*Int.J.Curr.Microbiol.App.Sci* (2018) Special Issue-7: 3430-3435

*International Journal of Current Microbiology and Applied Sciences*
*ISSN: 2319-7706* **Special Issue-7 pp. 3430-3435**
Journal homepage: http://www.ijcmas.com

**Original Research Article**

# Fabrication of Inclined Box Type Solar Cooker and to Compare Its Efficiency with Conventional Box Type Solar Cooker

**Neel Praveen Kullu*, Sweta Bara, Roshan Hapadgara, Abhishek Kujur and Soni Tirkey**

Department of Agricultural Engneering, Birsa Agricultural University, Kanke, Ranchi, India
**Corresponding author*

**A B S T R A C T**

Reduction of fossil fuel and increase in fuel price has led to utilization of solar energy for different applications. One of the important applications of solar energy is solar cooking. Commercially different variety of solar cookers is available: box type solar cooker and concentrating solar cooker. Box type solar cooker generally use flat reflectors. But there are diverse type of reflectors in design can be employed in the solar cookers like flat reflector, compound concentrating collectors, cylindrical parabolic collectors. Work has been done to increase the temperature inside the solar cooker and increase the efficiency of box cooker using different variety of reflectors. This paper gives a short review on box type of solar cooker using different types and number of reflectors. Paper wise review has been done which makes it easier to compare and evaluate the work of researchers. This review covers various box cookers designed and fabricated by altering geometrical parameters which effect thermal performance of the cooker, by using different type of reflector and varying number of booster mirror. Moreover, result of each paper has been discussed in the study.

**Keywords**

Flat reflectors, concentrating collectors, parabolic collectors

## Introduction

Solar cooker available, generally fall under two categories. One is box type and the other is parabolic reflector focusing type. The cooking ability of existing box type simple solar cooker is seems to be not satisfactory in comparison to the cost involved. Parabolic reflector focusing type cooker needs frequent adjustment to track the apparent motion of the sun. For these reasons this type of parabolic reflector solar cooker is not much popular. In the proposed box type cooker beam radiation is always perpendicularly accessible for its adjustable inclined position and for convenient implementation of two reflectors the cooking time is remarkably reduced than that of a usual box type cooker. The cost of cooker is however, slightly higher than usual box type but it can be considered reasonable in respect to its improved performance.

## Materials and Methods

### Detailed Constructional Features

The detailed constructional feature of the cooker is shown in Fig-1.The cooker box consists of a top open black painted inner box kept inside of the another box and the space between the two boxes is filled with glass wool insulation. The upside of this cooker box is covered by two layers of transparent glass keeping a gap in between and the supporting frame of the cover is

hinged with cooker box for keeping glass cover in inclined position to handle the cooking pots. So the cooker box is similar to conventional box type cooker, but the shape of the box is different from common type. The length of the box in presently proposed type is at about three times of its width and depth is equal to the width.

Four number of black painted aluminium cooking pots are used and are placed side by side at the longer side of the cooker on cooking trays. For each cooking tray two bolts acted as hinge are fixed at both longer sides of the cooker inner box. The cooking tray is suspended from the end of the bolts through M.S strips. Length of these strips is equal to the cooking pot radius and these strips are fixed with the ends of tray aligned with the exact middle position of the tray as shown in Fig-2. When the cooker box inclination is changed the cooking tray along with cooking pot, for its own weight, rotated around the bolts and always remained in horizontal position. To avoid the chance of tilting of pots, square shaped trays, length of which are kept equal to the diameter of pots are used and ends of the trays are folded upward. The cooker is to be placed facing sun, keeping longer side vertically inclined position and the inclination of the cooker box can easily be changed from 15 degree to 45 degrees with respect to the ground by the adjustable stand, attached at the back side of the box. Two mirror reflectors are used in this cooker, however even up to four reflectors can be conveniently arranged in this box type cooker (provided the reflectors are light weight). The reflectors are set along the length of the cooker box cover, one in each side, by hinge and holding strip. So length of reflectors are equal to the length of the glass cover. The widths are equal to the width of the glass cover. When the cooker is in use, each reflector is kept at the inclination of about 115 degree with the face of the box cover. In this position the reflections from the top edge of the reflectors touch the outer longitudinal edge of cover glass when the cooker is placed in perpendicular direction to the solar rays.

If four reflectors are used then other two reflectors are to be hinged at the top of the inner reflectors, one in each side at an angle of nearly 15 degree with the inner one All the reflectors can be folded for keeping on the top of the cooker box cover when not in use. The face of the cooker is to be placed perpendicular to beam radiation to collect the maximum energy. This perpendicular position can be easily achieved simply by the rotation of the cooker towards the sun with the help of caster wheels, suitably attached at the bottom side of the cooker and by changing the inclination of the cooker by adjustable stand of the back side. But the position of the reflectors remain unchanged throughout the working period.

