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DESIGN AND MANUFACTURING BIOETHANOL STOVES FROM USED CANS AS A MEANS FOR PLANTING GREEN COMMUNITY TECHNOLOGY

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Abstract

In an effort to reduce the role of fossil energy, the government conducts energy diversification and conservation policies. Along with that, environmental problems due to technological processes become a global problem where the environment is getting worse. One way to overcome this is by developing environmentally friendly technology, namely Green Technology. The author wants to try to combine the concepts of diversification energy conservation and green technology simultaneously by designing and making bioethanol stoves from used cans. The method used in this technological work uses a *design* and *manufacturing approach*. Design approaches with steps: identifying needs, creating geometric models, engineering and economic analysis, and making working drawings. Furthermore, manufacturing is carried out with steps: identification of the tools used, identification of materials needed, and manufacturing steps, as well as performance tests. The design results were obtained from working drawings of bioethanol stoves from used cans. The *manufacturing* results obtained bioethanol stove products in accordance with the demands of the working drawings. The manufacturing process uses simple equipment. The performance test results are very satisfactory, namely: (1) the flame of the stove is blue; (2) the stove is safe from fire hazards and/or melted stove materials; (3) the fuel cost of bioethanol stoves is 48% cheaper than paraffin stoves; (4) Bioethanol stove fuel is 95% more efficient than paraffin stove.

Keywords: Stove, Bioethanol, Used Cans.

INTRODUCTION

One of the problems that arise and develop in society related to human life, is the problem of energy. Scientists are currently required to respond quickly to the problem of limited fossil energy and predicted to run out, as well as the solution to find renewable alternative energy (Imam Kholiq, 2015). Sooner or later, fossil energy that is continuously exploited by humans will run out. Even if the exploitation does not pay attention to the balance of the ecosystem, it will also cause damage to nature (Abubakar Lubis, 2007).

To reduce greater risk, it is necessary to think about as well as make movements to reduce dependence on non-renewable energy. Therefore, movements and campaigns for the use of renewable energy are very important (Erkata Yandri, Ratna Ariati, Riki Firmandha Ibrahim, 2018). This movement must not only be the consciousness of the government, but must also be the consciousness of the people. *Mainstreaming* renewable energy policies must be done more massively and seriously.

Renewable energy sources are energy sources produced from sustainable energy resources, including geothermal, wind, biomass, sunlight, streams and waterfalls, as well as the movement and temperature differences of the ocean layer. (Law Number 30 of 2007 On Energy, Chapter 1 Article 1 Paragraph 6).

All renewable energy is sustainable energy, because it is always available in nature for a relatively very long time so there is no need to worry or anticipate running out of sources.

Energy consumption in Indonesia continues to increase along with the increasing population and accelerating economic activities. In an effort to reduce the role of fossil energy in all sectors of life, the government has implemented a policy of energy diversification and conservation (Agus Sugiyono, 2004). Energy diversification is to encourage the use of fuels other than fossil energy such as coal, bioethanol, charcoal, wood, solar energy, etc., while energy conservation is to increase the efficiency of cooking equipment (Directorate General of New Renewable Energy and Energy Conservation

Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2011). As far as the author knows, both energy diversification and conservation programs have been running independently, for example:

(1) Programs for the use of fuel for cooking from kerosene to Liquid Petroleum Gas (LPG) for energy diversification, and

(2) Energy-saving furnace engineering programs for energy conservation.

Every day we eat it means we are not separated from cooking activities and fuel. For household needs in terms of cooking, LPG gas is currently arguably the main energy source (World Bank, 2013).

LPG gas is a type of fuel derived from liquefied natural gas. LPG is known to be cheaper, more efficient and environmentally friendly than fuel oil, but LPG is included in the group of fossil energy that cannot be renewable and one day can run out. In the future, it is necessary to find renewable alternative energy as a substitute for LPG, including bio-liquid fuel energy (bioethanol) for daily cooking purposes (Senam, 2009). In line with this, efforts must also be made on how to form appropriate technology.

