

## • INTRODUCTION

In the mid-1700s, a European naturalist named Horace de Saussure built a small device intended to harness the energy of sunlight. Scientists at the time were doing a lot of work with converting sunlight to heat, but they were mostly using mirrors to concentrate the light into a single burning point. Saussure was focused on the heat-trapping capacity of glass.

What Saussure created was the earliest known solar cooker, most comparable to what we now call a solar **box cooker**. He nested five glass boxes one inside the other, and rested them on a black slab of wood. After several hours exposed to sunlight, the temperature inside the box reached just shy of 190 degrees Fahrenheit (88 degrees Celsius). He used the box to bake fruit.

What began in the 18th century as a science experiment, an attempt to find out why and how glass traps sunlight to create heat, is now a helpful tool in alleviating hunger and disease in the world's poorest countries. (It's also a very cool, environmentally friendly replacement for the typical backyard barbecue.) The modern concept of solar cooking first came on the scene in the 1950s but failed to gain popularity, perhaps due to faulty United Nations marketing techniques [source: Radabaugh. With the right device, the thermal (heat) energy in the sun's rays can be harnessed to achieve temperatures so hot they can fry food. A solar cooker can do almost anything a stove or an oven can do, only it uses a natural nonpolluting, free, abundant energy source. In this article, we'll find out how sunlight becomes heat, check out the different types of cookers available and how they work, see what makes solar cooking a potential lifesaver in many parts of the world and examine some of its shortcomings

## CULTURAL FACTORS

In addition to the primarily technical aspects of solar box cooker design, factors including culture, appropriate technology, and aesthetics play a major role in the successful technology transfer of solar box cooking.

Through the centuries, the power of the sun has been tapped in numerous ways. With solar cooking, as with other endeavors, some design approaches work better than others. Technology that is designed to efficiently accomplish a given task while meeting certain energy use, environmental, social, cultural, and/or aesthetic standards, is often referred to as "appropriate technology."

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Unfortunately, the field of solar cooking has its share of devices that fail these basic technical and social tests. For example, parabolic cookers can cook food, but when compared to the solar box approach, they are more difficult to build, require specialized materials and constant refocusing, may burn food, and are not likely to be accepted in most social and cultural contexts. In fact, because of the well publicized failures of these devices in several development projects in the '60s, many still believe that solar cooking is not feasible.

The better a given solar box design meets appropriate technology criteria, the more likely it is to be embraced by those using it. A very low-tech approach is to simply dig a shallow pit in the ground, insulate the bottom with dried grass or leaves, insert the food or water in a dark container, and place glass over the top. On the high-tech end of the scale, the very same solar principles could be used with standard building and insulating materials and high performance low-emmissivity glazing, to architecturally integrate a solar cooker into the south side of a contemporary kitchen. The solar oven door could be on the wall at a convenient height right next to the microwave.

Cardboard solar box cookers may be appropriate for many cultures because the materials are widely available and inexpensive. But disadvantages of cardboard include susceptibility to moisture damage and lack of durability compared to many other materials.

Aesthetics are usually important. Cultures having rounded forms as the norm may reject the entire solar cooking concept because the box is square. And certain social strata may reject cardboard as too "cheap" a material for their use.

## CONSTRUCTION & WORKING

### CONSTRUCTION :

#### A. Box size

A solar box cooker should be sized in consideration of the following factors:

- The size should allow for the largest amount of food commonly cooked.
- If the box needs to be moved often, it should not be so large that this task is difficult.
- The box design must accommodate the cookware that is available or commonly used.
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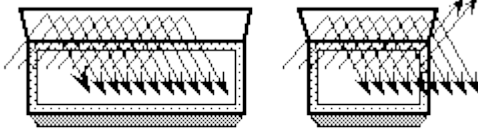


Figure 10: Wider solar boxes catch more of the east and west sunlight.

#### B. Solar collection area to box volume ratio

Everything else being equal, the greater the solar collection area of the box relative to the heat loss area of the box, the higher the cooking temperatures will be.

Given two boxes that have solar collection areas of equal size and proportion, the one that is of less depth will be hotter because it has less heat loss area.

