

THE SOLAR COOKING TABLE

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ABSTRACT

1) A new solar cooker

The Solar Cooking Table is a solar focusing collector, with an open focus. But many differences and advances are noticeable from the usual parabolic cooker:

- The cooker is made of two main parts: a table and a concentrator.
- The concentrator reflects and focuses the solar rays under the table, where a hole is made, and where you put the pot.
- The concentrator is asymmetrical. That way, it can collect all the solar rays. This also allows the table and the pot not to make any shadow on the concentrator.
- The table protects the cook from burns and dazzles. Even if the focus moves, the table shelters the user and is a safety device to do the cooking quietly.
- There are two simple devices used to track the solar position. The first one allows the control and the tracking of the variation of solar azimuth. The second one allows the tracking of the variation of solar altitude.
- A special device can regulate the heat under the pot. A shutter and an indicator allow the cook to reduce or increase the heat under the pot.

2) Applications

- Main advantages: the Solar Cooking Table allows dishes to be cooked with an open focus, and at high temperatures, in complete safety.
- Applications in Africa : all the dishes can be cooked: tô, different doughs (breads, pastries, porridges), rice with fish, and fried food.
- Applications in Northern countries: as a barbecue or as a fryer.
- As a cooking table: It is possible to access the dish during the cooking, at all times. It allows the cook to knead dough or stir the food while it is heating. It allows the regulation of the temperature and heat during the cooking.
- As a barbecue: it can cook ribs of beef, pork chops, sausages, kebabs, and grilled meat, with a special plate.

It can also cook French fried potatoes, fritters, Spanish chouros, doughnut, and all sorts of frying.

3) Field tests

The Solar Cooking Table, with a particular size, has given the following results:

- In France, in Normandy (North West), during summer, we obtained the following results: Fried potatoes for 4 people cooked in 1 hour. Sausages for 4 people cooked in 15 minutes.
- In West Africa: in Senegal, it cooked rice with fish. In Burkina it cook rice, pasta and fritters. Rice for 10 people cooked in 1 hour.

Conclusion : The Solar Cooking Table is easy to use as a barbecue, a fryer or to cook pastry. Depending on the area, it has given good results to do the cooking for 4 to 10 people.

Keywords: Barbecue, Fryer, Table, Open, Safety, Focus, Regulation, Stir.

1. INTRODUCTION

In 1993, in Burkina Faso (West Africa), as I was in Voluntary Service Overseas for a year, I became aware of desertification and wood rarefaction. These processes, which affect the Sahel, are kept up by the cutting of wood used for cooking.

Inspired by a Spanish friend, I began to imagine and design a solar focusing cooker. As an engineer, I finally produced three prototypes during a year, which has led today to the Solar Cooking Table.

The purpose of this paper is to introduce this new solar cooker.

2. BACKGROUND

Solar focusing cookers have existed for a long time, especially in the well known form of a parabola. This

turns round a spindle to point at the sun and focuses the solar rays on the pot. The pot and parabola support is often very simple.

In Burkina Faso, I have heard of complaints from paraboloid users, saying that they cause burns and dazzling (through a bad use no doubt!) and, since, some have been abandoned.

An idea occurred to me to use a table to protect the cook, while allowing a standing position. (see photo 1). In fact, my idea is not far from the principle of Mr Roger Bernard's Nelpa solar panel cooker (see ref 1). However, many differences between the cookers are noticeable and, first, the heating principle itself: The Nelpa is an inverted oven, which uses the greenhouse effect. The Solar Cooking Table is a focusing collector.

3. OPERATION

3.1 Solar Cooking Table description

The Solar Cooking Table (SCT) is a solar focusing cooker, with an open focus. It is closely connected to parabolic cookers, mainly made up of a concentrator, whose shape is a paraboloid of revolution. Their main advantage is to allow access to the dish during the cooking.

The SCT is made of two main parts: a table and a concentrator.

In the middle of the table, there is a circular hole, above which we put the pot. At this place, called focus, the concentrator reflects and focuses the solar rays.

A first problem is the shadow cast on the concentrator by the table and the vessel, and also by the cook, when he stirs the food. For this reason, the concentrator can't be a paraboloid of revolution.

The concentrator is asymmetrical, with a complicated shape, close to a truncated paraboloid. That way, the focus is thrown off-center and is located out of the sunlit zone that gets to the concentrator. (see photos 1 and 2). All the solar incident rays can be collected.



