

# HEAT- RETENTION COOKING AND NO - TRACKING PROPERTIES OF SOLAR OVEN WITH FIVE SIDES OF DOUBLE GLAZING

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## Abstract

Solar oven with five sides of double glazing is a solar cooker of box type with multiple reflectors that receive the solar radiation from five sides and needs no tracking during the cooking period. Heat-retention cooking is also a salient feature of the device. This paper reports on the study of heat-retention and no-tracking properties of the said device. For heat retention cooking in conventional solar cookers the pot is removed from the oven and is covered for heat retention cooking. While in Solar oven with five sides of double glazing the oven as a whole is covered with an insulated cap meant for the purpose and the heat present in food, pot, cooking chamber and the double glazing is trapped in. As a result the food keeps on cooking slowly at low temperature for an extended period of time in the absence of solar radiation. To evaluate the heat-retention property in this test a load of 3 kg of water was heated up to 94.5 °C by solar radiation and the oven was insulated for the heat retention cooking. After 4.5 hours the food temperature reached at 65.5 °C. No-tracking property was achieved by extending the length of the reflectors towards both ends. As a result span of the reflected radiation increased and re-tracking was not required up till 80 minutes of cooking.

**Keywords:** Ambient air temperature, double glazing, heat-retention, intermittent sunshine, no-tracking.

## INTRODUCTION

Energy is the backbone of human activities. The importance of energy in economic development is very critical as there is a strong relationship between energy and the economic activity [Shukla *et al.* 2009]. Due to rapid modernization the energy resources are depleting quickly throughout the world while the energy demand is rising steadily. The crude oil price has soared up and this has triggered the use of renewable energy resources [Farooque 2009].

It is known that solar energy is the main source of all forms of renewable energy on the globe, and is available abundantly in the region Pakistan lies in. Solar Cookers International has rated Pakistan as Number 3 country in the world in terms of solar cooking potential [Wiki/Pakistan]. Cooking with solar energy is a clean and green way to cook food and it reduces the carbon emission and deforestation. A solar oven, sometimes referred to as a solar cooker, is a device which uses solar energy in the form of sunlight as its energy source for cooking.

## **HISTORICAL BACKGROUND**

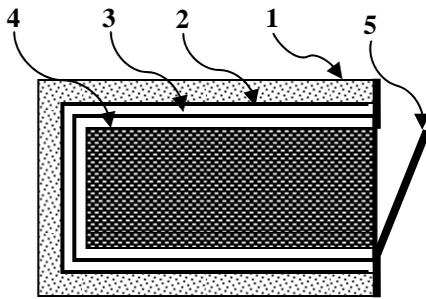
The first reported solar cooker user worldwide was by a Swiss, de Nicholas Saussure (1740-1799) who built his black insulated box cooker with several glass covers. Even without reflectors, he reported to have successfully cooked fruits at that time reaching temperature of 88°C. Over the years, de Saussure and others focused their solar box cooker design work on variations of shape, size, sidings, glazings, insulations, reflectors, and the composition and reflectance of the internal surfaces. In Africa, an Englishman, John Fredrick Herschel, used solar cookers in 1837, at the Cape of Good Hope, South Africa. He used a black box made of hard wood with a double glass window without a reflector and buried it in sand for insulation. The temperature reached was 66 °C. In Asia, experiments on solar cookers were carried out by an Englishman, William Adams, in Bombay, India in 1878. He used glass planar mirrors arranged in a shape of an inverted eight-sided pyramid that focused light through a cylindrical bell jar into the food container. In America, an American, Samuel Langel, pioneered solar cooking in 1884. He used a box type cooker at Mount Whitney, California, at an altitude over 4 km [Kimambo 2007].

