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RESEARCH ARTICLE

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Cow Manure Biogas Stove Design with Burner and Blower Performance for Housing Needs Scale

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ABSTRACT

Biogas is a renewable energy that is environmentally friendly, easy to obtain and can be updated. The technology is simple and the energy produced can be used technically, socially, and economically especially to solve energy problem in rural area. The purpose of this research was to produce a biogas stove performance with appropriate technology that can be utilized by the community. This experimental research method was designing biogas stoves with performance using 2 variations of blower (3 watt and 6 watt) and two burners that is 2 mm and 4 mm. To know the performance of biogas stove, a test is done, that is : Water boiling test. The dimension was the biogas stove, the body of the stove was made of zinc (9x38x70 cm) with two furnaces, Ø 0.5 mm iron tube distribution, 2 and 4 mm burners, 3 and 6 watt blowers, gas lighters. The results of water boiling test was stove power with fire hole Ø 2 mm blower 3 watt (0.446630 KW) and efficiency (60,54982%); fire hole Ø 2 mm blower 6 watt (0.705517 KW) and efficiency (55.86828%); fire hole Ø 4 mm blower 3 watts (0.913373 KW) and efficiency (54.45203%); fire hole Ø 4 mm blower 6 watts (1.231190 KW) and efficiency (51.06681%). The performance of the biogas stove showed that the smaller the hole is Ø (2 mm), the smaller the power will be, and more efficient. The greater use of the blower (6 watts) was, the greater power will be but more inefficient. These stoves can be utilized by the community especially those with biogas. For more minimal performance, cheap, durable and easy to use needs further research.

Keywords: biogas stove; digester; blower and burner

INTRODUCTION

Background

Biogas is an eco-friendly renewable energy that is easy to obtain and can be renewed. The technology is simple and the energy produced has feasible use technically, socially, and economically, especially to overcome energy problems in rural area⁽¹⁾.

The basic principle of biogas made of cow dung raw material consists of a tub for mixing cow dung with water (1:2) and then put in a digester so that the fermentation process takes place and produces what will be accommodated in the gas reservoir. The gas will be distributed to biogas stoves⁽²⁾. The design of this stove is different from LPG gas stoves which are designed with certain pressurized LPG gas. Besides, LPG gas has different character from biogas⁽³⁾.

Janggan village, Kec. Poncol Kab. Magetan is a village guided by Magetan Environmental Health Study Program whose population is mostly farmers and cattle-breeder, has 41 biogas units from the Bapermas Office of Magetan Regency and local people initiative. The problem comes when the modification of biogas stoves that

we made and used by the community cannot function properly. This occurs because the fermented digester biogas storage with a low-performance PE plastic device has low pressure resulting little biogas distribution to the stove. To produce a normal stove flame, enough pressure is needed on the biogas reservoir and that means the biogas storage must be fully maintained. Whereas the size of PE plastic with $\varnothing = 0.64$ to 0.76 m, for biogas storage in the village with a length of 2 to 3 m requires a minimum biogas volume of more than 0.96 to 1.35 m³ to keep it fully filled and has pressure. The temporary solution is to make the biogas tank burdened but this is not practical as every cooking time we must give a weight (pendulum) and set it free after cooking. Another problem is that the valve system is less practical and it needs a match to turn it on.

Purpose

The purpose of the research is to produce the performance of biogas stove with appropriate technology, namely:

- 1) To make and assemble biogas stoves consisting of bodies, gas distribution lines, blowers, valves and lighters system with biogas fuel.
- 2) To test the biogas stove produced with a water boiling test that is testing the power and efficiency of the stove.
- 3) To analyze the performance of biogas stoves assembled dealt with stove power testing and efficiency.

The results of this study are expected to produce a biogas stove that can be used by the community for housing needs.

METHODS

This research design of the experiment was a One-shot case study that is researchers designed a biogas stove and tested the performance of the stove with cow dung raw material. The biogas stove used a variation of two blowers (3 and 6 watts) and two variations of the burner hole (2 mm and 4 mm). Biogas stove performance tested location in Environmental Health Study Program Magetan conducted in 10 times replication test: water boiling test, stove power, stove efficiency, time required and heat.

Stages of Research

The study consists of two stages, namely pre-research and research described in the research diagram of Figure 1.

Stage of Designing Biogas Stove

At this stage the focus is on calculating the dimensions, shapes and components of the stove based on the desired size and specifications, drafting and determining the construction materials for biogas stoves.

