International Journal of Scientific Engineering and Science
Volume 7, Issue 9, pp. 32-36, 2023. ISSN (Online): 2456-7361

Increased Stove Efficiency by Modifying the Bottom Surface of the Pan

Nurfuadah[1], Badaruddin Anwar[2]
[1,2]Department Mechanical Engineering Vocation, Makassar State University, Makassar, South Sulawesi-Indonesian
**Corresponding Author: Badaruddin Anwar. E-mail: badaruddin.anwar@unm.ac.id

Abstract**—***This research aims to determine the amount of stove efficiency produced. This research uses an experimental method carried out on a pan whose bottom surface depth is (a) = 0 cm, which is called a flat pan; (a) = 1 cm which is called modification pan I and (a) = 1 ½ cm which is called modification pan II. This research was carried out by measuring the temperature on the bottom surface of the pan, gas stove flame, heated water, measuring the fuel rate and evaporation rate. The research results showed that the increase in stove efficiency occurred in modification I pan from 6.8% to 7.69% for valve 2, taking into account fuel consumption. In this case, the Modification I pan is more efficient and optimal in absorbing heat, can boil water quickly and is able to save fuel consumption.*

Keywords**—** *Pan, Fuel Rate, Evaporation Rate.*

I. INTRODUCTION

In the current technological era, people must be wise and clever in choosing equipment that is considered to increase efficiency. This increase in efficiency is one of the benchmarks for creating energy efficiency. Energy efficiency has been widely developed nowadays with various methods and applications. In application, of course it is carried out in all types of human life activities, including in the world of industry, plantations & agriculture. One way to achieve energy efficiency is by modifying energy-saving equipment.

Energy-saving equipment is an innovation that deserves appreciation in society. In its application, this equipment can minimize fuel consumption. One way is to minimize energy consumption by modifying the pan.

A pan is one of the kitchen utensils used to fulfill the primary needs of every human being, namely cooking food to be consumed. As for pan materials, generally they are aluminum, copper, stainless steel, carbon steel, and cast iron. When choosing a good heat transfer pan, it has beautiful aesthetics, is resistant to scratches, has no effect on the food being cooked (inert), and is affordable.

Increasing efficiency is also inseparable from the influence of the stove or furnace used. Seeing this reality, many researchers carry out research and technical engineering to obtain better efficiency.

Based on previous research, increasing the efficiency of LPG stoves is influenced by 2 factors, namely construction engineering and providing alternative fuel to replace LPG.

Construction engineering efforts have been carried out, namely Abdul Haris Subarjo (2019) make parabolic solar cooker with a diameter of 84 cm. The stove power results obtained were 36.59 Watts and the stove thermal efficiency was 6.18%. The power of the stove is influenced by the difference between the temperature of the water after being heated and the temperature of the water before being heated. The greater the temperature of the water after being heated, the greater the power of the stove. The greater the overall heat transfer is Qm and the smaller the intensity of solar radiation on the reflector that uses mirrors, the greater the thermal efficiency [1].

According to Vahrullah (2021), based on research results, it is known that the length of boiling time is directly proportional to the volume of water being boiled. The greater the volume of water, the longer the boiling time required. Likewise with pertalite fuel consumption. The greater the volume of water being boiled, the more pertalite fuel is needed. Apart from that, the greatest heat energy of alternative pertalite-fueled stoves was obtained at an additional pressure of 0.5 bar, namely 2.695 cal/second, but the greatest efficiency was obtained at an additional pressure of 0.2 bar with an efficiency of 24.734% [12].

Agustina (2022) also carried out construction engineering by adding grid material with a thickness of 3 mm in 3 variations, namely variation 1 with a hole diameter of 0.4 cm and 60 holes, variation 2 with a hole diameter of 0.6 cm and 50 holes, and variation 3 with a hole diameter of 0.8 cm and 40 holes. The addition of this material functions to focus the flame and minimize losses. Making tools includes preparing tools and materials, modifying the stove holder, making grid and reflector materials, and testing. The method used in testing is the Water Boiling Test (WBT) method. The average research results show that the boiling time produced by 1 variation grid and 1 fin row reflector is 18.06 minutes compared to 22.02 minutes without the addition of grid material and reflector.

Based on this research, one of the things that can affect the efficiency of the stove is modifications to the bottom surface. This research aims to determine the amount of heat energy used in fuel and the heat energy used to heat water.

