DESIGN A SOLAR ENERGY STOVE USING A WATER LENS

[1] KUMARA SADANA PUTRA, [2] KRESNO SULASMONO

[1] Lecturer, Faculty of Creative Industry University of Surabaya, Raya Kalirungkut Surabaya Indonesia
[2] Lecturer, Faculty of Creative Industry University of Surabaya, Raya Kalirungkut Surabaya Indonesia

Email: [1] kumy01@yahoo.com, [2] kresno.sulasmono@gmail.com
Contact: [1] +62.81318029429, [2] +62.83830662333

Abstract:. Indonesia is a rich country in natural resources such as solar energy. Utilization of solar energy on a daily necessities are cooking. Such use can save up to 30-50% of LPG usage, which saves significant use on a national scale. Problems need to resolve is the use of solar energy for cooking function requires tools so as to produce a constant heating intensity, parabolic compact size for simple home. Authors are encouraged to make a study entitled Design A Solar Energy Stove Using A Water Lens. By using qualitative research methods in the form of experimental design in the realm of industrial design, to produce a prototype lens cookware and pans that can absorb heat from above. Obtained some of the conclusions in the study should consider the construction of the prototype parabolic lenses made of acrylic, shape precision focus corresponding parabolic shape, the distance of movement of the focal point. So that at the next study improvements that must be taken is the setting angle lens and lens tilt by a cover.

Index terms: experiment, lens, parabola, product design, sun energy.

I. INTRODUCTION

Alternative energy that has not been used for cooking is solar energy, is very potential to be utilized because Indonesia located on the equator. The advantage of solar energy is we do not have to pay to get, but it has a weakness because it is not constant intensity. If solar energy can be utilized for cooking, although as auxiliary energy besides LPG, the savings are estimated between 30% - 50% (depending on the weather). Per household cost calculated generally not very large but quite significant on a national scale.

Until now the utilization of solar energy is limited to water heater by using a flat collector placed on the roof. Cooking utilization of solar energy required paraboloida collector form. The obstacles of paraboloida cooking uses is should be cooking outside with direct sun and resulted by having to remove and enter the cooking utensil.

Solar thermal energy is a potential energy source to be managed and developed further as a source of energy reserves, especially both countries located in equatorial areas including Indonesia, where the sun can shine throughout the year. Indonesia is a tropical country with temperatures of 32 C - 40 C where the intensity of sunlight, so that solar energy can be used for solar stoves. The average air temperature is high, because the sun is always vertical. Generally the air temperature between 20 - 23 C. Even in some places the average annual temperature reaches 30 C.

Cooking with parabola using sunlight reflector and focuses it on one point principle so that the heat arises. Parabolic shapes and materials can be made in a simple and inexpensive way, with special materials and fabrication. This means that a parabolic cooking device does not have a significant problem. Problems arise in the cooking operations that must be outside the room.

a. Mirror dish and other equipment must be removed when cooking and inserting when finished.
b. The sun is not constant intens (due to weather).
c. The weather barrier is unpredictable. So when cloudy the cooking time will be more difficult.
d. The parabolic storage 120 cm in diameter is too large for a simple house with $24m^2$ - 36 m^2.

Parabolic water lens is the solution of the problems that exist in the mirror parabola, because the position of cooking that is under the lens allows in the inner space. From the experiments that have been done there are several problems:

a. Lenses made of uneven plastic are wrinkled, causing irregularly shaped focus to reduce heat
b. Material for lenses of inexpensive plastic can not withstand heavy loads of water
c. The usual form of cooking utensils such as pots and pans is less

II. FUNDAMENTAL THEORY

2.1 Solar Energy

The Sun is the closest star to Earth with an average distance of 149.680,000 kilometers (93,026,724 miles). The equatorial diameter is 864,000 miles, with the inter-polar intermediate line 43 miles shorter with a mass of 98%. The sun mass density is 1.41 versus the mass of water. The amount of solar energy that reaches the Earth's surface is recognized as a constant solar equaling 1,370 watts per square meter at any time. The energy consumed by sunlight is actually only received by the earth's surface by 69% of the total energy of sunlight emitted.

But a small amount of energy is sufficient as a source of energy on earth. Based on the results of the study, every 1 cm2 of the earth's average atmosphere receives 2 hours of sun energy per minute (8.4 joules / min). The value of 2 calories per minute is here in after called the solar constant.

