FABRICATION AND PERFORMANCE STUDY OF SLOPE TYPE ELECTRIC CUM SOLAR OVEN

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In the present work we report the design and fabrication of an improved electric cum solar oven (ECSO) in which both solar energy and electricity has been utilized as energy source. The design consists of a tilted upper glass cover rectangular shape and the angle of slope 30 degree. The electrical heating was used in conjunction with the solar energy to make the oven useful during the periods of lesser sunshine. The temperature of the oven has been controlled using a thermostat. The oven has been found useful for cooking conventional food items in a very reasonable time under the local environmental conditions of Faisalabad city.

Keywords: Solar energy, solar cooking, renewable energy, solar oven, electric oven

INTRODUCTION

The energy problems in the world are at its peak and energy sources such as coal, firewood, fuel oil and gas etc. on which we have been depending for several years are limited. Thus, there can be little doubt that conventional fuel will become scare and expensive. There is also some fear about the possible environmental and safety risks associated with fossil fuels and nuclear power. These concerns have been focused world wide to explore the new sources of energy. Alternative sources of energy on which the scientists are focusing their attention are geothermal energy, ocean energy, nuclear energy, wind energy and solar energy. Among the various types of alternative energy sources, the solar energy is more appealing because it is abundant, non polluting and locally available. It can directly be used for cooking, boiling and baking through various devices one of which is solar oven.

The solar energy is being effectively used in India and China. The largest numbers of cookers are in India and China: more than 340 000 in India and 140 000 in China (Nandwani, 2007 and references there in). The present research deals with the improved design of slope type electric cum solar oven. In a previously reported work an electrical cum solar oven had resulted in 15% efficiency (Sengar and Kurchania, 2007).

A new concept of electric cum solar oven (ECSO) will be fabricated in which both solar energy and electricity will be used to increase the efficiency. The focus of this work is to provide an alternative energy source for cooking particularly in the rural areas where lot of sunshine is available throughout the year. Keeping in view the slow heating effect of the conventional solar cookers we have used the electrical heating to maintain the temperature even when the sunshine is not available.

MATERIALS AND METHODS

A new design of box type solar cooker has been fabricated using indigenous materials. The performance has been studied under the local environmental conditions of Faisalabad city. The box of the electric cum solar oven having dimensions 24” x 18” x 7” has been made from plywood sheet of thickness ½-inch. The inner side of the box has been made from 24-gauge copper sheet to ensure maximum absorption of the sunlight. Glass wool has been used as insulating material between the outer box and the inner frame. The upper side of the electric cum solar oven was covered with glass sheet of thickness 5mm (Excell, 2003). An electric heating plate with temperature controller has been fixed at the bottom of the cooker. The thermostat turns the electrical supply off when the cooker has reached a certain set temperature (depending on the nature of food being cooked in the cooker).
In order to check the efficiency of the electric cum solar oven we measured the ambient, inner space, base and food temperatures. The performance of the cooker with and without the electricity has also been investigated. We have also measured the cooking times of various conventional food items. The reduction in cooking times due to use of electricity has also been found (Amer, 2003).

RESULTS AND DISCUSSION

The performance of the oven has been tested during the summer season in the months of June and July 2007. It was observed that solar oven under study was much efficient at noon and there was no need of electricity during this time. We have tested the cooking of the conventional food items like vegetables, pulses, and meat using the oven. Baking of fruitcakes was also carried out. Average cooking time for these items varies from 30-90 minutes which is better as compared to the previously reported works (Nahar, 2003). In electric cum solar oven the base temperature and inner space temperature in sunshine were 110°C and 100°C respectively. The electrical heating resulted in temperatures higher than 120°C and 110°C respectively. The ambient temperatures, cooking times and cooking temperatures were also observed. Cooking, boiling and baking were usually done from 9 A.M. to 1:30 P.M. Oven direction due to the fact that the angle of sun does not vary significantly during these hours and there is very little need of reorientation of the oven direction. It was observed that cooking at noon was faster than morning and evening hours. The average values of variation in ambient, base and inner space temperatures of the oven are shown in ures 1, 2 and 3 respectively. Almost all food items of daily use were cooked in this oven and were found to be well cooked and delicious. During cooking, boiling and baking, there was no need of extra vigilance and stirring the food. Also there was no hazard of burning and flowing out the food from cooking pots. Working of this electric cum solar oven is not restricted upon the availability of sun shine and it can effectively be used throughout the year as well as in a hazy or cloudy days. The cooking times for various food items are given in Table 1.

Table 1. Cooking time for different items

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit cake</td>
<td>¾ kg</td>
<td>1 hour</td>
</tr>
<tr>
<td>Frying egg</td>
<td>1</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Boiling of eggs</td>
<td>2</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Boiling of milk</td>
<td>500 ml</td>
<td>20 minutes</td>
</tr>
<tr>
<td>Rice</td>
<td>250 grams in 500 ml of water</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Custard</td>
<td>175 grams in 500 ml of milk</td>
<td>35 minutes</td>
</tr>
</tbody>
</table>

During this study the maximum ambient air temperature reached 39°C. The variation in average ambient temperature versus time is shown in Fig. 1. The data regarding inner space temperature of electric cum solar oven with respect to time days was noted. Data regarding the inner space temperature when only electricity applied was also noted. It was seen that at time t=0, the inner space temperature was almost equal to the ambient air temperature on every day. As the time increases, the increase in inner space temperature was rapid during first 45 minutes and slows afterwards. The observed maximum value of inner space temperature was 107°C. The graph drawn between averages inner space temperature versus time shows the variation in space temperature. Base temperature of oven was recorded from a thermometer placed in the oven touching the base after an interval of every fifteen minutes. When the oven was placed in the sunshine for cooking, the time was considered as zero time. Data for various working days of the oven were noted. Data regarding the base temperature when only electricity applied were also noted. The base temperature has risen about 115°C whereas base temperature which is suitable for cooking in this oven is 100°C for most of the edibles. The increase in temperature is rapid during first 45 minutes then it slows down afterwards. We have compared our work with a previously reported work by Stumpf et al. (2001). On clear days the shortest heat-up times from 40 to 99.5°C for 5 kg water were 36, 32 and 17 min corresponding to an average thermal power of 580, 653 and 1220 W for the three systems they had reported. Our locally fabricated solar cooker has shown good efficiency in comparison as depicted from the figures 1, 2 and 3. In this cooker the base temperature and inner space temperature in sunshine were 110°C and 100°C without electrical heating and 120°C and 110°C with electrical heating respectively. The predicted values of ambient, base and inner space temperatures shown in figure 1, 2 and 3 have been taken from “slope type electric cum solar oven” and are compared with measurements made under actual weather conditions. Results under the same operating conditions show that the absorbers of the box type cooker and the double exposure cooker attain 140°C and 165°C respectively. The temperatures of the air inside the two cookers are 132 and 155°C respectively. The double exposure cooker reduces the cooking time by about 30-60 min. The taste and appearance of the food is quite good (Amer, 2003).
Electric cum solar oven

Fig. 1. The mean temperature (°C) values of ambient temperatures versus time

Fig. 2. Average values of inner space temperature (°C) versus time
While in case of our electrical cum solar cooker with single exposure has shown slightly lower temperatures but almost similar cooking times. This is due to the backup power provided by the electrical heating system.

CONCLUSION

The indigenously fabricated electrical cum solar cooker is a low cost alternative for cooking conventional food items under the local environmental conditions of our country. Its electrical backup facility makes it useful in hazy days as well as in winter. The cooking times have also been found to be good. The cost of solar oven is low and is easily affordable by a family of average income.

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REFERENCES