Stage of Preparing Equipments, Materials and Measuring Instruments

At this stage, the procedure is to determine and provide various tools and materials as well as the research measuring instruments needed in the study, including:

- 1) Determining and providing preparation tools and materials:
- 2) Devised / modified stove
- 3) Two burners with holes diameter of 2 and 4 mm
- 4) Two types of blowers with capacity of 3 and 6 watts
- 5) Biogas fuel from biogas containers
- 6) Determine and provide tools and materials for testing: Pyrex glass pot, thermometer, gas flow meter, stopwatch, digital scales, water and biogas fuel from biogas containers

Stage of Biogas Stove Fabrication

The procedures of biogas stove fabrication is carried out in partnership under responsibility of The Environmental Health Study Program. It aims to make the planned design done better.

Stage of Testing

At this stage 4 (four) tests are carried out and each step is replicated 10 times, i.e.

- 1) The first step is using a biogas stove with a 3 watt blower and 2 mm burner hole (Figure 1), and the procedures are as follows:
 - a) Ensure that the biogas in the shelter is more than a half of its capacity.
 - b) Install a burner with a hole of 2 mm
 - c) Get the measured water poured into the pan.
 - d) Measure the initial temperature of water (T1)
 - e) Measure the initial fuel in the flow meter.
 - f) Turn the biogas stove on
 - g) Data collection for the temperature and use of biogas is carried out at intervals of 2 minutes until the water boils (T2)
 - h) Measure the remaining water in the pan.
 - i) Do the above procedures for 10 times, note the results to determine: power of the biogas stove, stove efficiency, duration and heat

- 2) The stove efficiency, (Resiana Winata, 2012):

$$\eta_{\text{overall}} = \frac{(M_w.C_p + M_{pa}.C_{pa})(T_2 - T_1) + M_g.H_{fa}}{(M_f.E)} \times 100\%$$

Description:

Mass of heated water (mw): 0.5 kg	Metal specific heat (Pyrex): 4,186 kJ / kg
Mass of the pan used (mpa): 0.145 kg	Final temperature (T2): 100 °C
Mass of evaporated water (ms):..... kg	Initial temperature (T1): 30°C
Mass of used fuel (mf): kg	Latent Evaporation Heat: 2526.53 kJ / kg
Water specific heat (cp): 4,186 kJ / kg	Fuel calorific value: 18,939 kJ / kg

- 3) Stove power, (Syamsuri et al., 2015)⁽³⁾:

$$P = \frac{(M_f.E)}{(t)} (KW)$$

Description:

P = Stove power (KW); mf = Fuel consumption during t time (kg)

E = Calorific Value Fuel kJ / kg; Δt = Test time (seconds)

The second stage is using a biogas stove with a 3 watt blower and 4 mm burner hole. Principally, the procedures is conducted in the same way as what has been done in the first step.

The third stage is using a biogas stove with a 6 watt blower and 2 mm burner hole. Principally, the procedures is conducted in the same way as what has been done in the first step.

The fourth stage is using a biogas stove with a 6 watt blower and 4 mm burner hole. Principally, the procedures is conducted in the same way as what has been done in the first step.