2.2 Principle of Solar Energy Utilization

In bright weather conditions, the Earth's surface receives about 1000 watts of sun energy per meter^2. Less than 30% of the energy is reflected back into space, 47% is converted to heat, 23% is used for all work circulation on the surface of the earth, a small 0.25% is occupied by wind, waves and currents and there is still a very small 0.025% is stored through the process of photosynthesis in plants that is eventually used in the process of forming coal and petroleum (fossil fuels, the process of photosynthesis that takes millions of years) which is currently used extensively and exploratively not only for fuel but also for plastic forming materials, formica, other synthesis materials. So it can be said that the source of all energy is solar energy.

The solar radiation period is more than 6 hours per day or equal to 2,400 hours per year. Then also supported by the intensity of solar energy exposure in Indonesia for 4.5 - 4.8 kWh / m^2 per day. In the middle of the day sunny radiation of sunlight on earth is able to reach 1000 W / m² = 1 kW / m² = 100 mW / cm².

Table 1 Area in Indonesia & its radiation potential

Area	Potensial Radiation	Month Variation
West Indonesia	4,5 kWh/m^2 per day	10 %
East Indonesia	5,1 kWh/m^2 per day	9%
Average Indonesia	4,5–4,8 kWh/m^2 per day	9,5%

2.3 Utilization of Solar Energy For Cooking

Indonesia is a country rich in natural resources in the form of oil and natural gas. Oil products and natural gas used as fuel for various purposes such as for cooking. With the depletion of petroleum reserves, many are trying to find alternative energy to further save the use of oil and gas. Eventhough solar energy has a lot of potential advantages, it also have weakness because it is not constantly intens.

2.3.1 Working Principles of Solar Power Parabolic Stoves

There are different types of solar cookers. Everything uses heat from and sunlight to cook food. Some basic principles of solar cookers are as follows:

1. The concentration of sunlight. Some devices, usually a mirror or a type of light reflecting metal, are used to concentrate light and solar heat into small cooking areas, making energy more concentrated and potentially producing enough heat for cooking.
2. Turning light into heat. The inside of a solar cooker and pot, from any material of black origin, can increase the effectiveness of converting light to heat. A black pot can absorb most of the sunlight and turn it into heat, fundamentally increasing the effectiveness of the solar stove. The better the ability of the pan to heat, the faster the stove and the oven work.
3. The effort to isolate the air inside the stove from outside air will be important. The use of hard and clear materials such as plastic bags or glass pan caps allows light to enter the pan. After light is absorbed and turned into heat, a plastic bag or a glass-covered lid will trap heat in it like a greenhouse effect. This allows the stove to reach the same temperature when it is cold and windy as it is when it's sunny and hot.

The strategy of heating a product using solar energy becomes less effective when using only one of the above principles. In general, solar cookers use at least two ways or even three basic principles of a solar cooker to produce sufficient temperature for cooking.

Regardless of the need for sunlight and the need to place the solar stove in the right position before using it, this stove does not vary much with a conventional stove. However, one of the disadvantages is that solar cookers generally ripen off food on hot days, when people tend to be reluctant to eat hot food. However, the use of a thick, slow, hot pans (like cast iron pans) can reduce the rate of heat loss

Although this type of solar cooker can cook as well as conventional stoves, but the stove is difficult to make. The parabolic stove is capable of achieving high heat and fast cooking, but it always requires regulation and supervision to operate safely. The numbers around the world are around a few hundred thousand pieces, mostly in China. Making parabolic stoves is considered a bit more expensive due to the ingredients.

2.3.2 Working Principle of Water Lens Parabola Stove

The lens of water is an old idea that has been known for a long time, but is often forgotten and underestimated and underused in public life. Because oil and gas began to decrease a lot then this water lens began to be developed. One of them is used for cooking. The basis is very easy that is by focusing sunlight coming to a point, so that the heat can be used for cooking.

2.3.3 Design of Solar Stove by using Water Lens

The purpose of this study is to overcome the reluctance of users to cook outdoors. At present, the socialization of solar energy is important because kerosene is getting hard to come by and its successor LPG is still in trouble with its use. The result of this research is the concept of folding the parabolic stove. In the execution of the research, a thought arises when a mirrored parabola is replaced with a parabolic lens, made of water-filled acrylic.

Conclusion

With a parabolic-shaped solar stove that can be folded folded look will facilitate the user, and with the aesthetic shape also hope users will be interested.

From experiments The use of water lenses on a small scale, obtained heat up to 120 C, where the temperature can be used for cooking.