At present Barbara Kerr is one of the primary founders of the solar cooking movement. In the early 1970s she and her friend Sherry Cole designed a cardboard solar box cooker and an early solar wall oven. She later helped develop a panel-type solar cooker known as the Cookit [Wiki/Barbra\_Kerr]. Panel solar cookers are the first solar cookers that are truly affordable to the worlds neediest. In 1994, a volunteer group of engineers and solar cooks associated with Solar Cookers International developed and produced the Cookit, based on a design by French scientist Roger Bernard. Elegant and deceptively simple looking, it is an affordable, effective and convenient solar cooker [Wiki/Cookit]. Cookit solar cookers are now produced in bulk quantity for sale and are distributed among the needy families in Kenya by Solar Cooker International (SCI) [Anonymous 2007].

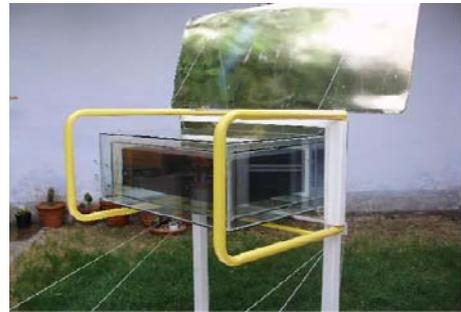
## **BRIEF DESCRIPTION OF THE INVENTION**

Solar oven with five sides of double glazing is a box type solar cooker with multiple reflectors devised by the author. It has the innovative features not found in other solar cooking devices. Firstly, the cooker is double glazed from five sides to receive the solar radiation while the sixth side serves as a door to put in or remove the cooking pots. Secondly, the device does not need to be tracked with the movement of the sun, as is a practice with all other solar ovens around the world. Just aim the cooker towards the expected noon position and it will receive an equal amount of solar radiation right through the cooking period. Finally the device is also equipped with the heat-retention cooking facility. (Author holds the intellectual property rights of the device (Patent # 139945).

The present invention, both as to its organization and manner of operation may be understood with reference to the drawings shown in Fig. 1 and the pictures A, B and C. Fig. 1 illustrates a cross section view of solar oven with five sides of double glazing, also shown in picture A, in which: the cooking chamber 4 is covered with double glazing 2 and 3. A door 5 to put in or remove the cooking pots is also provided. An insulated box 1 made up of 1inch thick polyurethane sheet lined with aluminized reflector inside is shown in picture B. This serves to insulate the cooking chamber and double glazing for heat-retention cooking during the intermittent sun shine. Picture C represents a side-view of solar oven with five sides of double glazing. In this picture the cooking chamber is covered with the insulated box.



**Fig. 1:** Cross section view of the Cooking Chamber.



**Picture A:** The Cooking Chamber.



**Picture B:** The insulated Box.



**Picture C:** Side view of the Solar Oven covered with the insulated Box.

## NO-TRACKING

All types of solar cookers need frequently tracking the sun. Box-type cookers typically require adjustment every 15 to 30 minutes or when shadow appears on the absorber plate, while the concentrating-type units may require more frequent adjustment to keep the solar image focused on the cooking vessel or absorber plate [Anonymous 2003]. This is a fuss, while the concentrating-type units if not re-tracked frequently may cause burning of the equipment due to focusing the sun rays on the body of the device.

## HEAT- RETENTION

Heat-retention cooking is an old age practice to cook food with the heat energy present in the under cooked food and is boosted by preheated pebbles or bricks prepared for the purpose. The usual method is to heat up the food to the boiling point and then to remove the pot from the fire, and to cover it with blankets, cushions or any other material like hay or dry grass. Consequently, the food keeps on cooking slowly by the help of heat energy present in the food, pot and the preheated mass. In solar cooking the same method is applied to cook food when the



**Picture D:** The pot insulated for heat-retention cooking

direct heat energy from the sun is obscured by the clouds, or when the sun is too low in the sky and the oven temperature starts falling.

Heat-retention cooking saves cooking fuel because after the food has been heated to the cooking temperature it is placed into an insulated box as illustrated in picture D, where it continues to cook until done. Heat-retention cooking is often introduced along with solar cooking since it further reduces the use of traditional fuels such as firewood or gas stove. Use of this method allows much more food to be cooked each day in a solar cooker. This method of cooking is also known as heat-retained cooking, fireless cooking, haybox cooking, or wonder box cooking [Wiki/Pakistan].

