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# AN EXPERIMENTAL METAL MATERIAL AS HEAT ABSORBENT MATERIAL IN THE SOLAR OVEN

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***Abstract-*** ***Thermal energy storage is an important factor to be considered in the study of solar energy. This is because at night the earth is protected from direct sunlight. Modern energy needs require continuous energy available. Metal is one of the ingredients used to store solar energy in the form of heat due to its nature as a good conductor of heat. The purpose of this study is to analyze the metal as a thermal energy storage material for use in a solar oven. Aluminum and copper were selected for the study. This experimental method has been carried out in a stagnant environment. The data obtained from experimental methods are tabulated in the form of graphs. Results of the experiments that have been conducted show that the use of aluminum and copper in the solar oven can increase the heat stored in an enclosed space. Aluminum metal shows an increase in temperature better than copper at noon when solar radiation readings maximum, but the temperature of aluminum also decreased faster than copper where the temperature readings in the solar oven is the same in the evening for the two metals. In conclusion, aluminum can act as thermal storage for solar oven and use of aluminum can be used to increase the oven temperature even higher, especially when solar radiation received is high. Copper is suitable for use when solar radiation received is not fixed, especially when clouds cover the sun.***

***Keywords:*** Solar Oven, solar radiation, solar thermal

## I. INTRODUCTION

The need for energy in this modern age is critical. Solar energy is one of the renewable energy that has attracted the interest of researchers to help improve the energy shortage in modern times[1]. There are weaknesses in the solar energy which is limited sunlight during the day due to cloud cover and also at night with no sunlight[1, 2]. Solar oven that uses solar energy as the main source of energy require thermal energy storage method for improving the efficiency of the solar oven[3, 4]. Solar cookers cannot cook food in the late afternoon and when the sun is covered with clouds. This weakness can be resolved by the storage unit associated with the solar cooker[2]

Apart from metals, Sahoo in his writings highlight the use of phase change materials (PCMS) to keep the heat in the form of latent heat has been recognized as one of the alternatives to provide a compact and efficient storage system for high-density storage and continuous operating temperature [5]. Turkmen in his designs, has studied a solar cooker consists of an insulator, the absorber plate, pot in it, two layers of transparent cover on it, the cover is used to put the pot and four-barrel moving reflective mirror used to cover solar cooker. Turkmen using galvanized plate as a heat absorber[6]. Ayala also use aluminium trays as thermal energy absorbing device[7, 8]. Kariuki using the cylinder block in the study of solar cookers, but not stated in the study of the metal material used for the cylinder block[1].

Thermal energy storage is needed because the uncertain sunlight to reach the earth's surface due to radiation is often covered in clouds, at which specific times only a small amount of radiation received. For example at night or during heavy cloud, the amount of solar energy received by solar collectors oven is a small volume in which energy storage is necessary to stabilize the operation of a solar oven. The storage units were used in this project is an aluminum plate that is used to store thermal energy. Storage unit can store excess energy produced during the period of maximum productivity, and will be released when productivity is decreasing. Thermal energy storage can be considered important, because when there is a mismatch between the supply and use of energy, thermal energy that has been stored will be used when necessary. [9]

### Solar Oven Description

Several aspects should be taken into account for each solar oven design to ensure the design is able to operate properly. Aspects to be considered for each design are high efficiency, portable, easy to install or construct, pollution-free, and user-friendly[10, 11]. This solar oven design is based on a design that had been developed before[10], and in this study the solar oven will be enhanced with aluminum metal that serves as a thermal energy storage and aluminum metal is placed in the middle of a solar oven.

