FABRICATION AND PERFORMANCE STUDY OF AN IMPROVED DESIGN OF PENTAGON TYPE
SOLAR OVEN FITTED WITH SINGLE REFLECTOR

BY

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ABSTRACT
In this research project, the performance of newly designed solar oven with single reflector was studied in order to enhance the ability and efficiency than that of the existing solar oven. Plywood was used for side and back walls. This oven was fabricated with indigenous material consisting of glass sheets, copper sheet & steel sheet. Sunlight enters through the upper and side glass sheets inside the chamber. A single reflector was also reflecting sunlight through upper glass sheet inside the chamber to increase the temperature. The parameters studied were ambient temperature, inner space temperature and base temperature. The time consumed for cooking and baking purposes was also recorded. The performance of the pentagon type solar energy food oven was checked during the months of January & February 2006. Results revealed that that in sunny regions of the world, the concentrator type solar oven was helpful to reduce the energy problems. This technology was safe and pollution free.

KEYWORDS: Performance, glass sheet, Pentagon & Reflector

INTRODUCTION
Sun has been the natural source of energy since the creation of solar system. Fortunately, Pakistan is blessed with plenty of sunshine. Thus the research work on the utilization of solar energy is of great importance. It can be said with confidence that the fuel problem in the Pakistan can surely be minimized by means of solar applications. Our earth receives huge amount of solar energy i.e. 5.4 x 10^24 joules/year, which is equivalent to about 30,000 times the energy used at present time (Mahmood, 1999). Besides industrial uses the domestic consumption of energy is an appreciable part of total energy consumption. There are number of ways in which solar energy can be put into use. Many devices such as solar water heaters, solar collectors, concentrators and cookers etc. have been constructed. Pakistan, like many other countries of the tropics is blessed with plentiful sunshine (all the year round). The annul average of the total solar radiation for the country as a whole is about 449 cal/cm²/ day (Akhtar, 1992).

Pakistan possesses large potential for the utilization of solar energy for various purposes. But the fundamental characteristic of solar energy is intermittency. This intermittency and dispersal of solar energy means that only relatively low temperature can be achieved with solar devices because its intensity is very low, with out some form of concentration. In other words, the solar radiation from a large area can be concentrated on to a smaller area by focusing it with the aid of different types of concentrators and by tracking the sun.

Solar ovens are of generally two types; hot box type and concentration type. In hot box type solar oven the direct and diffuse radiation goes directly through glass window, in addition, radiations are reflected from the side reflectors as well. In concentration type solar oven, parabolic reflectors are used with oven placed at their focal point.
A solar oven is similar to a hot-box cooker using an insulated box and multiple reflectors. The area of the box is kept as small as possible while the reflector area is large. In a solar oven, additional solar radiation is penetrated through the glass window; therefore, quite high temperatures inside solar ovens can be attained. Three basic natural laws are employed in making and using solar box cookers. One natural law is that when solar radiation (sunlight) strikes a dark surface it changes to infrared radiation (heat). The second natural law is that when light falls on light-colored or shiny surfaces it reflects and so can be directed to where it is needed and the third one natural law is that solar radiation (sunlight) passes through a transparent window easily, but infrared radiation (heat) does not, so heat can be trapped. A solar cooker cooks because the interior of the box is heated by the energy of the sun. Given this heat input, the temperature inside of a solar box cooker will continue to rise until the heat loss of the cooker is equal to the solar heat gain. Actual cooking consists of putting the food in a dark, lidded pot, pointing the SBC at the sun and giving it sufficient time to cook. That is all most people need to consider when using their SBC (Mullick, 1997).

In this paper an improved design of pentagon type solar oven was fabricated. In this design sunlight enters inside the pentagon type solar oven through upper and side glass sheets. The base of pentagon type solar oven was made of copper sheet (24-gauge). A single reflector was used to reflect the sunlight into the oven. In this way the temperature inside the pentagon type solar oven was raised. The oven was checked for its cooking and backing performance.

**MATERIALS & METHODS**

The fabrication and performance study of a pentagon type solar oven fitted with single reflector was conducted. The construction of oven was completed in the following three stages. The pentagon type solar oven fitted with single reflector consisted of following main parts. A brief description of the construction of parts was as follows:

In the first part an external box of solar oven was made of a chipboard sheet having dimensions (12’ x 16½’ x 16½”) with diagonal length 26”. In the front wall of the external box, a lid was made. Silver angle was used at the front corner of the external box to reinforce the solar box oven (Chao Tan and Tom Sponheim, 2001). In the second part, inner container was actually an absorber plate that absorbed solar radiations and the heat energy acquired by it was employed for the cooking of food placed on the lid of this container in cooking utensils. In the present research it was made of 24-gauge copper sheet having dimensions (21/4” x 22”) with depth 4/”. In order to make it air tight, foam strip (24/” x 2/” x 0.5”) was used between the front walls of external box and the lid. Silver angle was used at the top of the copper sheet for smooth raling of the lid. The designs for cardboard cookers have gotten simpler; fitting a lid can still be difficult and time consuming. In this version, a lid is formed automatically from the outer box (Chao and Tan, 2002). A mesh was fitted at the base of the lid on which blackened utensils were placed for the purpose of boiling, cooking and baking of the food. The lid piece was used in such a manner that it becomes a part of the external box. The lid was provided with a handle to remove it to move pots in and out of the oven. A lock was used for the lid to move it fixed and unable to move. The inner container was totally blackened with blackboard paint in order to make it good absorber for solar radiation (Nag and Mathur, 1983). A transparent glass sheet was fitted at the top of the external box and the inner container. Strips of foam (25/” x 26/” x 1½”) were pasted between glass sheet and the external box to protect it from shocks during the transportation of solar box oven. The space between the external box and the copper sheet was filled with glass wool, which served as insulation. Glass wool weight was almost 500.50 gm (Hoda, 1977). Plane Reflector consisted of framed stainless steel sheet (15’’ x 14’’) hinged on the backside of the external box. The reflector was foldable as well as replaceable and could be tilted easily at the desired inclination for proper trapping of solar radiations. For this purpose, a moveable curved metallic string was welded with the reflector in such a manner that it served as a stand for the reflector. To set the reflector at suitable place, the metallic string was screwed with the outer box. To see the performance of above described lid type solar box oven following other materials were used (Tiwari and Yadav, 1986). An angle frame was fabricated for the transportation of solar box oven. For this purpose, an angle iron having dia ¾” with dimensions (25.8/” x 25.2/”) was used wheels associated has made this assembly completely transferable from one place to another. Stand was without legs. Silver utensils were used for cooking of food having diameter (18cm) with depth (7.5cm). The cooking utensils were 350 grams in weight. These pots have a capacity of nearly ½ kg of food. These pots were placed inside of the lid for cooking purpose (Khalifa et al. 1985). Mercury thermometers were used to observe the performance of portable solar oven. Thermometers having range 0°C-360°C were used to measure the inner space temperature and base temperature. For ambient temperature, thermometer having range 0°C-110°C was used.
RESULTS AND DISCUSSION

Graphs 1-3 depict the impact of three different parameters of the fabrication and performance study of pentagon type solar oven fitted with single reflector. The purpose of the research was to use the solar energy and to save the conventional fuels and money. The solar energy provides sufficient temperature for cooking and baking purposes. This study was conducted during the month of January & February 2006. The parameters studied relevant to the cooking phenomenon were as following.

Graph No.1 shows an average ambient air temperature versus time which was recorded by a mercury thermometer in glass having range from 0°C to 110°C after an interval of 15 minutes. In order to see its variation with respect to time, because ambient temperature was actually a measure of the solar energy received to us. It was observed that higher the ambient temperature more was the energy accumulated in accumulating devices which was solar oven (Hoda, 1977).

Graph No.2 shows an inner space temperature of the oven versus time which was recorded by mercury thermometer having range from 0°C to 360°C after an interval of every 15 minutes. The increase in temperature was rapid during first 90 minutes and slow after this time. It was also obvious from this data that inner space temperature decreased slightly when the cooking pot was placed in the solar oven but after some time it once again began to rise and continued to increase with the lapse of time. Clearly, in sunny days, the optimum value of the inner space temperature was 94°C (Hoda, 1977).
Base temperature was recorded after an interval of every thirty minutes by mercury thermometer having range of 0°C to 360°C that was touched with the base of the inner container. The average values of base temperature verses time is plotted in graph.3. The maximum base temperature achieved is 102°C when ambient temperature was 26.5°C (Hoda, 1977). There were wide variety of cooking techniques used and most common forms of cooking were boiling steaming frying, baking, roasting, etc. for cooking using above techniques, the temperature above 100°C were required (Hoda, 1977).

### Graph # 3: Average values of base temperature versus time

<table>
<thead>
<tr>
<th>Time (Hours)</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30</td>
<td>20</td>
</tr>
<tr>
<td>9:45</td>
<td>40</td>
</tr>
<tr>
<td>10:00</td>
<td>60</td>
</tr>
<tr>
<td>10:15</td>
<td>80</td>
</tr>
<tr>
<td>10:30</td>
<td>100</td>
</tr>
<tr>
<td>10:45</td>
<td>120</td>
</tr>
</tbody>
</table>

Cooking times

The cooking, baking and boiling times has been given below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Temperature (Base &amp; Space)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiling Rice</td>
<td>½ kg</td>
<td>100°C &amp; 90°C</td>
<td>25 minutes</td>
</tr>
<tr>
<td>Boiling Egg</td>
<td>4 eggs</td>
<td>100°C &amp; 92°C</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Chicken</td>
<td>2 pieces</td>
<td>102°C &amp; 94°C</td>
<td>35 minutes</td>
</tr>
<tr>
<td>Baking cake</td>
<td>¾ kg</td>
<td>102°C &amp; 94°C</td>
<td>80 minutes</td>
</tr>
</tbody>
</table>

From graphs it was concluded that the pentagon type solar energy food oven had showed better performance than a simple box type solar oven. The food required for baking ranges from 94°C to 102°C thus with the help of present solar cooker, almost all types of cooking techniques were possible this concentration type solar oven has ability to cook food in a very short time as compared to for type solar oven. Height from the concentrator strongly affects on the efficiency of the solar oven. Some of the drawbacks of this pentagon type solar food oven were that in cloudy and rainy days, cooking was not possible. Also in partially cloudy days, the temperature inside solar oven was not feasible for roasting, baking etc. In partially cloudy days, the maximum inner space temperature was 78°C and base temperature was 84°C when the sun rays were focused at the base of inner container (Parikh, 1976). The temperature variation was also very large in partial cloudy days. Thus the present study showed that in sunny regions of the world, the concentrator type solar oven was helpful to reduce the energy problems. This technology was safe and pollution free.
REFERENCES