#### C. Solar box cooker proportion

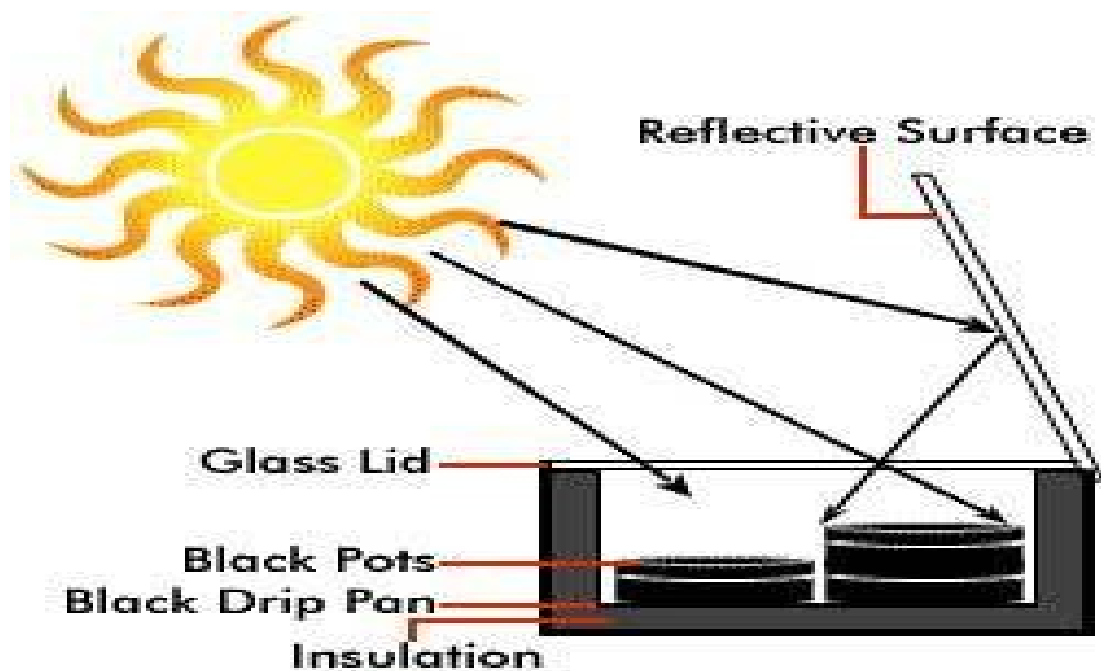
A solar box cooker facing the noon sun should be longer in the east/west dimension to make better use of the reflector over a cooking period of several hours. As the sun travels across the sky, this configuration results in a more consistent cooking temperature. With square cookers or ones having the longest dimension north/south, a greater percentage of the early morning and late afternoon sunlight is reflected from the reflector to the ground, missing the box collection area.

#### D. Reflector

One or more reflectors are employed to bounce additional light into the solar box in order to increase cooking temperatures. Although it is possible to solar cook without reflectors in equatorial when the sun is mostly overhead, reflectors increase cooking performance significantly in temperate regions of the world.

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## OPERATION :

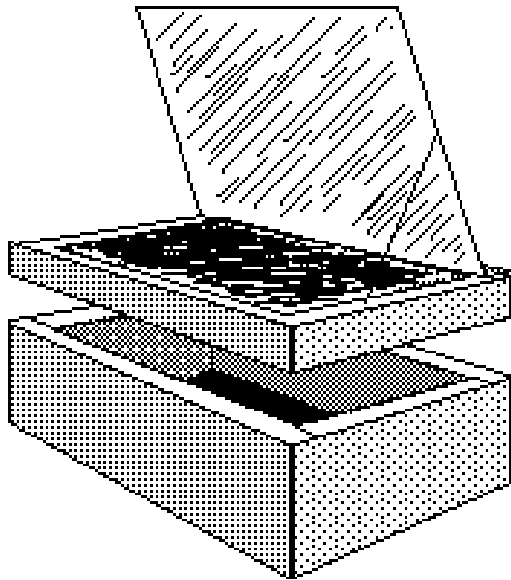


Solar cooker designs generally fall into one of two categories. One category is the box -type cooker which essentially consists of a rectangular enclosure insulated on the bottom and sides, and having one or two glass covers on the top. Solar radiation enters through the top and heats up the enclosure in which the food to be cooked is placed in shallow vessels. A typical size available has an enclosure about 50cm square and 12 cm deep. Temperature around 100 degree C can be obtained in these cookers in sunny days and pulses, rice, vegetables, etc., can be readily cooked. The time taken for cooking depends upon the solar radiation and varies from half to two and half hours.