Along with this, technology and environment are two important things in human activities. In this era of the Industrial Revolution 4.0, these two things are the attention and discussion of the world community because they are interrelated and determine human survival (Trilling and Fadel, 2009). Whether we realize it or not, we often overlook environmental issues. Environmental problems due to technological processes have become a global problem. Facts prove that environmental problems are getting worse and worse (Sutarsi Suhaeb, Muh. Ma'ruf Idris, Mantasia, 2013). Therefore, ways must be found to overcome it, one of which is by developing environmentally friendly technology. Green Technology is one of the answers to this problem (Norizan Hassan, Hussin Salamon &; Hasimah Abdul Rahman, 2017). What is meant by green technology is technology that is beneficial to mankind characterized:

(1) Environmentally friendly or minimal / does not cause pollution;

(2) It is *sustainable* so that the use of technology can be felt for a long time;

(3) The technology can be applied (Deputy for Natural Resources and Environment, Bappenas, 2014).

The author wants to try to combine the concepts of energy diversification, energy conservation, and green technology simultaneously by designing and making bioethanol stoves from used cans.

METHOD

Bioethanol is very suitable for kitchen stove fuel as a substitute for LPG. Bioethanol has colorless and volatile properties with a distinctive aroma and is flammable (Ni Ketut Sari and Dira Ernawati, 2017). Bioethanol stove is a stove made from bioethanol. The working principle of the stove is that if bioethanol is put into a closed vessel, then some of the bioethanol evaporates. Evaporation will become faster when the surface of the vessel is expanded (Soemargono and Laurentius Urip Widodo, 2018). Inserting cotton into the closed vessel makes the surface of the vessel wider. Steam in a closed vessel will cause pressure. Furthermore, if a small hole is made in the vessel, the steam will radiate out. Then if the steam comes into contact with oxygen and fire, combustion will occur and cause a flame that can be used for cooking. The question is how effective is the design so that used cans that function as vessels can be used as stoves for cooking.

Stove Product Design

This stove product in terms of shape, material, and size must pay attention to user demands. From this side, it can be analyzed that the stove must be safe, easy to use, lightweight, easy to make, and effective for cooking. Based on the demands of these users, the design of the stove can be described as follows.

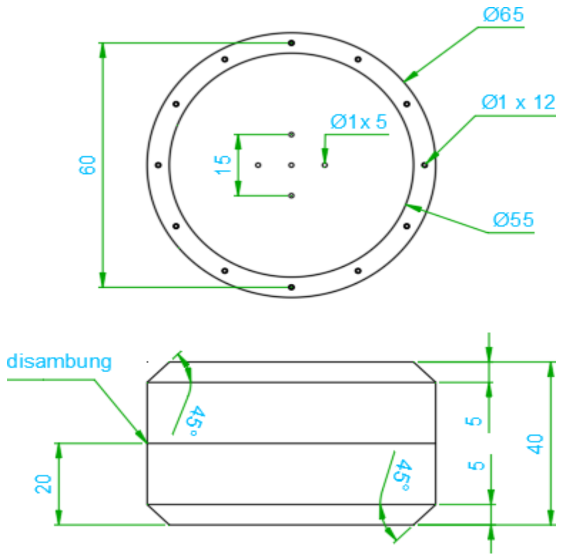

Figure 1: Used Tin Stove Design

Materials and Tools Used

Used cans of rhinoceros stamp drink	2 pieces.
Scissors	1 buah
Ruler	1 buah
Compass	1 buah
Spidol	1 buah
Cosmetic cotton	1 lapis
Cutter	1 buah
Reng wood for cannabis	30 cm.
Bioethanol	500 cc
Cakilan	1 buah

Api cork	1 buah
Torong	1 buah
1 liter bottle for bioethanol storage	1 fruit
Mug glass to turn off the stove	1 buah

RESULTS AND DISCUSSION

Technical Analysis

In the analysis of this technique what is seen is the shape, size, and material. As presented in Figure 1, the shape of the stove product is a cylinder with a main size of 65 mm in diameter and 40 mm in height. The top edge of the stove is given 12 bioethanol vapor channels with a diameter of 1 mm, while on the middle surface of the stove, there are 5 bioethanol intake holes with a diameter of 1 mm. The bioethanol intake hole on the upper surface of the center of the stove must be covered with coins when the stove fire has been lit so that the stove flame only comes out through the edge hole.