## PROJECT

### FINDING THE HEAT-RETENTION PROPERTY

To find out the Heat-retention property of the device a test was performed at Chichawatni, 30° 32' 0" North, 72° 42' 0" East and Alt.158 meters on a sunny day. A load of 3kg of tap water at 5 degrees above the ambient temperature was put into three different pots spread evenly on the floor of the cooking chamber. The oven was faced due south and the water temperature was recorded using digital thermometers. The ambient air temperature was recorded from three different places around the oven at a distance of one foot from the oven under the shade and the mean value was considered. The water temperature reached 94.5 °C in 160 minutes. At this moment the oven was covered with the insulated box and was wheeled/moved into the shade. Later the decrease of temperature was recorded every twenty minutes interval. The temperature profile recorded in this experiment is presented in Table 1 and further explained in Fig. 2.

### NO-TRACKING FEATURES

Two innovations of solar oven with five sides of double glazing support the no-tracking features of the device as:

- a) The five sides of double glazing and
- b) The extended reflectors.

Five sides of double glazing is a unique feature of the device which supports the no-tracking characteristic of the oven as explained in Fig. 3. The device is aimed at the expected noon position and it receives an equal amount of solar radiation right through the cooking period without tracking the sun.

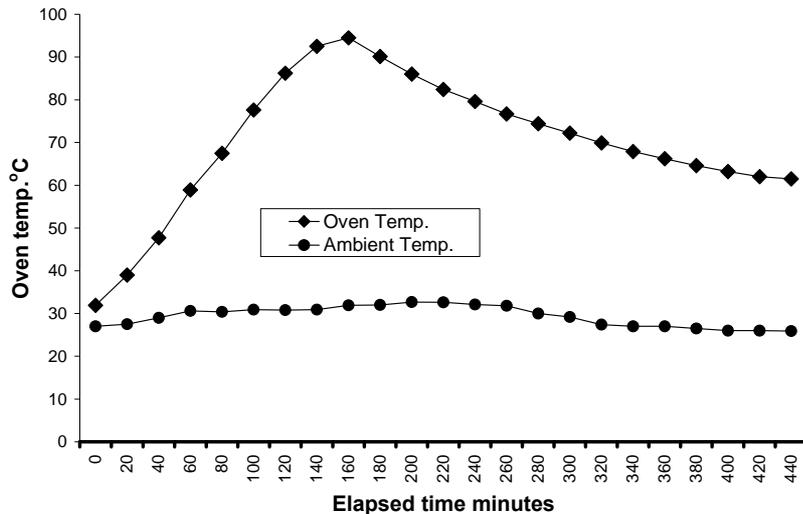


Fig. 2: The temperature recorded during the heat-retention test.

Extended reflectors also support the above mentioned features. In conventional box type solar cookers length of the reflectors is equal to the length of the box. As the sun moves, the reflected radiations on the oven top also move eastwards leaving a shadow on the west side of the oven top as shown in Fig. 4. But in Solar Oven with five sides of double glazing, the upper and the lower reflectors are twice the width of the absorber plate, extended equally towards both ends as depicted in Fig. 5. As a result the reflected radiations cover a wider area and take a longer period of time to leave the left corner of the oven top as sun moves.

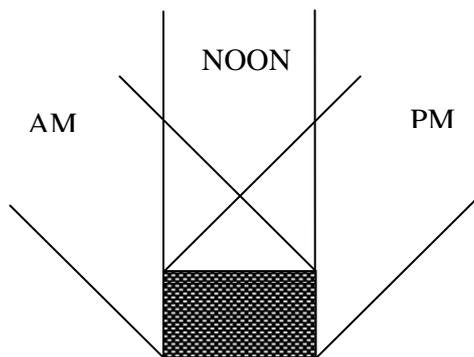


Fig. 3: Solar radiations received before, after and at noon.