2.5.3 Water Lens Capability Experiment

Following the idea of using water lenses for cooking, a simple experiment was made to observe its warming ability. With a water lens of 24 cm diameter of 0.6 mm clear mica formed with vacuum printing. The heat obtained from the focusing at 09:17 is 120oc. Focus rate 1: 450

III. METHODS

This study is a real experimental study, which carried out full-scale experiments to obtain data that supports the purpose of utilizing solar energy using water lenses for cooking. This research is in the realm of Industrial Product Design because the sought is objects, components - connecting components of technology and human (human interface). Engineering is in the realm of applied physics, where the dimensions are certain and undefined so that only live in the course of this research.

This research is divided into several stages, starting with the historical study in the form of data collection of the development of the use of solar energy for cooking, especially those using parabolic collectors. Followed by analyzing calculating sunlight concentration ratio for cooking use. more accurate dimensions. Prior to conducting the experiment, the basic definitions and main variables were defined, as well as the design of the experiments.

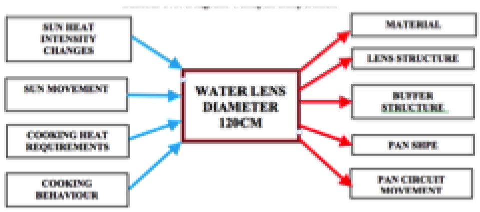

Diagram 1: Experiment stage

The first experiment used a 120 cm diameter water lens with a plastic / acrylic material formed by gravity, hanging with water. Then try to cook water or other with the usual cookware. The experiment was done on a flat roof and made a small space of plywood to avoid the wind. While the second experiment, making a water lens with a precision parabolic contour. How to create with gravity but with reinforcement and molding, or by way of vacuum printing consisting of several segments. Make a pot that can absorb heat from the top. The next experiment is done the same as before using:

- a parabolic mirror axis 1.2 m at 1.13 m²
- Heat that can be used in the morning = 400 Watt
- Heat that can be utilized during the day = 500 Watt

When the energy for cooking takes about 500W, then with the parabolic lens with full solar heat 1L of water in a pot with a diameter of 20cm can boil within 15 minutes. The base of the pot is about 300cm2, meaning the focus ratio is 30. If only with 1/3 the intensity of the sun (eg in cloudy weather), 1L of water in the pot can not boil. To increase the temperature the focus ratio is added so that the pan is smaller with less water content. The addition of the focus ratio to the size reduction of the pot is tried until the water can boil. Then note the ratio ratio of the focus. If the size of the pan is fixed and the focus ratio uses the experimental results, larger parabolic sizes can be found, eg. 200-240cm. The large lens parabolic size does not matter because the lens is permanent and its users are at the bottom.

Note: 800 Kcal / m² / h (295 BTU / ft²h) of maximum solar heat

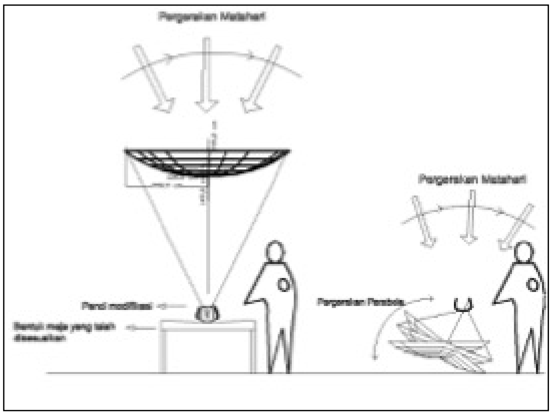

Figure 1: 2 types of parabolic stove

IV. EXPERIMENTAL RESULT

IV.1 Small Parabolic Lenses

Purpose: Parabolic parabola experiment by making segment cuts

Size: diameter 50 cm with focus distance 60 cm

Material: 0.5 mm mica, aluminum pipe, silicone glue, cyano acrylic glue

To form a parabolic circle, a ring (ring) with a diameter of 50 cm, made of aluminum pipe diameter of 1 cm. On top of the ring the plastic segment in the rectangle forms a parabola, the first attachment using clear tape, then glued using cyano acrylic glue. Next parabola in waterproof test, after no leaking conducted experiment focus (hotspots).

The experiment was conducted in an open place, where in this case it is on the roof, the experiment aims to see if the shape and size of the hotspots are correct.

Figure 2: Small parabolic lenses & its result

Parabolic shape is correct but the shape of the focal point can not be round, with a distance of 1.2 m. Then carried out experiments heating water as much as 20 cc put into a can of black paint. As a result, the highest temperature reached was 85 ° c.