II. THEORETICAL BASIS

SP Hasibuan (1984; 233-4) who quoted from H. Emerson's explanation stated that efficiency is the best comparison between input and the results that emerge between profits and the resources used (output) as well as success in achieving results. optimally using limited resources. Stove efficiency

International Journal of Scientific Engineering and Science
Volume 7, Issue 9, pp. 32-36, 2023. ISSN (Online): 2456-7361

shows the percentage of useful heat in a stove and can be used to determine the heat lost during use of the stove.

Stove Efficiency

To increase the efficiency of the stove, a large amount of fuel energy is needed to be able to boil water in a relatively short time by comparing 3 types of pans, namely flat pans, modified pans I and modified pans 2. The main components needed in the calculation include:

1. Amount of fuel energy (Qbb)
2. The amount of energy absorbed by water (Q water)

Based on energy balance, to obtain stove efficiency:

$$\eta_{Stove} = \frac{Q_{Water}}{Q_{Fuel}} \times 100\% \quad (1)$$

Where: Q water = energy used to heat water
Q fuel = fuel energy

III. METHODOLOGY

A. Research design

Increasing the heat transfer efficiency of the pan can be done. One way is to modify the bottom surface of the pan. The methods used in this research include literature studies in the form of books or journals which discuss the effect of modifying the bottom surface of the pan on heat transfer efficiency and experimental studies to obtain data that will be used.

In this research, several parameters will be shown in the image below:

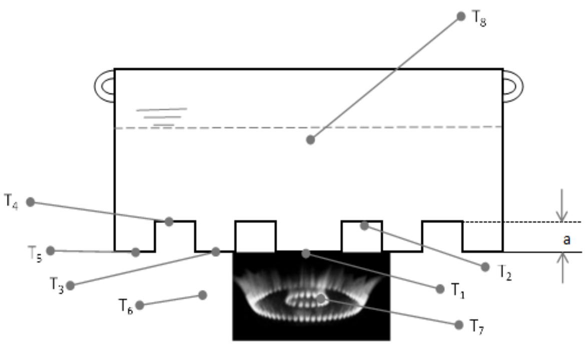

Figure 1. Test Objects

Information
T1 = Center temperature of the pan (ºC)
T2 = Temperature around the center of the pan 1 (ºC)
T3 = Temperature around the center of pan 2 (ºC)
T4 = Temperature around the middle of the pan 3 (ºC)
T5 = Pan edge temperature (ºC)
T6 = Ambient temperature of the fire (ºC)
T7 = Flame temperature (ºC
T8 = Water temperature (ºC)
a = Depth of the pan surface (cm)
On a flat surface the pan has a depth of (a) = 0 cm.

The varying surfaces of the pan will each have a depth of (a) = 1 cm and 1 ½ cm.

When collecting data, thermocouples will be installed at several predetermined points, as in the picture above.

The material specifications and sizes of each pan are the same as shown in the table below:

TABLE 1. Pan Specifications

Specification	
Material	Aluminum
Diameter (mm)	210
Height (mm)	140
Thickness (mm)	1.5

B. Materials and tools

Some of the materials and equipment used in this research are:

1. 3 pans, namely 1 pan with a flat bottom surface, and 2 pans whose bottom surface has been modified with respective depths, namely 1 cm and 1 ½ cm

Figure 2. Modified pan

2. Water

Water is the medium used for heating with a volume capacity of 2 liters and a volume of 3 liters

3. Gas stove

The gas stove used is a general gas stove, the same as those sold on the market.

Figure 3. Gas stove

4. 3 kg LPG cylinder

Figure 4. Elpigi tube

5. Thermocouple

This tool is used to measure the temperature of the water and the bottom surface of the pan based on the specified time.

International Journal of Scientific Engineering and Science
Volume 7, Issue 9, pp. 32-36, 2023. ISSN (Online): 2456-7361

Figure 5. Thermocouple

6. Temperature reader

Figure 6. Temperature display

C. Measurement System

a. Temperature measurement via thermocouple

The thermocouple is used to measure the temperature of the bottom surface of the pan which is installed at several points, namely T1= temperature in the middle of the pan, T2 = temperature around the middle of the pan 1, T3 = temperature around the middle of the pan 2, T4 = temperature around the middle of the pan 3, T5 = temperature at the edge bottom surface of the pan, T6 = temperature around the fire and T7=fire temperature.

Thermocouple specifications:
Model/type : Type K
input : CA (K)
Temperature range: 200 – 1250 OC
Voltage: 41 µv / oC

b. Temperature measurement via a thermometer

A mercury thermometer is used to calibrate by measuring the air temperature of the surrounding environment. The thermometer used has a measurement limit between 0~100 ˚C and has a fast response to temperature changes.