Economic Analysis Fixed capital			
Scissors	1 pcs	Rp	5.000,00
Ruler	1 pcs	Rp	4.000,00
Compass	1 buah	Rp	8.000,00
Spidol	1 buah	Rp	8.000,00
Cosmetic cotton	1 lapis	Rp	7.500,00
Cutter	1 buah	Rp	9.000,00
Reng wood for cannabis	30 cm.	Rp	4.000,00
Bioethanol	500 cc	Rp	12.000,00
Cakilan	1 buah	Rp	15.000,00
Api cork	1 buah	Rp	10.000,00
Torong	1 buah	Rp	2.500,00
Conductor 5 ltr for bioethanol storage	1 buah	Rp	5.000,00
Mug cups to turn off the stove	1 pcs	Rp	15.000,00
Sum		**Rp**	**105.000,00**
Working capital			

Inventory of raw materials	IDR 100,000.00
Sum	**Rp 100.000,00**
Total capital (total investment)	
Total nodal	= fixed capital + capital work
	= IDR 105,000.00 + 100,000.00
Total capital	**= IDR 205,000.00**
Operating costs	
Raw materials	IDR 200,000.00
Average tool depreciation Rp 105.000/(12)	Rp 8,750.00
Sales operations	IDR 50,000.00
Sum	**Rp 258.750,00**
Profit Calculation	
Cost of material per pair	= IDR 2,000.00
Sum	**= Rp 2.000.00**

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So, the cost of the material is Rp 2000.00 per pair. Furthermore, the selling price per piece is determined at IDR 3,000.00. Thus, the profit per piece is IDR 3,000.00 - IDR 2,000.00 = IDR 1,000.00.

Break Even Point (BEP) Calculation

By a simplified equation, BEP is calculated as follows.

$$BEP = \frac{\text{operating expenses}}{\text{Selling Price}}$$

$$BEP = \frac{\text{IDR } 258{,}750.00}{\text{IDR } 3{,}000.00}$$

$$= 87 \text{ Pieces}$$

If calculated in days: 87

$$BEP = \frac{\text{Pieces/month}}{\text{25 days/month}} = 4 \text{ pieces/day}$$

Thus, in order not to lose, at least 4 pieces must be sold per day.

Product Performance Test

Performance tests are intended to find out if the stove can function properly. The following presents a series of stove performance tests. First, the stove is filled with bioethanol through the middle hole until ethanol is as high as the middle hole.

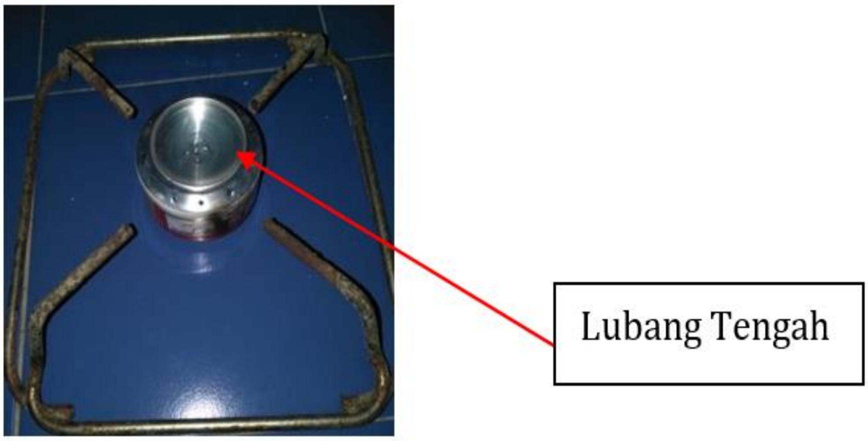

Figure 2: Stove Ready to Turn On

Second, ignite the middle hole with a lighter, and after the stove is lit cover the middle hole with a 500 rupiah coin.

Figure 3: 1st minute after turning on

Third, after the stove is turned on, it can immediately be used for cooking purposes. The stove will dim and turn off after 30 minutes.

Figure 4: 30th Minutes the Stove Dimmed

Bioethanol Stove Optimization

To obtain optimal bioethanol stove parameters, further experimental research was conducted. The experimental research steps for the optimization of bioethanol stoves are as follows.