A single glass reflector whose inclination can be varied is usually attached to the box type cooker. The addition of the mirror helps in achieving enclosure temperatures which are higher by about 15 to 20 degree C. As a result, the cooking time is reduced. Cookers with reflectors on all four edges have also been built.

The item to be cooked has only to be placed inside and taken out, so that with some experience, the operator does not have to spend much time in the sun.

## WORKING PRINCIPLE



**Figure 1. Solar box cooker with cover, window, and reflector**

With an understanding of basic principles of solar energy and access to simple materials such as cardboard, aluminum foil, and glass, one can build an effective solar cooking device. This paper outlines the basic principles of solar box cooker design and identifies a broad range of potentially useful construction materials.

These principles are presented in general terms so that they are applicable to a wide variety of design problems. Whether the need is to cook food, pasteurize water, or dry fish or grain; the basic principles of solar, heat transfer, and materials apply. We look forward to the application of a wide variety of materials and techniques as people make direct use of the sun's energy.

The following are the general concepts relevant to the design or modification of a solar box cooker:

## Principles of Solar Box Cooker Design

People use solar cookers primarily to cook food and pasteurize water, although additional uses are continually being developed. Numerous factors including access to materials, availability of traditional cooking fuels, climate, food preferences, cultural factors, and technical capabilities, affect people's approach to solar cooking.

With an understanding of basic principles of solar energy and access to simple materials such as cardboard, aluminum foil, and glass, one can

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## HEAT PRINCIPLES

The basic purpose of a solar box cooker is to heat things up - cook food, purify water, and sterilize instruments - to mention a few.

A solar box cooks because the interior of the box is heated by the energy of the sun. Sunlight, both direct and reflected, enters the solar box through the glass or plastic top. It turns to heat energy when it is absorbed by the dark absorber plate and cooking pots. This heat input causes the temperature inside of the solar box cooker to rise until the heat loss of the cooker is equal to the solar heat gain. Temperatures sufficient for cooking food and pasteurizing water are easily achieved.

Given two boxes that have the same heat retention capabilities, the one that has more gain, from stronger sunlight or additional sunlight via a reflector, will be hotter inside.

Given two boxes that have equal heat gain, the one that has more heat retention capabilities - better insulated walls, bottom, and top - will reach a higher interior temperature.

The following heating principles will be considered first:

- Heat gain
- Heat loss
- Heat storage

## A. Heat gain

**Greenhouse effect:** This effect results in the heating of enclosed spaces into which the sun shines through a transparent material such as glass or plastic. Visible light easily passes through the glass and is absorbed and reflected by materials within the enclosed space.

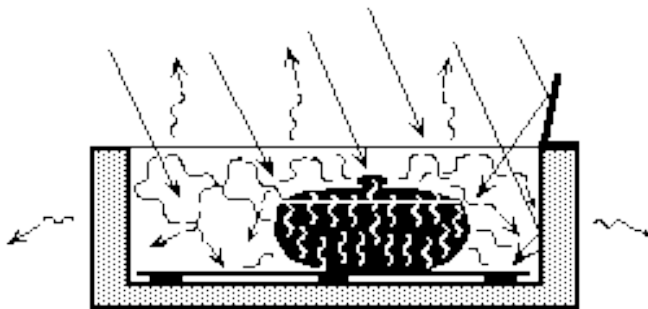


Figure 2. The greenhouse effect

The light energy that is absorbed by dark pots and the dark absorber plate underneath the pots is converted into longer wavelength heat energy and radiates from the interior materials. Most of this radiant energy, because it is of a longer wavelength, cannot pass back out through the glass and is therefore trapped within the enclosed space.

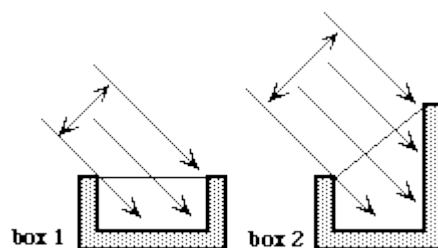


Figure 3. Glass orientation

Critical to solar cooker performance, the heat that is collected by the dark metal absorber plate and pots is conducted through those materials to heat and cook the food

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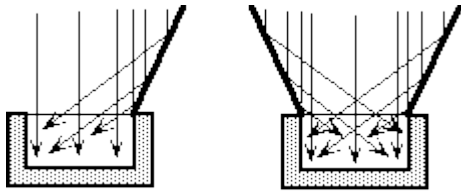


Figure 4. Reflectors for additional solar gain

**Reflectors, additional gain:** Single or multiple reflectors bounce additional sunlight through the glass and into the solar box. This additional input of solar energy results in higher cooker temperatures.