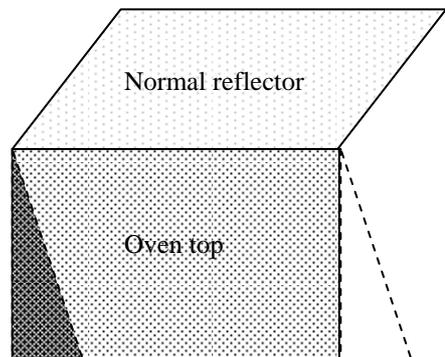


Fig. 4: Normal reflector leaves a shadow at left corner.

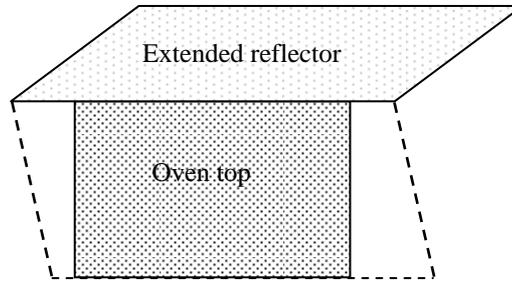


Fig. 5: Extended reflector does not leave a shadow.

### DETERMINATION OF NO-TRACKING PERIOD

To find out how long the No-tracking property of the device works; two small pieces of mirrors A and B, shown in Figs. 6 and 7, were glued over the right and left corners of the lower reflector. At the start of the experiment the oven was faced due south at such an angle that the reflected radiation from the mirror A fell on the east side of the cooking chamber and the radiation reflected from the mirror B fell away from the cooker. As the sun moved the reflected radiation also moved clockwise. It was observed that the span of reflected radiation was wide enough that it kept on falling over the oven for 80 minutes. After 80 minutes interval the reflected radiation from the mirror B touched the left side of the cooking chamber and the radiation reflected from the mirror A left the oven. At this moment re-tracking of the oven was performed, and this re-tracking was sufficient for the next eighty minutes.

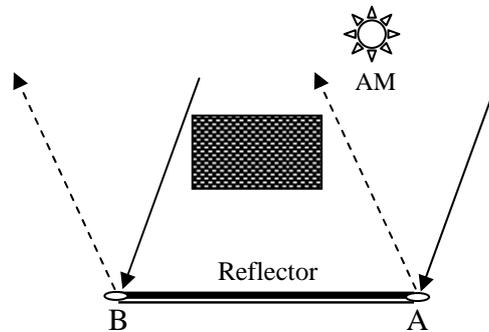


Fig. 6: Span of the reflected radiation before the solar noon.

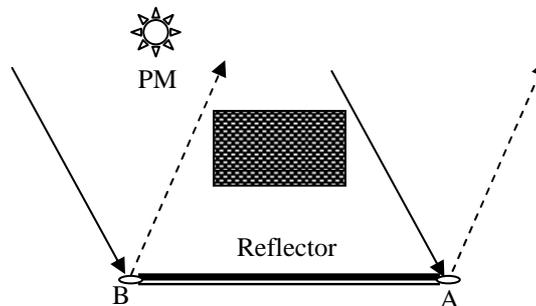


Fig. 7: Span of the reflected radiation after the solar noon.

## CONCLUSIONS

It was observed from the above experiment that if cooking temperature is taken to be 82 °C and above, then cooking continued for 80 minutes under insulated cover due to heat-retention property of the oven. Later the food was still hot at 61.5 °C even after 3 and a half hour i.e., up till 6 pm. It was also found that Solar Oven with five sides of double glazing once faced due south takes 80 minutes of no-tracking. During this time period easy to cook foods like rice, eggs, or veggies could be done. But hard to cook foods require re-tracking the device only once and it will be ok for the next 80 cooking minutes. It means that during 160 minutes of cooking re-tracking is required only once.

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