Research Plan

The purpose of this bioethanol *stove optimization study* is to determine the effect of hole diameter and number of holes on the efficiency of bioethanol stoves. An independent variable is the diameter of the hole and the number of holes, while a dependent variable is the speed of heating water, which is an indicator of the efficiency of the stove. As control variables, namely room temperature, stove height size, stove diameter size*, the volume of bioethanol* in the stove, the volume of water heated, type of water heated, and temperature *range* of water heated.

The course of research begins by preparing bioethanol stoves at various hole sizes and number of holes as shown below.

Figure 5: Materials, Tools, and Instruments Used

Materials Tools and Instruments Used

The materials used in this study are:

(1) *Bioethanol* Stove;

(2*) Bioethanol*;

(3) Measuring cups;

(4) Matches;

(5) Stove ignition;

(6) Water;

(7) Measuring cups;

(8) Thermometer;

(9) *Stopwatch*.

Research Data Retrieval Design and Techniques

Data collection is carried out by direct observation. The measurement uses instruments that include a thermometer and stopwatch. To avoid accidental effects, each observation point is carried out with 3 repeats. The data retrieval procedure is carried out in a systematic sequence referring to the *flowchart* and research design that has been set. The steps are presented like a flow chart as follows.

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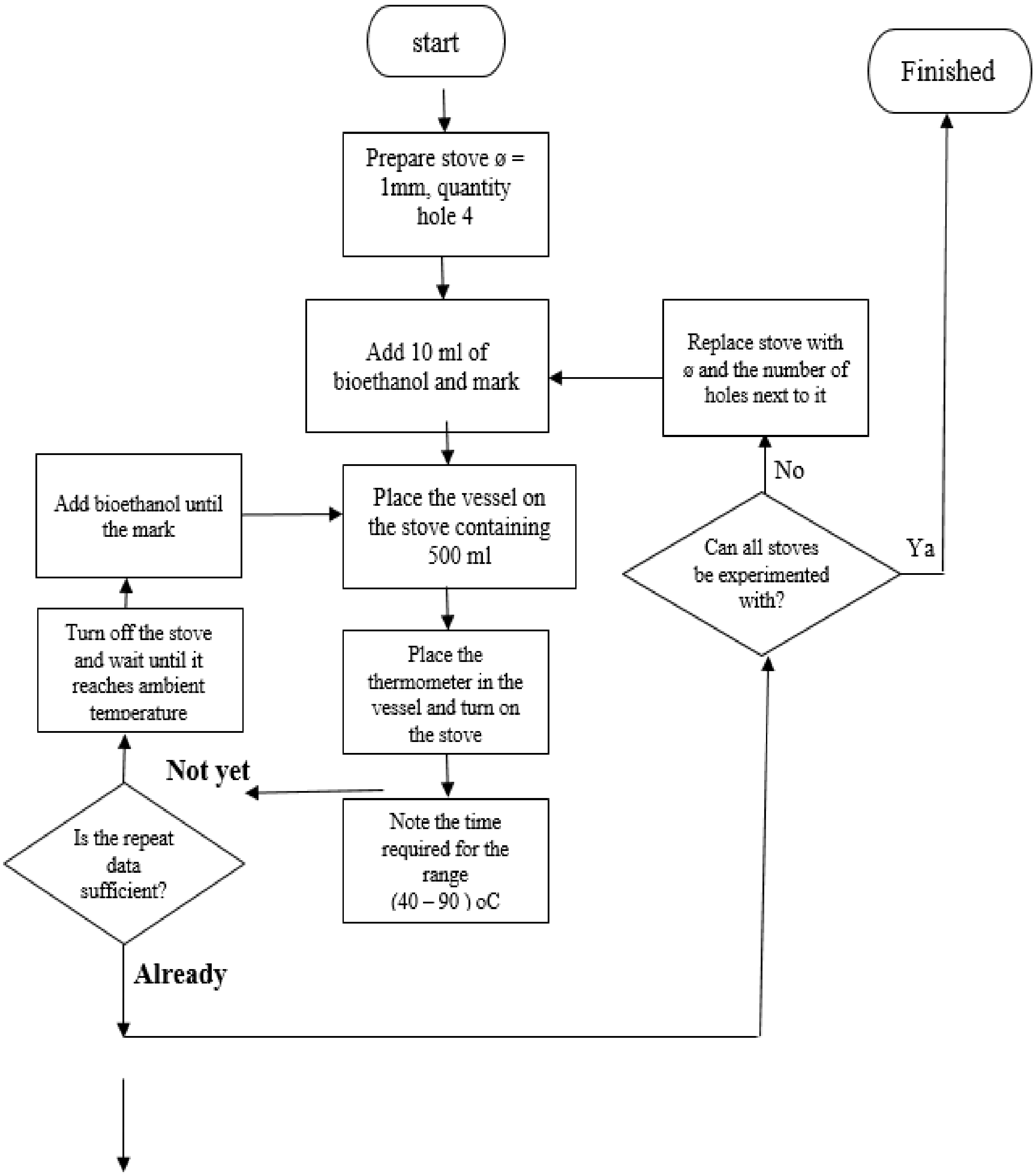

