth) is the amount of heat energy used during the energy-change process which is useful divided by the amount of heat energy released by the fuel during the burning process. The calculation of thermal

efficiency for briquette was 1 (mesh 20 and 40) which could boil water 2 times and the maximum fire temperature obtained was at 430 °C with burning time of briquettes was 155 minutes (2,583 hours), and consumed 3 burnt briquettes of 0.25 kgweight briquette before burning. Furthermore, the data can be seen as follows:

1. ηth = Thermal efficiency of briquette burning on briquette stove (%)
2. Ma = Heated water mass (kg) = 1.1 kg
3. Cpair = Water specific calorific (kJ / kg 0C = 4.1769 kJ / kg ^{0}C
4. Ta = Water boiling temperature in pan (oC) = 100^{0}C
5. Tb = Initial water temperature (oC) = 20^{0}C
6. Mp = Mass pan (kg) = 0.25 kg
7. Cpal = specific heat of aluminum / pot material (kJ / kg 0C
   = 0.9 kJ / kg 0C
8. Tc = Fire briquette temperature (0C) = 430 0C
9. HL = The latent heat of vapor (kJ / kg) = 2256,487 kJ / kg
10. Mu = Mass of water vapor (kg). = (1.1 kg - 1.05 kg) x 2 = 0.1 kg
11. LHV = Bottom calorific valueof briquette (kJ / kg)
    For briquette 1 (mesh 20 and 40)
    = 5721 Cal / gr x 4,186 = 23948,106 kJ / kg
    = 23948,106 kJ / kg - 3240 kJ / kg) = 20708,106 kJ / kg
12. Mbb = Mass of used briquettes (kg) For briquettes 1 = 0.25 kg - 0.022 kg = 0.228 kg

Through the following equation, thermal efficiency (ηth) obtained was as follows:

$$\eta th = \frac{Q_{air} + Q_{panci} + (MuxHl)}{LHV\ x\ Mbb} x100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

$$\eta_{th} = \frac{(1038{,}47) + (254{,}7) + (225{,}649)}{0{,}228x20708{,}11} x100\%$$

$$\eta_{th} = \frac{1518{,}819}{4721{,}449} x100\% = 32{,}17\%$$

Furthermore, the same thermal efficiency (ηth) resulted in briquette 2 (mesh 30 and 50) and briquette 3 (mesh 40 and 60) can be seen in Table 4.3.

Table 4.3 Calculation of pine fruit charcoal briquette thermal efficiency (ηth)

No.	Satuan	Briquette 1	Briquette2	Briquette 3
1	ηth (%)	32,17	33,18	43,58
2	Ma (kg)	1,1	1,1	1,1
3	Cp_{air} (kJ/kg^{o}C)	4,1769	4,1769	4,1769
4	T_a (^{o}C)	100	100	100
5	T_b (^{o}C)	20	20	20
6	M_p (kg)	0,25	0,25	0,25
7	Cp_{al} (kJ/kg^{o}C)	0,9	0,9	0,9
8	T_c (^{o}C)	430	430	432
9	H_L (kJ/kg	2256,487	2256,487	2256,487
10	M_u (kg)	0,1	0,1	0,15
11	LHV(kJ/kg	20708,106	19113,240	20561,596
12	M_{bb} (kg)	0,228	0,228	0,227

Discussion

Discussion in this section includes: the result of making pine charcoal briquettes, heating value test results (HHV), physical properties test result, briquette burning test on briquette stove, and thermal efficiency result (ηth) burning of pine fruit charcoal briquettes.

Result of Making Pine Charcoal and Its Specification

To get a good quality briquette, before briquette making, it is necessary to dry the raw material before and after the cultivation. After the charcoal has been dried, then pounded the result of charcoal collision separated by using 3 types of filter pairs 20 mesh and 40, mesh 30 and 50, and mesh 40 and 60, so the ash can be released. In addition, it is also needed to add tapioca starch and clay with the composition of each 10% to increase the density and compressive strength.

Results of Calorific Value Test (HHV) on Briquettes of Pine Charcoal

The moisture content, ash content, and bound carbon content, and grain size of briquette can affect the calorific value of briquettes. If the water content and ash content on the briquette is low, it will increase the calorific value and vice versa. The higher the carbon content is bound in charcoal briquettes, the higher the heating value of the charcoal briquettes. Likewise the greater the grain of briquette, then the calorific value of briquettes will increase but if the water content and ash content on high briquettes, the calorific value of briquettes is low.

Based on the results of the testing by the Laboratory of Animal Feed and Chemistry of the Faculty of Animal Husbandry of UniversitasHasanuddin Makassar on the calorific value (appendix 1, page 52), that the calorific value content which was obtained in briquette 1 (mesh 20 and 40) = 5721 cal/gr, briquettes 2 (mesh 30 and 50) = 5340 cal/gr, and briquettes 3 (mesh 40 and 60) = 5686 cal/gr. Thus, briquette 1 (mesh 20 and 40) had a high heating value but could boil 1100 grams water twice (attachment 3, page 54). While briquettes 2 (mesh 30 and 50) had very low calorific values and could boil 1100 grams water twice (appendix 4, page 55) and briquette 3 (mesh 40 and 60) had low calorific values but able to boil 1100 grams water three times (appendix 5, page 56). So, the calorific value (ηth) on pine fruit charcoal briquettes could be influenced by water content, ash content, bound carbon content, and the size of the grain of pine fruit charcoal briquettes.