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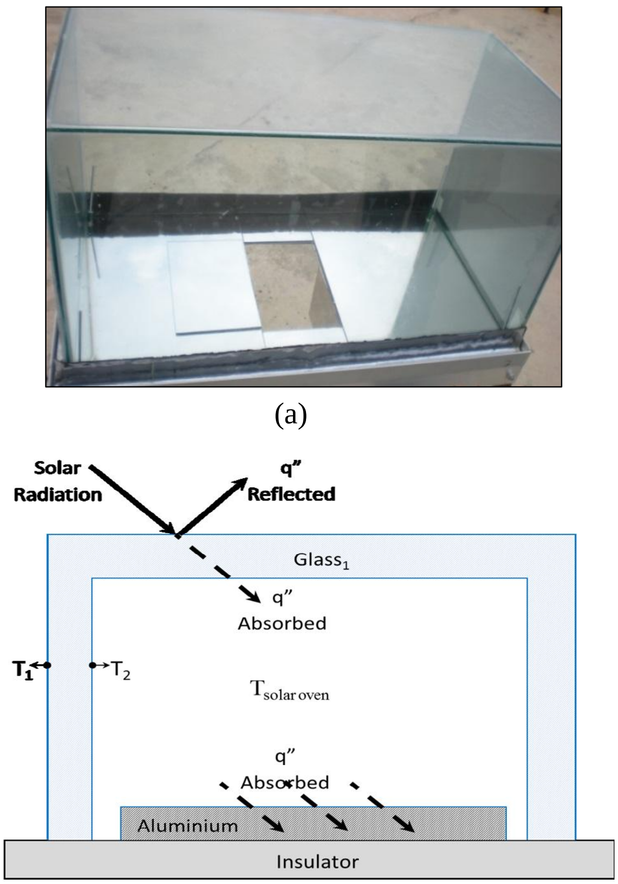
Experimental model was built in 2011 and was rebuilt several times in order to get the intended results[12]. The model for this experiment was constructed as shown in Figure 1 above. Solar ovens have the same height and length of 0.3 meters and width of the solar oven is 0.6096 meters. The wall thickness of the solar oven is 0.0254 meters.

Figure 1 shows a design concept for a solar oven with five solar exposures. Solar ovens are designed to have five exposures and rectangular. Important factors that were taken into account in the design of solar oven is that it is more convenient and practical, portable, economical and easy to use [2]. Solar oven is constructed with an opening and comes with a cover on the bottom so that the oven can be accessed.




(a)

(b)

**Figure 1: (a)The Solar Oven (b) Schematic diagram of solar oven**

## II. Experimental and Test Methods

Tests and experiments have been carried out for a solar oven at the roof level of 21 Science and Technology Tower, UniversitiTeknologi Mara (UiTM). The data collected are temperature readings in the solar oven and solar radiation received rate. For this, the apparatus and equipment used is Solarimeter and data logger with thermocouple located inside the solar oven. A solar oven oriented facing eastward.

Ambient temperature data are taken and obtained by using a thermometer with a range of 5% of reading accuracy. Reading data from thermal radiation and ambient temperature are taken from 8:00 am to 6:00 pm. Each thermocouple will be marked and placed as in the diagram above.

Experiments are carried out with thermal analysis with the highest temperature readings will be recorded in the solar oven. Solar ovens are generally work by collecting heat will be exposed to direct sunlight which is also known by the full load condition. Each test was carried out to analyze the potential of increasing the temperature in the solar oven with different metals in the solar oven.

Exposure solar oven to sunlight is maximized by exposing it in the direction of movement of the sun, knowing that the sun rises from the East and sets in the West. Experiments related to the distribution of the total radiation from the sun in Malaysia was conducted by Wazira[13] at the beginning of this year, and according to a report done by Wazira that the monthly average daily solar radiation Malaysia is the highest in the month of February. Experiments and tests were carried out on normal day time hours from 8:00 to 6:00 for two weeks.

Experimental stagnation for solar oven was done by Suharta[14], Sahoo[5] to determine the maximum temperature solar oven during operation[15]. Solar ovens have been tested without a load of food to determine the stagnation temperature and to check the condition of the solar oven in stagnation. The same method was used to determine the effect of metal absorption in the solar oven to maximum temperature, the stagnation tests were carried out starting at 8:00 am and ends at 6:00 pm. Data Logger used to determine the temperature in the box solar oven. Data were collected every hour to ensure reasonable stagnation curve. Each of the thermocouple will measure the temperature separately in the solar oven. Data were collected every hour were presented in graphical form.

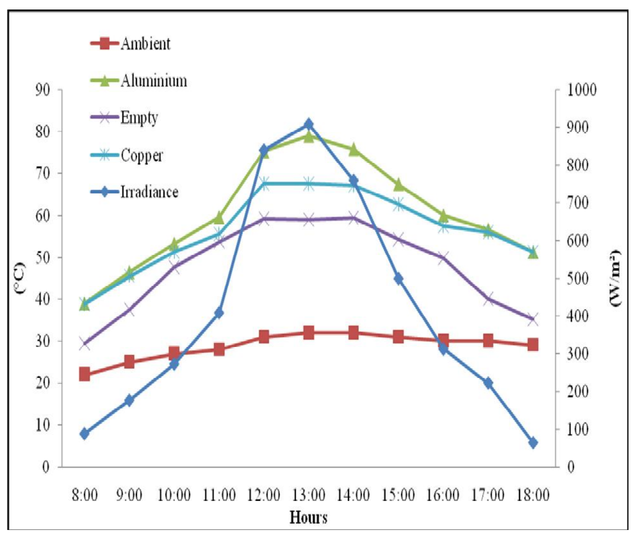



**Figure 2: Graph showing the distribution of solar radiation data from 0800 to 1800 hours which affects the temperature distribution in the solar oven.**