Photo 1: Rice cooking in Burkina Faso

3.2 Tracking indicators

The table's legs bear the concentrator, through a spindle. The concentrator can turn round this spindle. A lever, fixed on the concentrator, slides through a groove, along a table leg.

This lever allows the concentrator's tilt to be changed. In this way, when the sun is going up or down in the sky, we can track the altitude variation by changing the concentrator's tilt, in order that the rays always focus under the vessel.

To track the variation of solar azimuth, we simply move the table in front of the sun, by moving the table to one side.

Two indicators, located on the right side of the table, give information of the SCT orientation:

- A mirror, fixed on the concentrator's side, reflects a light spot, on the table. This spot is projected on to a paper, and indicates the correct concentrator's tilt.
- A stick's shadow on the table indicates the table's right position in front of the sun. (see photo 3).

3.3 Regulation device

The table is equipped with a sliding shutter, made of galvanized steel (see photo 2). When we want to raise heat to a maximum, we slide the shutter as far as possible away from the hole. The hole is completely open. When the shutter stops half the hole, the heat intensity is reduced by half. We can also reduce it 10%, 20% ...

When it isn't used, the Solar Cooking Table can be collapsed. We take away the lever, lift the concentrator and put it straight up along the table.



Photo 2: Table underneath view
The galvanized shutter is slid to the left of the hole.

4. ADVANTAGES

The advantages of the Solar Cooking Table are those of a parabolic cooker, namely:

- Open focus cooking. We can access the pot at any time during the cooking.
- Intense fire cooking. Due to the concentration, the heat is very high. It allows high temperatures to be reached, which is necessary for the cooking of some dishes.

The additional advantages brought by the SCT are specially interesting for the cook:

4.1 Heat regulation

Thanks to the sliding shutter, it is possible to reduce the heat under the vessel, which is useful for some dishes or when it comes to the boil. We don't have to put up with the solar heat, we can regulate it and therefore we get it under control. This regulation avoids burnt dishes, pots boiling over.

4.2 Safety device

Cooking and making meals can be done with less care. The user won't risk being burnt, or dazzled, when he wants to access the vessel. Furthermore, the food can be stirred, or mixed without stopping the heating. A dough (of millet, of corn, sorghum...) can be kneaded while it goes on heating or boiling.

In consequence, to secure the cooking, some safety elements are fixed on the table: a protector panel behind the focus, a sliding shutter that stops the hole before removing the vessel, the table itself that protects against the focus. (see photo 2).

4.3 Shadow

The concentrator, due to its form and position, avoids the table and cook casting shadow on it. However, when the sun is zenithal, a small part of the concentrator is shaded (under the table). But, at this moment, the insolation is greater and the surface exposed to solar rays is larger, therefore it compensates the loss.

Moreover, the cook can be under the shade of a shelter, fixed on the table. Located above the table, the shelter won't cast any shadow on the concentrator.

4.4 Indicators

Like the parabolic cookers, it's necessary to track the sun, in order that the rays always focus under the vessel. Every 20 to 30 minutes, the concentrator is oriented. The two indicators give safe information (see preceding section). Moreover, the indicators are very convenient for the cook, who is informed at a glance.(see photo 3).

4.5 Wind stability

The SCT is very stable, because the concentrator is near the ground and its centre of gravity is low. Also, the concentrator's horizontal position allows it to get only a small surface exposed to the wind.

The 4 legs table are distant and give a good support.



Photo 3: Tracking indicators

5. VARIOUS USES

As a solar focusing cooker, with an open focus, the Solar Cooking Table is suitable for various uses. For more clearness, the following uses are divided into three sections.

5.1 Barbecue

Cooking different meats : put in a black metallic dish, the meats grill quickly. Kebabs, sausages, ribs of beef, mutton chops, and so on can be grilled.

Use in particular in the Northern countries, where the barbecue has become democratic.

5.2 Dough Cooking

Cooking a dough or a pastry, while kneading: the cooking of « tô » (millet dough), of « foutou » (yam dough), of corn dough and sorghum one needs to knead the dough while it is boiling fast. The pot is put on the table and then fixed firmly between jaws (not to move during the kneading).

Cooking sauces and stirring and mixing the ingredients.

Applications in African countries, where the main dish, composed of a dough and a sauce, is still widespread.

5.3 Frying

Frying vegetables and fruits: the oil is brought to the boil in the pot, and filled with the ingredients.

Cooking of apple fritters, « churros » (Spanish fritters), French fried potatoes, doughnuts, bean fritters, etc.