## Specifications of the Cooker

### Cover Plate

Number of glazing: Two

Material: Plain glass

Spacing between two glazing: 20mm

Glass thickness: Inner: 3mm & outer - 4mm

General appearance of glazing: Free from bubbles/ rough surfaces

Aperture area: 184800 sq.mm

Additional Design Feature--Provision or keeping cover plate in inclined position

(Opened -Position) with respect to its closing position by use of hinge.

### Inner Box

Material: Aluminum Sheet

Thickness of Sheet: 0.5mm

Size: Length=840mm, Width=220mm, Depth=220mm

Thickness of wall: 0.5mm

Paint on Inner Surface: Mat black finish by black board paint

### Suspended Cooking Trays

Material: Aluminum

Size: 170mm x 155mm

Thickness of Sheet: 0.5mm

Paint on Inner Surface: Mat black finish by black board paint

Length of M.S strips (for suspension of the trays): 90mm

Depth of hinge (for suspension of trays) from inner box top: 65mm.

### Cooking Pot with Lid

Material: Aluminum
Thickness: 0.5mm
Number: Four Diameter: 150mm
Depth: 90mm

Total capacity of the pots: 5 Liters (1.25 liters x 4)

### Cooker Box (Outer)

Material: G.I. Sheet

Thickness: 1mm

Size: Length=940mm, Width=320mm, Height=295mm

General Finish: Smooth, Free from sharp edges

### Gasket and Insulation

Gasket Material: Compressed asbestos fiber

Thickness: 2mm

Insulation Material: Glass Wool

Pad (insulation) thickness: Side=50mm, Bottom=50mm

### Reflecting Mirror

Number of reflector: Two

General Appearance: Free from bubbles /waviness

Thickness: 4mm
Size: Length=840, Width=220mm

Additional design Feature**:** Provision for keeping the mirror in inclined position (working position) with respect to its folding position (when not in use)

### Caster Wheel

Number- Four
Construction- Nylon Ball

### Advantages of the cooker

Almost 90% of the energy collected by a solar system occurs between 9 am to 3 pm. The provision for changing the inclination of proposed cooker from 15 degree to 45 degree with the horizontal is sufficient to collect direct solar radiation perpendicularly throughout the mentioned period.

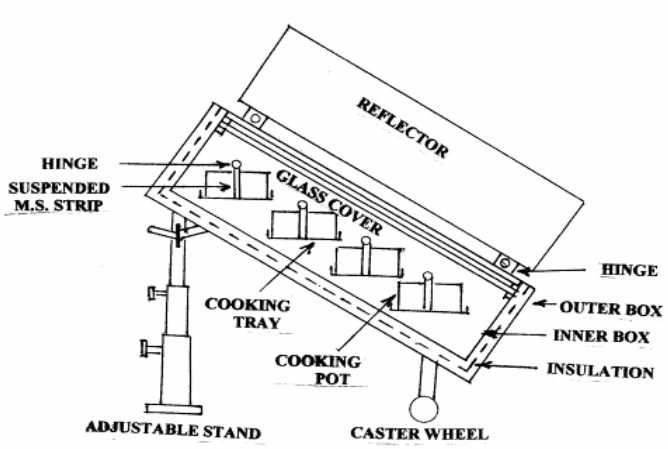



FIG-1. INCLINED BOX TYPE SOLAR COOKER

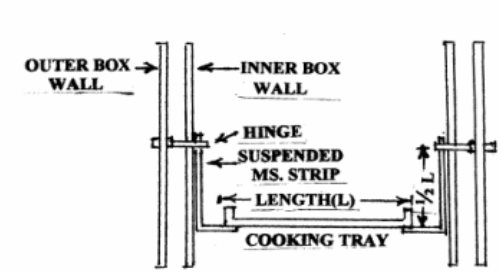
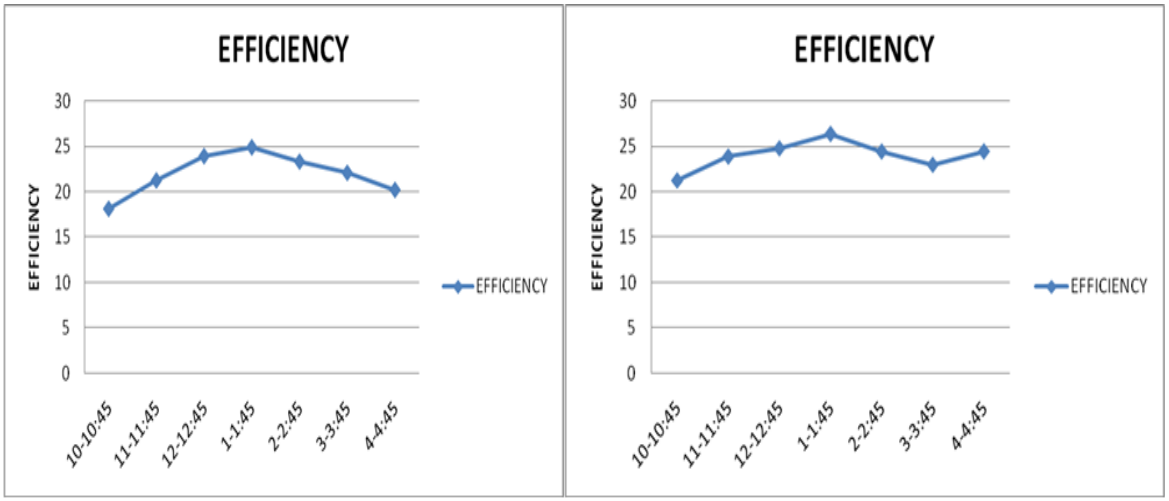