Figure 6: Data Retrieval Process Flow Diagram

Data Analysis Techniques

Referring to the research variables mentioned above, the research design uses a factorial design or a two-track experimental design. With the analysis of the two-lane variant, it can be known whether the diameter of the hole and the number of holes affect the efficiency of the stove.

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RESEARCH RESULTS

Data on water clearance rates on *bioethanol* stoves at various numbers of holes and hole diameters are presented in Table 1 below.

Table 1: Table of Bioethanol Stove Observations on Various Number of Axis Holes and Axis Hole Diameters

Number of Axis Holes	Inner Axis Hole Diameter(mm)											
	d1 = 1 mm			d2 = 1.5 mm			d3 = 2 mm			d4 = 2.5 mm		
	Observation to (sec)		Average (sec)	Observation to (sec)		Average (sec)	Observation to (sec)		Average (sec)	Observati on to (sec)		Average (it)
4	1	11,27	**11,36**	1	18,04	**18,20**	1	10,23	**10,22**	1	11,09	**11,30**
	2	11,43		2	18,30		2	10,09		2	11,34	
	3	11,38		3	18,20		3	10,36		3	11,47	
6	1	11,19	**11,23**	1	18,15	**18,15**	1	10,39	**11,20**	1	08,17	**09,22**
	2	11,35		2	18,17		2	11,43		2	10,01	
	3	11,15		3	18,12		3	11,37		3	09,49	
8	1	06,06	**06,32**	1	09,29	**09,32**	1	08,34	**08,43**	1	06,38	**07,00**
	2	06,37		2	09,50		2	08,45		2	07,12	
	3	06,53		3	09,17		3	08,51		3	07,21	
12	1	05,13	***05,11***	1	07,32	**07,29**	1	08,03	**08,14**	1	06,59	**06,53**
	2	05,00		2	07,15		2	08,24		2	07,01	
	3	05,21		3	07,41		3	08,15		3	06,38	

Note:

- The volume of boiled water is constantly controlled at 500 ml.
- The volume of *bioethanol* in a constant stove is 10 ml.
- The experimental place is constantly controlled, the location is in the applied mechanics lab of the Department of Machinery FT UNY.
- *The observation range* of temperature rise is controlled constant (40 C $^{-90\ C)}$.
- Control techniques of control variables that are difficult to control or measure, such as environmental temperature, are overcome by conducting experiments in places where the temperature is relatively constant.
- Boiled water is obtained from the same source.

Hypothesis Testing

The hypothesis testing procedure is carried out based on the results of two-track variance analysis from the measurement data as presented in Table 1 upfront. Data analysis using the help of Excel application programs. The full two-path anava results, a summary of which are presented in Table 2 below.

Table 2: Anava Summary Two Paths from Research Results Data

Source	Sum of Square	DF	Mean Square	F Ratio	Prob.
Pigeons/α (diameter lubang)	181.801	3	60.6	546.422	0
Row/β (number of holes)	345.484	3	115.161	1038.387	0
Interaction/γ (hole diameter and number of holes together)	108.456	9	12.051	108.658	0
Error	3.549	32	0.111		
Total	5374.312	47			

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Analysis and interpretation of the results of the two-track anava test upfront are as follows.