Frying fish, eggs and meat in a special pan.

Applications in Northern and Southern countries.



Photo 4: Rice cooking at Caen

6. RESULTS

6.1 Tests in France

The following field tests have been performed in France, at Caen, in Normandy. This area is located on the 49,2° North Latitude. The area has less than 1750 hours of sunshine a year. The tests were done during summer, when the sky was not cloudy.

The following insulations are given according to the analysis of many measures made in France by Perrin de Brichambaut, who gives the formulae :

$$I = 1260 (\exp(-1/(2,3 \sin(h+3))) \text{ Solar insolation } W/m^2.$$
$$G = 995 (\sin h)^{(1,25)} \text{ Global insolation } W/m^2.$$

The results:

- 1 liter cold water (20 °C) boils after 15 minutes.

Temperature around 100 °C.

July 16th, 13h30-13h45.

I= 770 W/m². G= 820 W/m².

- Meat grilled for 4 people:

6 Sausages (weight = 330 g) grilled after 15 minutes and very grilled after 20 minutes.

September 5th, 13h-13h20.

I= 700 W/m². G= 645 W/m².

4 pork chops (weight = 740 g) grilled after 30 minutes and very grilled after 40 minutes. (see photo 5).

September 4th, 12h40-13h10.

I= 690 W/m². G= 620 W/m².

- 1 liter cold oil (20 °C) boils after 20 minutes.

August 28th, 12h30-12h50.

- Frying : Potatoes fried after 45 min, and very fried after 1 hour, after cold oil start. 1,5 kg of potatoes.

I= 720 W/m². G= 690 W/m².

August 28th, 12h30-13h30.



Photo 5: Chops grilled at Caen

6.2 Tests in Burkina

The following field tests have been performed in Africa, in Burkina Faso. This area is located on the 12,1° North Latitude. The tests were made during May, a usual month for the sunshine. The global irradiation was about 7 kWh/m²/day in Burkina. (for the previous tests, it was about 4 kWh/m²/day in France).

- Rice cooking for ten people:

Rice cooked after one hour and ten minutes, after a cold water start (30 °C). 3 kg of rice.

May 10th, 12h-13h10.

- Spaghettis cooking for eight people:
Spaghettis cooked in 30 minutes, after a cold water start (30 °C). 1 kg of spaghetti.
May 12th, 12h20-12h50.

7. REALISATIONS

7.1 SCT 1 Model

The concentrator dimensions : 1m x 0,7m.
It is made of wood and covered with square mirrors, 10cmx10cm size, stuck on.
The table is metallic, made of sheets and welded tubes.
The lever, the spindle and the shutter are metallic.

7.2 SCT 1,5 Model

The concentrator dimensions : 1,4m x 1,1m.
It is made of wood and covered with square mirrors, 15cmx15cm size, stuck on.
The table is metallic, like the SCT 1 pattern.

7.3 SCT 1,6 Model

The concentrator dimensions : 1,4m x 1,1m.
It is made of wood and covered with aluminium sheets.
The table is made of wood, sheltered by sheets close to the focus. (see photo 5).
The lever, the spindle and the shutter are metallic.

7.4 SCT 2 Model

The concentrator dimensions : 1,4m x 1,1m.
It is made of reinforced polyester and covered with square mirrors, 15cmx15cm size, stuck on.
The table is metallic.

7.5 Comparison

The wooden table is cheaper than the metallic table but less rigid.

The wooden concentrator has a good stiffness and a long lifetime. However careful work is necessary to build it.

The polyester concentrator is manufactured from a mould. But the mould must be very precise.

The SCT 1, SCT 1,5 and SCT 1,6 can be built with materials available in most countries : wood, metal, mirrors or aluminium sheets. The SCT 2 can be manufactured after investing in a mould.



Photo 6: Wooden concentrator

8. CONCLUSION

The Solar Cooking Table is a focusing cooker, equipped with a table, to cook easier and in complete safety. More elaborate, it is also a little more expensive than a traditional parabola. However, the SCT gives the advantages of an easily used device, allowing various dishes to be cooked. The Solar Cooking Table wishes to diversify the actual solar cookers proposal.

9. REFERENCES

- (1) The Nelpa Solar Panel Cooker, by Roger Bernard, Solar Cooking Archive.
- (2) Cooking with the Sun, Morning Sun Press, USA, 1992.
- (3) Moving ahead with Solar Cookers, GTZ, March 1999.