FIG-2. SUSPENDED TRAY ARRANGEMENT

**Fig.4, 5** Relationship among time and efficiency of box type solar cooker



Thus radiant energy falling per unit aperture area of the cooker face is increased than if the cooker is placed horizontally like conventional box type cooker. Also transmissivity of the cooker glazing is increased for its perpendicular position with the beam radiation.

In this cooker system with two reflectors, energy collection is high and even four reflectors can be conveniently used to concentrate solar radiation similar to tracking reflectors, but without the hazards of frequent manual adjustment to follow the apparent motion of the sun.

Arrangement of multiple reflectors is also possible in horizontally placed box type cooker, but except of the south facing reflector other reflectors will not be able to reflect radiation properly to the inside of the cooker box except the noon time. This is due to the fact that either effective area of the reflecting surface of the reflectors exposed to the sun will be very less than its actual area or major portion of the reflection from the reflectors will not fall on the cooker inside

## Efficiency of the cooker

The water heating test was conducted by placing a vessel with 2000 gm. of water in inner box of box type solar cooker and 3000 gm. of water in parabolic solar cooker at the focus of the solar cooker and its initial temperature was noted. The water was then heated for 45 minutes. The final temperature attained was noted and the rise in temperature was calculated. Heat gained by water and vessel was calculated by multiplying the rise in temperature with mass of water and vessel and specific heat of water and vessel. Sun shine intensity at the mirror level in the mirror level in box type and normal to the reflector at the parabolic solar cooker was also measured with the help of solarimeter at 45 minutes regular interval. The tests were measured at the beginning of every hour from 10 am. To 5 pm. Calculation of efficiency was calculated with the help of the formula.

$$\text{Efficiency of the cooker } (\eta) = \frac{\text{Heat gained by vessel and water}}{\text{Heat received by solar cooker at reflector}}$$

## Pay Back Time

The payback period of any cooker depend upon the quantity of food items cooked and the fuel it replaced. The payback period varied with respect to the fuels such as firewood, coal, kerosene etc. We assumed a family of four members having two adults and two children consume 500 gm of rice, 250 gm of dal and 250 gm. of potatoes two times a day. Weighed quantities of food item like dal, rice, potatoes was cooked and the time taken for cooking was noted. The same quantities of food items was then cooked on stove using kerosene oil and calculate the amount of kerosene oil consumed per day. It was found that the kerosene consumed for cooking of 500 gm. rice 250 gm. of dal and boiling of 250 gm. of potatoes two times a day was half a litre per day. The present cost of half litre of kerosene was 20 rupees. Cost of box type and parabolic solar cooker was 3000 and 6500 respectively. Payback time was calculated by dividing the cost of the cooker bye cost of the kerosene consumed per day.

$$\text{Payback time of box solar cooker} = \frac{\text{cost of the box solar cooker}}{\text{cost of the kerosene consumed per day}}$$

= 3000/20 = 150 days

$$\text{Payback time of fabricated solar cooker} = \frac{\text{cost of the fabricated solar cooker}}{\text{cost of the kerosene consumed per day}}$$

= 2000/20 = 100 days

The study was undertaken to calculate the energy efficiency, cooking time of Box type solar cooker and Fabricated Inclined box type solar cooker. The study was conducted in the Department of farm machinery and at Sam Higginbottom Institute of Agriculture Technology and Sciences Deemed to be University.

On the basis of results obtained and discussed the following conclusions were made: Efficiency of Box type solar cooker was found as 19-22% whereas efficiency of Fabricated Inclined Box Type solar cooker was 23-25%.

Time taken by Fabricated Inclined box type solar cooker to cook 250 gram of rice, 250 gram of dhal, 250 gram of potatoes and boiling of eggs was 30% less in comparison to Box type solar cooker.

## References

Ekechukwu, O.V., and N.T. Ugwuoke. Design and measured performance of a plane reflector augmented box-type solar-energy cooker, 2002.

Mirdha U.S., S.R. Dhariwal. Design optimization of solar cooker. Solar energy conservations, 2007.

Nahar NM. Design, development and testing of a double reflector hot box solar cooker with a transparent insulation material. Renew Energy 2001.

Naveen Kumar, Tilak Chavda, H.N. Mistry. A truncated pyramid non-tracking type multipurpose domestic solar cooker/hot water system Gujarat 388 120, India, 2009.

Subodh Kumar. Estimation of design parameters for thermal performance evaluation of box-type solar cooker, 2005.