## B. Heat loss

The Second Law of Thermodynamics states that heat always travels from hot to cold. Heat within a solar box cooker is lost in three fundamental ways: **Conduction, Radiation, and Convection**

### Conduction:

The handle of a metal pan on a stove or fire becomes hot through the transfer of heat from the fire through the materials of the pan, to the materials of the handle. In the same way, heat within a solar box is lost when it travels through the molecules of tin foil, glass, cardboard, air, and insulation, to the air outside of the box.



Figure 5. Heat conducted through the pan to handle

The solar heated absorber plate conducts heat to the bottoms of the pots. To prevent loss of this heat via conduction through the bottom of the cooker, the absorber plate is raised from the bottom using small insulating spacers as in **figure 6**.

**Radiation:** Things that are warm or hot -- fires, stoves, or pots and food within a solar box cooker -- give off heat waves, or radiate heat to their surroundings. These heat waves are radiated from warm objects through air or

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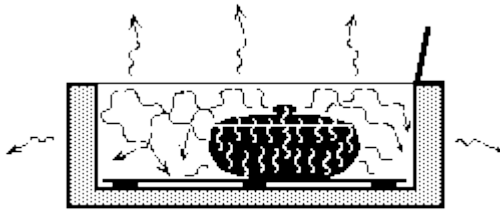


Figure 6. Heat radiates from warm cookware.

space. Most of the radiant heat given off by the warm

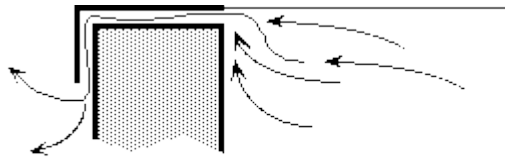


Figure 7. Heated air may escape through cracks.

**Convection:** Molecules of air move in and out of the box through cracks. They convect. Heated air molecules within a solar box escape, primarily through the cracks around the top lid, a side "oven door" opening, or construction imperfections. Cooler air from outside the box also enters through these openings.

### C. Heat storage:

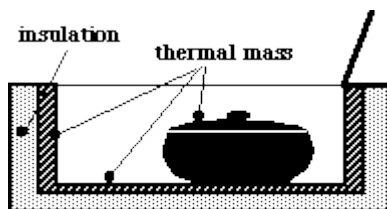


Figure 8. Thermal mass inside of the solar box.

As the density and weight of the materials within the insulated shell of a solar box cooker increase, the capacity of the box to hold heat increases. The interior of a box including heavy materials such as rocks, bricks, heavy pans, water, or heavy foods will take longer to heat up because of this additional heat storage capacity. The incoming energy is stored as heat in these heavy materials, slowing down the heating of the air in the box.

These dense materials, charged with heat, will radiate that heat within the box, keeping it warm for a longer period at the day's end.

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## **DESIGN**

### **Cover Plate(Glass Lid)**

Material: Plain glass

Spacing between two glasses: 17mm

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

General appearance of glazing: Free from bubbles/ rough surfaces

Frame area: 1681 sq.cm

Glass area: 1664 sq.cm

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: Asbestos Sheet

Thickness of Sheet: 5mm

Size: Length=380mm, Width=380mm, depth=70mm

Thickness of wall: 5mm

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

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### **Cooking Pot with Lid**

Material: Stainless Steel

Thickness: 0.5mm

Number: Three.

Diameter: 170mm

Depth: 55mm

Total capacity of the pots: 3.72 Liters (1.24 liters x3)

Additional Design Feature: One pot with temperature sensor.