IV.2 Large Parabolic Lenses

Size: diameter 120 cm

Material: 3mm thick acrylic, 20mm styrofoam, stiro glue, silicon glue, cyanoacrylic glue, pipe stainles diameter 20 mm 1.5 mm thick

The segment shape must be made from the original carton, to get the curved line on its long side. After the try its accuracy 3 mm acrylic stone cut, wear grinding. With a circular shape ring structure in which the outer circumference can be a strong segment holder. The connection is done by giving a 1x3 cm drama of acrylic also glued and boat, at the end of its encounter, while the elongated slot at the meeting of the segment is covered with 0.5 mm thin acrylic. then coated with clear silicone glue.

The acrylic parabola is reinforced with a ring of stainless pipe on its outer side, connecting using a plastic clamp commonly used for PVC pipe

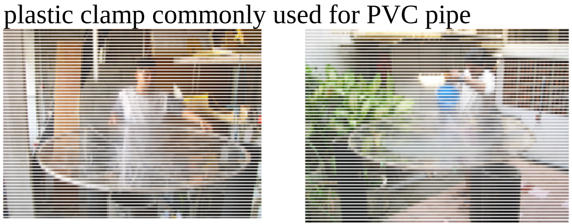

Figure 3: Large parabolic lenses & its process

IV.3. Parabolic Lens Experiment

Structural experiments carried out by burdening the lens by filling the water to the full, then see whether there is a change in shape. From the experiments performed, the changes occur about 2 mm, does not mean overall. Loading is done for 3 days no damage or leakage occurs.

His parabolic experiments are carried out on the roof of the top-floor concrete plate of the Ubaya PE building. After studying the situation in place there were some obstacles, among others, the wind is quite hard, also must create a 4 m high buffer structure is quite strong and expensive. Next there should be a ladder to fill the water on the water lens, also there must be enough water pressure up over the lens. With these constraints then the experiment was conducted at the researcher's home jl.Karang Asem Va no 5. Surabaya, with consideration there is a large enough page where there is already a structure to put the water lens. Besides that around the buffer structure there is already a terrace to reach the lens either to install or fill the water.

Figure 4: Structural experiment

IV.4. Position Experiment

Table 2 Experiment position

	Hangs on structure buffer	Attach on structure buffer
Lens-floor Distance	330 cm	335 cm
Fire point shape	Almost circle, dia 34cm	Circle, dia 25cm
Water temp.	92° C	98° C

V. CONCLUSION

From the research that has been done to get some conclusion that is:

1. Construction of parabolic lenses using acrylic is more accurate, and can be adjusted the thickness of the lens, so that the distance of the focus point can be adjusted according to the height of the location of the lens in the kitchen.
2. The round focus shape shows the precision of the parabolic shape. But at the angle of angled sunlight, the shape of the focus becomes oblong and distorted by the effect of a bulge on the joint.
3. The distance of the focus point movement due to the movement of the sun to be far to the size of the kitchen is about 3 m, at a lens height of about 4 m from the floor.
4. As a result of the shape of the focus point that is not always round, then the heat generated is also not constant and not maximum.

From these conclusions the improvement suggestions are:

1. Author recommend that the lens can be set in its angle so it can position perpendicular to the sun, or at least at an angle where the focus remains round
2. Water-filled lenses, to be tilted need to be tightly sealed so that water does not spill. Obtained some of the conclusions in the study should consider the construction of the prototype parabolic lenses made of acrylic, shape precision focus corresponding parabolic shape, the distance of movement of the focal point. So that at the next study improvements that must be taken is the setting angle lens and lens tilt by a cover.

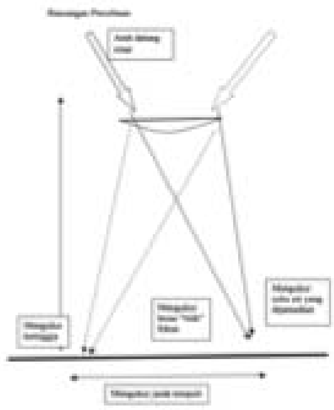

Figure 5: Conclusion design

REFERENCES

[1] Bramston. David, "Basic Product Design 2 Material Toughts", AVA Publishing SA, 2009

[2] Morris Richard, "The Fundamentals of Product Design", AVA Publishing SA, 2009

[3] Palgunadi Bram, "*Desain Produk 3 Analisis dan Konsep Disain*", ITB: Bandung, 2008

[4] Tilley, Alvin R, "The Measure of Man and Woman Human Factors In Design", John Willey & Sons INC, 1993

★★★