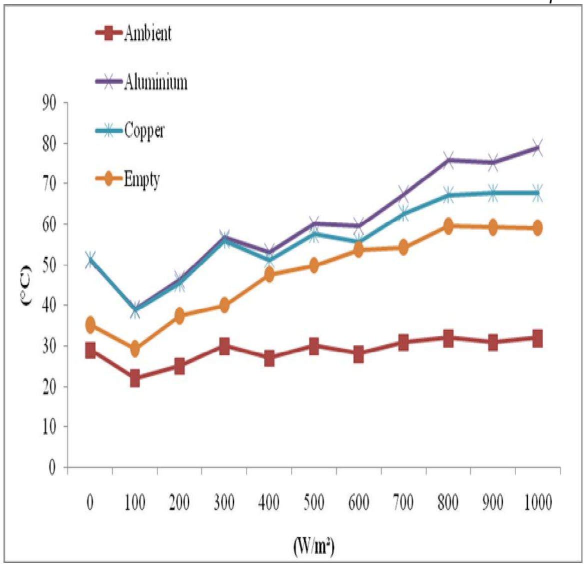



**Figure 3: Graph showing the effects of solar radiation on the temperature distribution in the solar oven without metals, aluminum in the solar oven and a solar oven fitted with copper metal. The higher the solar radiation, increasing the high temperature readings in the solar oven**

## III. RESULT AND DISCUSSION

Solar oven is placed in the open and exposed to sunlight under stable weather conditions. Wind speed was measured is less than 0.5 m / s on average during the day. Any change in temperature for each heat absorbers placed inside the solar oven is presented in Fig. 2 and 3, respectively. Figure 2show the change in temperature has the same trend with solar radiation. It increases at the beginning, continued to rise until about noon and then decreases after noon. Absorber temperature reaches the greatest, while the solar oven that does not have a heat absorber has the smallest temperature readings.

Figure 2 above shows the temperature distribution in the three solar oven with the same experimental method. The first solar oven has been tested in conditions devoid of heat-absorbing metal is placed and the highest temperature recorded was 59 degree Celsius when solar radiation 908w / m 2 at 1300 hours. The second solar oven filled with metallic aluminum as the heat absorber and the highest temperature recorded between the three solar oven. Temperature recorded in the solar oven is 79 degrees Celsius also at 1300 hours when the solar radiation 908w / m2. The third solar oven filled with copper as a metal capable of absorbing heat and raising the temperature in the solar oven over solar oven without heat-absorbing metal. Temperature recorded was not able to achieve the same peak temperature solar oven filled with metallic aluminum as the heat absorber. Temperature recorded was 68 degrees Celsius during peak hours in 1300 when solar radiation is 908w / m2.

Figure 3 above shows the temperature distribution in the solar oven according to the distribution of solar radiation received. In the figure shows the higher solar radiation received, the higher the temperature in the solar oven. Aluminum showed the highest heat-absorbing properties than copper which causes the temperature of the solar oven filled metal aluminum absorber recorded the highest reading.

Although aluminum has shown better heat absorbing properties than copper, aluminum also releases heat faster than copper. This can be seen in figure 2 above at sunset temperatures recorded by the solar oven filled metal heat absorbing aluminum recorded the same temperature as compared to copper. At 1800 hours, the ambient temperature readings recorded around 29 degrees Celsius and the temperature of empty solar oven were recorded around 35 degrees Celsius. Solar oven each filled with copper and aluminum as a metal heat absorption was recorded reading of 52 degrees Celsius, the same reading for both.

## IV . CONCLUSION

Solar oven has been successfully fabricated and developed in UiTM Shah Alam. Experimentation has shown the presence of aluminum and copper as metal heat absorber can increase the oven temperature than in the absence of solar heat absorbing metal. Aluminium has shown heat absorbing properties faster and higher than copper, but aluminum also releases heat faster than copper. For future studies, the application of aluminum in solar oven can be used to raise the temperature of the oven at a time when the solar apex. Copper is suitable for use when solar radiation received is not constant, especially when the clouds covered the sun.

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