The hypotheses proposed in this study are:

Answer: $\alpha = 0$ Ha: $\alpha \neq 0$

Ho: $\beta = 0$ Ha: $\beta \neq 0$

Ho: $\gamma = 0$ Ha: $\gamma \neq 0$

Where:

α = influence of hole diameter

β = effect of the number of holes

γ = Influence of hole diameter and number of holes together

Critical Value

Using a confidence level of 0.05 the F value of the table is:

$F\alpha$ (3; 32; 0.05) = 2.92

$F\beta$ (3; 32; 0.05) = 2.92

$F\gamma$ (9; 32; 0,05) = 2,21

F value calculates the results of the analysis with the Exel application program

$F\alpha$ = 546.422

$F\beta$ = 1038.387

Fc = 108,658

Conclusion

- $F\alpha$ count > F α table, or $F\alpha$ count outside the reception area Ho, the conclusion is that the diameter of the hole affects efficiency.
- $F\beta$ counts > F β table, or $F\beta$ counts outside the reception area Ho, the conclusion is that the number of holes affects efficiency.
- $F\gamma$ count > F γ table, or $F\gamma$ count outside the reception area Ho, the conclusion is that together the diameter and number of holes affect efficiency.

DISCUSSION

Production stoves have specifications as Table 3 below.

Table 3: Product Specifications of Bioethanol Stove

No	Parameters viewed	Specifications
1	Diameter	65 mm
2	Tall	30 mm
3	Total ignition holes	12 holes
4	Ignition Hole Diameter	1 mm
5	Volume Bioethanol	9,950 mm3 or about 10 cm3
6	Flame Color	Blue
7	Long Time Stove Turns On	30 minutes
8	Price	IDR 3000,-

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The results of the stove performance test produce a blue flame, the shape of the flame is similar to a gas stove, and can ignite in about 30 minutes. When the stove was tested it was used directly to boil 0.5 liters of water, the water boiled in a relatively short time.

From the test results from the time the stove turns on until the stove dies, the stove is safe from fire or melted stove materials. Technically it can be explained as follows, stove materials made of Aluminum oxide have a melting point of 2020-2050 C, while the temperature of the blue flame is only around 516-542 C (R.R. Vienna Sona Saputri Soetadi and Djoko Sungkono Kawano: 2012). So the melting point temperature of the stove material is much higher than the temperature of the stove flame, so it can be concluded that the stove is very safe from fire hazards and melted stove materials.

This bioethanol stove has much cheaper operational costs compared to a candle stove (paraffin) for Scouts which costs 70 thousand. The analysis is as follows: an 8-tablet paraffin stove for Rp 32.5 thousand can turn on in about 160 minutes or 2.7 hours, while a bioethanol stove with 1 liter of spirits for Rp 17 thousand can run for about 3,000 minutes or 50 hours. Based on these data, it shows that in terms of fuel costs, bioethanol stoves are 48% cheaper than paraffin stoves, while bioethanol stoves are 95% cheaper than paraffin stoves. So this bioethanol stove is cheaper and more fuel efficient than paraffin stoves. Therefore, this bioethanol stove is suitable when used for camping for scouts.

For millennial girls and young mothers today, who are not used to using firewood or charcoal for cooking, by using this bioethanol stove they feel they get the right solution if at any time they run out of LPG gas, because this bioethanol stove can be used in an emergency.

Based on the experimental results as presented in Table 1 above, visually it can be seen that the most efficient *bioethanol* stove parameters are in the condition of the number of holes 12 pieces and the diameter of the holes 1 mm.

CONCLUSION

1. Bioethanol stoves are simple construction and can be made using used soft drink cans and by using simple equipment such as cutters, cork nails, markers, scissors, and rulers.
2. The performance of the bioethanol stove is very satisfactory. From the test results from the time the stove turns on until the stove dies, the stove is safe from fire or melted stove material, because the melting point temperature of the stove material is much higher than the temperature of the stove flame, so it is very safe from fire hazards and melted stove materials.
3. The results of the economic analysis of this bioethanol stove's operational costs are much cheaper than the candle stove (paraffin) for Scouts which costs 70 thousand.
4. Experimental results, show that the most efficient *bioethanol* stove parameters are in the condition of the number of holes 12 pieces and the diameter of the holes 1 mm.

In terms of fuel costs, bioethanol stoves are 48% cheaper than paraffin stoves, while from fuel economy, bioethanol stoves are 95% cheaper than paraffin stoves. So this bioethanol stove is cheaper and more fuel efficient than paraffin stoves.

In the future, this bioethanol stove needs to be socialized to support the success of the energy diversification program, because this stove is fueled by renewable energy.

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