### **Cooker Box (Outer)**

Material: G.I. Sheet

Thickness: 1mm

Size: Length=500, Width=500mm, Height=170mm

General Finish: Smooth, Free from sharp edge

### **Gasket and Insulation**

Gasket Material: Heatlon

Thickness: 5mm

Insulation Material: Glass Wool, Asbestos Sheet

Thickness:5mm

### **Reflecting Mirror**

Number of reflector: One

General Appearance: Free from bubbles /waviness

Thickness: 4mm

Size: Length=445, Width=440mm

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

### **Support Frame**

Material: Cast Iron

Size: Length=650mm, Width=300mm, Height=300

Additional design Feature: Painted in Blue powder finish

## **MANUFACTURING OF PARTS (PART DRAWINGS WITH PROCESS SHEETS)**

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## 1. **Outer Box**

The outer box of solar cooker is made up of Galvanized Iron sheet.

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## **2. Inner cooking box**

This is made from Asbestos sheet. The inner cooking box is slightly smaller than the outer box. It is coated with black paint so as to easily absorb radiation and transfer the heat to the cooking pots.

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2. **Double Glass Lid:** A double glass lid covers the inner box or tray. This cover is slightly larger than the inner box. The two glass sheets are fixed in an aluminum frame with a spacing of 2 cm between the two glasses. This space contains air which insulates and prevent heat escaping from inside. A rubber strip is affixed on the edges of the frame to prevent any heat leakage.

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**4. Thermal Insulator:** The space between the outer ox and inner tray including bottom of the tray is packed with insulating material such as glass wool pads.

**5. Reflector:** Mirror as a reflector used in solar cooker to increase the radiation input on the absorbing space and is fixed on the inner side of the main cover of the box. Sunlight falling on the mirror gets reflected from it and enters into the tray trough the double glass lid. This radiation is in addition to the radiation entering the box directly and helps to quicken the cooking process by raising the inside temperature of the cooker.

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## **6. Container With sensor**

: The cooking containers (with cover) are made of aluminum or stainless steel. These pots are also painted black on the outer surface so that they also absorb solar radiation directly.

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## **7. Frame**

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## **8. Electronic Circuit for Digital Temperature Sensor**

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## **9.Angle Plate**

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## **10. Indicator support**

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### Process Chart

Sr.No	Operation Performed	Machine used
1	Cutting Sheets as per drawings	Hand shearing machine
2	Bending according to marking	Fly Press

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3	Remove Sharp Corners	File
4	Joints And Fixtures using hinges, screw fittings, nuts and bolts	Screw driver , hammer, Drill,
5	Final assembly	Assembled with hands

## **COSTING**

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<b>Sr.No.</b>	<b>ITEM</b>	<b>COST</b>
1	Box cooker	7500 Rs.
2	Indicator and Sensor	5500 Rs.
3	Frame	2000 Rs.
<b>TOTAL</b>		<b>15000 Rs.</b>

## **FUTURE SCOPE**

In Future the use of solar cooker will rise to a great extent because of its following advantages

- In an age where domestic fuel costs are rising each year, the solar cooker is a real boon.
- Reasonably priced, easy-to-use and completely trouble-free, the solar cooker is an ideal supplement to the conventional cooking appliances.
- Can be used 300 days a year.
- No fuel required for cooking.
- All items can be cooked except the fried and chapattis.
- Cooking is safe and clean.
- Solar cooking is entirely non-polluting and has no ill effects on health.
- Food cooked in solar cooker tastes better, is more nutritious and healthy.
- No need to keep close watch during cooking as the process is slow.
- Cooking time is around 1.30 to 2.30 hours.
- Food remains hot as long as the glass assembly is not opened.
- Three LPG cylinders can be saved annually as a result of solar cooking.
- Pay-back period is around three years.
- Life is around 10-15 years.
- Operating and maintenance cost is negligible.

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## TESTING

### **Title:**

Test rig for solar box cooker

### **Procedure:**

- 1: Observe the solar cooker and different components of solar cooker.
- 2: Identify and locate different components with the help of figure / photograph.
- 3: Teacher shall explain constructional features, working principles of the cookers.
- 4: Understand the functions of each component of the solar cooker system.
- 5: Place the box type solar cooker in such a way that the mirror reflects the sunrays on the double glass lid.
- 6: Fill fixed quantity of water in the container.
- 7: Measure the initial temperature of water.
- 8: Place the container inside the box type solar cooker.
- 9: Measure the temperature of water after interval of 15 minutes. Take 4-5 readings
- 10: Take the container out of the cooker.
- 11: Measure the quantity of water remaining in the container.
- 12: Allow the container to regain room temperature.

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Time in minutes	15	30	45	60	75	90
Temp. in 0 C						

**Test Conclusion:**

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## CONCLUSION

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