Result of Pine Charcoal Briquette Burning on Briquette Stove

Testing of briquette burning was carried out by boiling water method in a pan of 1100 grams waterand recording the temperature of fire and water every 5 minutes until the water in a pan boiled. After boiling (100 ^{o}C), then hot water was removed from the pot to weigh the weight. After that the pot was filled with new water and ready to be boiled. This was done repeatedly until the briquette fire can no longer boil water. The test was continued by weighing the remaining briquettes of burning and weighing the weight of the boiling water. The briquettes used in each burningthree pieces with total weightwere 250 grams, while the weight of the aluminum pans was250 grams. Burning briquettes and boiling water were carried out on three types of pine charcoal briquettes based on granular variations (appendix 9, page 61), namely:

For briquette 1 (mesh 20 and 40), maximum fire temperature 430 ^{o}Cwas reached after 4 minutes boiling, and burning time for 155 minutes. Maximum water temperature reached 100 ^{o}Cfor 2 (two) times.It means that this briquette could boil water 2 times for 1100 gramwater until the fire temperature decreased and water temperature constant at 86 ^{o}C after 155 minutes (Appendix 3, page 54).

For briquettes 2 (mesh 30 and 50), maximum fire temperature 430 ^{o} C was reached after 3 minutes with burning time for 145 minutes. Maximum water temperature was reached 100^{o}C for twice (2), forthe weight of water was1100 gram, until then fire temperature was decreased and constant water temperature at 76 ° C to 145 ° (appendix 4, page 55).

For briquettes 3 (mesh 40 and 60) a maximum temperature of 432 ^{o}Cwas reached after 4 minutes boilingwith a burning time of 135 minutes, while maximum water temperature of 100 ^{o}Cfor 3 (three) times for the water weight of 1100 grams, until then the temperature of the fire was decreased and the water temperature was constant at 21

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°C after 135 minutes boiling (appendix 5, page 56). Relation of burning time to fire temperature and water temperature can be seen on graph 4.2, and graph 4.3.

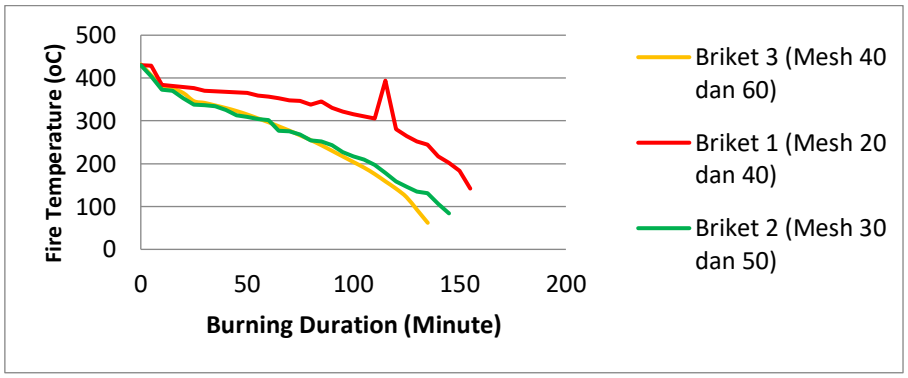

Figure 4.1. Graph Relation of Burning Time of Briquette to Fire Temperature

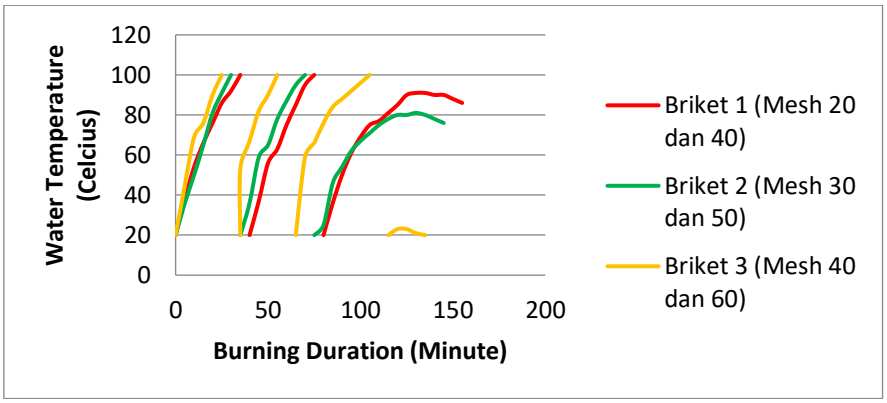

Figure 4.2. Graph Relation of Burning Time of Briquettes to Water Temperature

Conclusion

Conclusion

Based on the results of the research, it can be concluded as follows:

1. The highest calorific test result was B1 of 5721 cal/gram, followed by B3 equal to 5686 cal/gram and the last B2 was 5340 cal/gram
2. Result of burning test on stove got highest thermal efficiency on B3 by 43,58%, then B2 by 33,18% and lowest B1 by 32,17%.

Suggestion

To increase the heating value (HHV) and thermal efficiency (ηth) of pine charcoal briquettes, better tools for printing is needed so that the next researcher's expectation in researching, processing and making briquettes of pine fruit could be achieved.

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