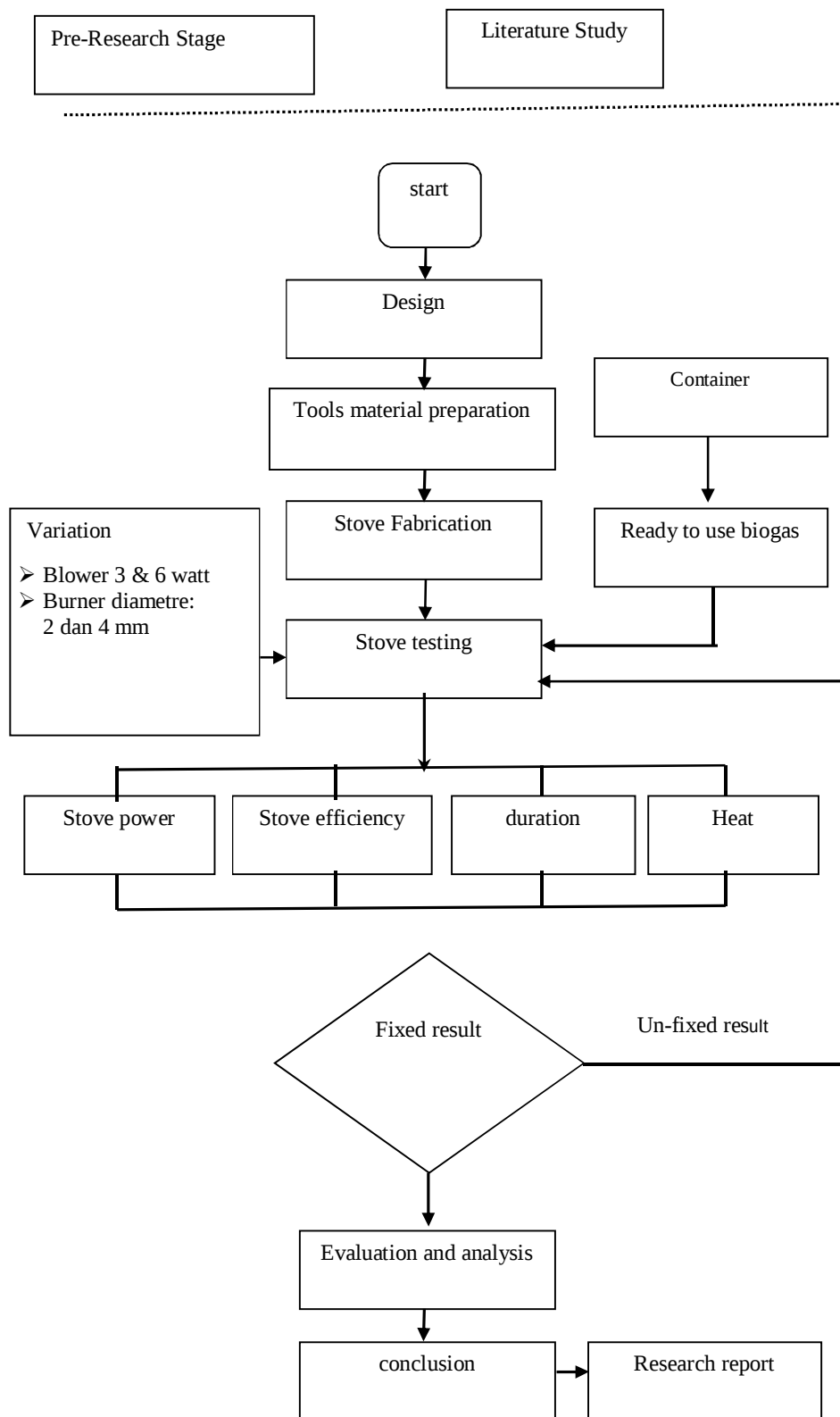


Figure 1. Reseach flow

RESULTS

Stove Specifications

The modified biogas stove with detail specifications can be seen as follows:

Table 1. Details specifications of former biogas stoves, LPG and biogas stoves

No	Specification	Inovated stove will be tested by type	
		1	2
1	Body of stove	Manufacturer and modification	Manufacturer and modification
2.	Gas distribution	Iron pipe Ø 5 mm	Iron pipe Ø 5 mm
3	Burner diametre	2 mm tested will be	4 mm tested will be
4	Lighter	Batory and or gas tested will be	
5	Gas pressure	None	none
6	Vacuum gas Blower	Available in 3watts and or 6 watts of AC, tested will be	
7	Power setting	Digital power setting which can be used for max power of 10 watts	
8	Stove power setting	The amount of stove power to boil water which is got from the multiplication of the biogas fuel mass and calorific value of biogas fuel divided by time used to boil water. Unit of measurement : KW(Kilowatt) used	
9	Stove efficiency	Heat procentage compared with available heat on pyrex during test. Unit of measurement : procentage (%)	

Test Result

Average recapitulation of the results of biogas stoves test with 10 replications with each specification using formula 1 and 2 are as follows:

Test of the Stove Power

Table 2. Recapitulation of the average results of stove power test with various specifications

No	Stove specifications	E (kJ/kg)	ΔT (seconds)	Mf (kg)	Stove power (KW)
1	Diametre 2 mm, blower 3 W	18939	787.8	0.0185	0.446630
2	Diametre 2 mm, blower 6 W	18939	552.3	0.0205	0.705517
3	Diametre 2 mm, blower 3 W	18939	441	0.0212	0.913373
4	Diametre 4 mm, blower 6 W	18939	369.3	0.0240	1.231190

Test the Biogas Stoves Efficiency Level

Table 3. Recapitulation of the average results of efficiency test and stove specifications

No	Stove specifications	ΔT (° C)	ms (kg)	mf (kg)	Stove efficiency (%)
1	Diametre 2 mm, blower 3 W	70	0.229	0.0185	60.54982
2	Diametre 2 mm, blower 6 W	70	0.025	0.0205	55.86828
3	Diametre 2 mm, blower 3 W	70	0.0253	0.0212	54.45203
4	Diametre 4 mm, blower 6 W	70	0.0304	0.0240	51.06681

DISCUSSION

From the results of the calculation of the power of the biogas stove and efficiency, specific discussion can be drawn as follows. The recapitulation results of biogas stoves test with specifications of burner diameters of 2 mm and 4 mm with blowers of 3 watts and 6 watts.

Based on tables 2 and 3, it shows that the use of a 6 watt blower produces greater stove power than that of a 3 watt blower. This occurs in the use of burner holes 2 mm and 4 mm. The greater the flame hole (4 mm) is, the greater the power of the stove will be, compared to the 2 mm flame hole. This condition is in line with the theory of continuity ($V_1.A_1 = V_2.A_2$) means that the same V (biogas flow velocity) that is the greater diameter of the flame hole will result greater biogas discharge and the heat energy / heat produced will be even greater.