For the purposes of measuring temperature with a thermocouple, it is first calibrated against a mercury thermometer by:

1. Take a thermometer then put it in the pan.
2. Take all the thermocouple sensor cables that have been connected to a computer that has temperature reading software, then put them together with the thermometer in a pan containing water that is heated until boiling. The process of taking calibration data from the initial temperature before heat to the final temperature after boiling and also calibrated at the freezing point temperature.
3. Data from the thermometer and thermocouple calibration results are shown in the regression equation and graph below:

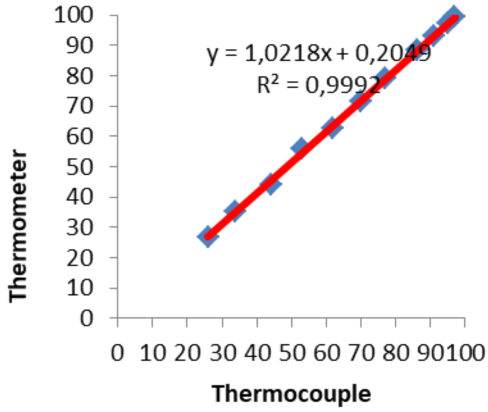

Figure 7. Graph with thermocouple vs thermometer calibration equation

D. Data collection procedures

The steps that will be taken in this research include:

1. Calibrate temperature measuring instruments
2. Prepare 3 kinds of pans, namely 1 pan with a flat surface, and 2 pans with varying bottom surfaces, each with a depth of 1 cm and 1½ cm.
3. Place thermocouples on the bottom surface of the pan, each in the middle of the pan, and around it at 4 points. Then one thermocouple each in the eye of the stove, around the fire and in the heated water.
4. Place pans containing 2 liters and 3 liters of water each on the gas stove alternately.
5. After turning on the gas stove, data collection begins at a predetermined time, starting from 1 minute until it reaches a constant (steady) temperature.
6. In the process of lighting the stove fire each is varied to open valve 1, valve 2 and valve 3
7. After data collection is complete, data processing will be carried out to calculate pan efficiency and stove efficiency.
8. Research for each pan is carried out alternately starting from step 2 to step 5.

In experiments carried out to calculate the efficiency of the stove by measuring the heat of the water being heated compared to the heat of the fuel used.

IV. RESULTS ANALYSIS AND DISCUSSION

A. Data analysis and calculations

A.1 Observation data

The temperature characteristics of the pan are shown in the figure below:

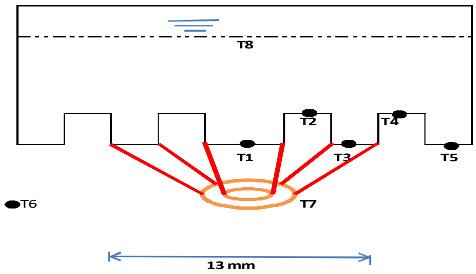

Figure 8. The flame of the stove emits onto the bottom surface of the pan

International Journal of Scientific Engineering and Science
Volume 7, Issue 9, pp. 32-36, 2023. ISSN (Online): 2456-7361

2. Data analysis and calculations for stove efficiency

To increase the efficiency of the stove, a large amount of fuel energy is needed to be able to boil water in a relatively short time by comparing 3 types of pans, namely flat pans, modified pans I and modified pans 2. The main components needed in the calculation include:

1. Amount of fuel energy (Qbb)
2. The amount of energy absorbed by water (Q water)

To support the calculations above, several measurement result variables, calculation results and several physical properties obtained from tables (reference books) are needed.

Measurement outcome variables include:

Flat Pan

Valve 1

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0028 kg/minute

Evaporation rate for 2 liters = 0.0179 kg/minute

Evaporation rate for 3 liters = 0.0264 kg/minute

Valve 2

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0041 kg/minute

Evaporation rate for 2 liters = 0.0429 kg/minute

Evaporation rate for 3 liters = 0.0375 kg/minute

Valve 3

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0046 kg/minute

Evaporation rate for 2 liters = 0.0441 kg/minute

Evaporation rate for 3 liters = 0.044 kg/minute

Modified Pan I

Valve 1

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0028 kg/minute

Evaporation rate for 2 liters = 0.0304 kg/minute

Evaporation rate for 3 liters = 0.0305 kg/minute

Valve 2

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0041 kg/minute

Evaporation rate for 2 liters = 0.0474 kg/minute

Evaporation rate for 3 liters = 0.0397 kg/minute

Valve 3

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0046 kg/minute

Evaporation rate for 2 liters = 0.046 kg/minute

Evaporation rate for 3 liters = 0.0479 kg/minute

Modification Pan II

Valve 1

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0028 kg/minute

Evaporation rate for 2 liters = 0.0334 kg/minute

Evaporation rate for 3 liters = 0.0346 kg/minute

Valve 2

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0041 kg/minute

Evaporation rate for 2 liters = 0.0481 kg/minute

Evaporation rate for 3 liters = 0.0436 kg/minute

Valve 3

The rate of fuel used to heat 2 liters and 3 liters of water = 0.0046 kg/minute

Evaporation rate for 2 liters = 0.055 kg/minute

Evaporation rate for 3 liters = 0.0485 kg/minute

Variables obtained from the Table:

Cp_{water} = 4.174 kJ/kg

Variables obtained from

Calorific value of LPG Fuel: 45227kJ/kg

Example of calculation for Modification I Pot (2 Liter) on Valve 2:

Thermal energy produced by gas fuel:

LHV = 45227 kJ/kg

Q in = Q fuel = mbb x LHV

=0.0041 kg/minute x 45227 kJ/kg

=185.4307kW = 185430.7W

Energy used to heat water:

Q water = m_{water} x cp_{water} x ΔT

= 0.0474kg/minute x 4.174 kJ/kg°C x (99.61-27.49)°C

= 14.2687 kW = 14268.7 W

$$\eta_{stove} = \frac{Q_{water}}{Q_{Fuel}} \times 100\%$$

$$\eta_{stove} = \frac{14268{,}7}{173250} \times 100\% = 7{,}69\%$$

V. CONCLUSION

From the results of the research that has been carried out, it can be concluded that of the three types of pans made, the pan that has many advantages and benefits is the Modification I pan with 2 valve openings. The increase in stove efficiency occurred from 6.8% to 7.69% for valve 2 Because this pan is able to save fuel consumption by 0.02 kg and is able to absorb heat optimally and efficiently compared to flat pans and modification II pans.

REFERENCES

[1] Abdul Haris Subarjo, Benedictus Mardwianta, Anugrah Budi Wicaksono (2019). *Efficiency of Parabolic Solar Stoves with Mirror Reflectors to Support Energy Security.* Solar Energy Journal of Electrical Engineering, UM-Palembang. Vol.4 No 1

[2] Bejan , 1993, *Heat Transfer*, John Willy & Sons Inc Singapore New York, Toronto

[3] Bird. RB Steward, WE &Lightfoat .EN1994, *Transport Phenomena*, John Willy & Sons Inc Singapore New York, Toronto

[4] Cengel YA, Ghajar AJ, 2007, *Heat Transfer and Mass Transfer, Fundamentals And Applications*, 4th Ed, McGraw Hill, Singapore.

[5] Dewi Agustina, Zeni Ulma, Mochammad Nuruddin, Bayu Rudiyanto, (2022). *Grid Addition Study and*Reflectors on Stove Efficiency, Journal of Energy Engineering Exergy, *Vol.18 No.1*

[6] F. Mill Anthony, 1992, *Heat Transfer*, Richard. D. Irwin Inc

[7] Holman, JP, *Heat Transfer*, Translated by E. Jasjfi, MSc, 6th Edition, Erlangga, Jakarta, 1997.

[8] Incropera, F., Dewitt D. P., Bergman, R., TL, and Lavine, AS 2007. *Fundamentals of Heat and Mass Transfer*, 6th edition. College of Engineering, University of Notre Dame

[9] John H. Lienhard IV/John H. Lienhard V, *A Heat Transfer Textbook*, 3rd Edition, Phlogiston Press, Cambridge Massachusetts, 2003

[10] Krauss, A.D., Aziz, A., and Welty, J., 2006, *Extended Surface Heat transfer*, 5th Ed, John Willy and Sons, Inc., England

[11] Kreith Frank. 1991, *Principles of Heat Transfer*, Third Edition, Arko Prajono MSc, Erlangga Publisher

[12] Mokoagow, V. (2021). *Stove Efficiency Analysis Using Pertalite Fuel*. Gorontalo Agricultural Technology Journal (JTPG), 6(1), 7-13.https://doi.org/10.30869/jtpg.v6i1.745

Volume 7, Issue 9, pp. 32-36, 2023.
ISSN (Online): 2456-7361

[13] Ganpathy. V. 1982, *Applied Heat Transfer*, Penniwill Publishing Company
[14] Kays. WM 1993, *Convective Heat and Mass Transfer,* Third edition, Tata MC Graw Hill Publishing Company Limited, New Delhi.
[15] Ozisik. NM 1985, *Heat Transfer*, MC Graw Hill Books Company, New York, Tokyo, Toronto.