The greater stove power will save time or need less time to boil the water and use of the biogas fuel becomes greater. This is in line with the research of Syamsuri et al., 2015 that the greater flame hole diameter is, the greater heating will be, the temperature will also increase more and the time is shorter.

While the level of efficiency (%) proves that the use of a 3 watt blower produces a better level of efficiency than using a 6 watt blower in boiling water. Likewise, the more efficient (economical) it is, the less fuel use will be. This also occurs in the 2 mm burner flame which proves that the use of a 3 watt blower produces a level of efficiency (60.54982%) more efficient than the use of a flame hole and blower (2 mm, 6 watts); (4 mm, 3 watts); (4 mm, 6 watts). Thus, it can be concluded that the larger the hole (mm) and the greater the blower used in this study is, the greater need of biogas fuel to boil water will be. The greater biogas fuel used will cause greater heat energy so that the time needed to boil water is getting smaller (shorter).

The flame of both 2 mm and 4 mm diameter burner using 3 and 6 watts blower shows evenly distributed height and is different from those using no blower. Besides, the use of blower has a positive value, namely low pressure biogas which is accommodated in polythylene plastic (0.15 mm thick) can still be used because the blower as a vacuum biogas does not require pressure and the flame released through the flame hole is stable. It is very different from the flame released without using a blower, it depends on the pressure on biogas in polythylene plastic and uneven discharge. This condition influences the process of cooking activities for daily needs.

The economic calculation of electricity from blowers (3 and 6 watts) requires a fee assuming 1 KWH (kilo watt hours) of Rp. 1,550 for 900 watt house electricity can be calculated as follows:

Blower is on for 2 hours of cooking required a fee:

Cost = 3 watts / 1000 watts x 2 hours x Rp. 1,550, = Rp. 9.3 and if a month is 30 days then spending money of Rp. 279, -.

Whereas if you use a 6 watt blower with the same calculation method, it will cost Rp. 558 per month. The calculations is assumed based on the use of blower usage continuously 2 hours a day. For the reason of safety and convenience, the user of the biogas stove in this study needs to pay attention to the operational procedures of the stove as not only they use flammable biogas but also household electricity. The blue flame produced shows that it contains more than 45% methane gas (Ehsan, et al. (2013). The amount of methane gas in biogas will result in greater combustion power and the sustainable flame. The blue flame of the burner in this study shows that the greater the power of the blower is, the greater the flame (high) will be and is wasteful fuel.

CONCLUSION

Biogas stove with body specifications of zinc (9 cm high, 38 cm wide and 70 cm long) two furnaces, iron pipes gas distribution lines Ø 0.5 mm, fire pit (burner) 2 mm and 4 mm, blower 3 watts and 6 watts, the manufacturer's valve opens a max of 5 mm, the refueling lighter system forms a gun – like separated from the stove, biogas fuel from cow dung.

Water boiling test results, namely the stove power with a fire pit Ø 2 mm 3 watt blower (0.446630 KW) and efficiency (60.54982%); fire hole Ø 2 mm 6 watt blower (0.705517 KW) and efficiency (55.86828%); fire hole Ø 4 mm 3 watt blower (0.913373 KW) and efficiency (54.45203%); fire hole Ø 4 mm 6 watt blower (1.231190 KW) and efficiency (51.06681%)

The performance of the biogas stove shows that the smaller the fire hole is Ø (2 mm), the smaller power will be, and more efficient. The use of a blower is greater (6 watts) the power generated is getting bigger but more inefficient.

Need further research on the stove body design to use home industry product to increase their economy. Need further research related to the use of efficient electricity energy, gas supply distribution, blower resistance.

Based on the description of the results of the research above, the recommendations for the economical reason, the use of a biogas stove with a 4 mm burner flame pit with a 6 watt blower is quite cheap and the power of the stove produced is large even though it is a bit wasteful of fuel. However, that it is faster for the cooking needs, is another advantage.

The user of the biogas stove in this study needs to pay attention to the operational procedures of the stove as not only they use flammable biogas but also household electrical energy to turn on blowers. The procedures to turn on biogas stoves are as follows control whether the volume of biogas in a polythylene plastic container is available. Install and ensure the biogas distribution line is safe and no leakage. Turn on the electric energy blower. Open the valve path section (suction) in the biogas distribution from the biogas container. Gently open the valve on the stove and turn on the matches right above the burner until the stove lights up normally. Adjust the flame based on the needs, make sure that the available gas is enough for cooking by checking the biogas storage container. Turn off the blower after cooking, then close the valve on the stove and the blower suction line.

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