SMALL MARMALADE FACTORY IN ARGENTINA WORKING WITH SCHEFFLER TYPE INDUSTRIAL COOKER

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ABSTRACT

In the year 2003 "CEDESOL Ingeniería" built for the small marmalade and liquor factory "Hecho en Casa" located in the Argentinean town of Clorinda an industrial solar cooker destined mainly for cooking pulp of tropical fruits to transform it into marmalade or chutney and to can vegetables. The solar cooker is made of a 4.5 m^2 Scheffler type reflector with a clockwork tracking system and a cooking place incorporated into the north facing wall jutting out of it. The 50 liter cooking pot is equipped with an electric mixer and thermal insulation. Due to the pot's height of over 160 cm above the ground and its heavy weight, it was necessary to install a lift to manipulate the pot. Energy efficiency measurements with water gave results of around 50%.

Keywords: Scheffler reflector, industrial food processing, solar cooking, Argentina, Paraguay

1. INTRODUCTION

"CEDESOL Ingeniería" is a small Paraguayan company located in Capiatá, a suburb town of the Capital Asunción. It was created in 1996 by the author, a Swiss engineer and member of the ULOG Group of Switzerland, and Cesarino Benítez, a Paraguayan master mechanic, with the support of the "Celestina Pérez de Almada" Foundation. This Foundation was created in 1992 by the well known Paraguayan lawyer and educator Martin Almada, who in 2004 won the "Right Livelihood Award" for his struggle against dictatorship and for human rights in his country. In the frame of its activities in environmental protection the Foundation started in 1994 to promote also the use of solar energy in Paraguay with the financial support of different international development organizations. For its effort in this area during all these years it won in 2005 the "European Solar Prize" in the category of Education, which is awarded yearly by "Eurosolar e.V.".

"CEDESOL Ingeniería", which is managed jointly by the two founders, develops and manufactures small and medium scale solar equipment appropriated to the local conditions, such as solar water heaters, cookers and food dryers, but also energy efficient firewood stoves. Some five years ago the company started also to design and install photovoltaic solar energy systems. Before coming to Paraguay, the country which the author chose finally as his permanent residence, he had already been trained in the manufacturing of Scheffler community solar cookers by the inventor, who also is member of the ULOG Group, and between 1989 and 1993 he had built several of them in different countries of Africa and South America.

Fig 1. The three Mayans sisters of Clorinda, owners of the "Hecho en Casa" factory in their shop during its inauguration

In the beginning of the year 2003 the three Mayans sisters (see Fig. 1) from the Argentinean city of Clorinda, a neighbor city of Asuncion located just at the border to Paraguay on the other side of the Paraguay river, founded together a small handicraft marmalade and liquor factory they named "Hecho en Casa" (Home Made). When it was the matter to decide how to cover the cooking needs of the factory, they had the idea to install an industrial solar cooker in order to spare as much liquid petroleum gas (LPG) as possible_, the most common conventional cooking energy. LPG has become quite costly, despite_the fact that Argentina is a producing country of this fuel. After they_contacted us, we recommended they install a Scheffler type solar cooker with a reflector area of 4.5 m^2. In comparison with the standard model which has 8 m^2 this is almost half the surface, but this size was considered to be enough to heat up the planned 50 liter cooking pot.

The area of Asuncion, like most parts of Paraguay and the northern part of Argentina, has quite good solar radiation conditions almost all_the year. The annual average_daily horizontal global radiation is 4.72 kWh/m^2 corresponding to 77 % of the average global radiation on clear days.

2. THE SCHEFFLER SYSTEM

The Scheffler system was invented by the Austrian physicist Wolfgang Scheffler in the late 1980s with the intention to offer a technology mainly to developing countries rich in solar radiation to solve cooking fuel problems of community institutions like schools, hospitals, religious centers, prisons, etc. and which allows cooking in a comfortable and safe way. Besides, the technology should be sufficiently simple, so that it can be transferred to practically any country of the world. The only trained manpower necessary is a welding workshop with basic tools and common materials like steel profiles and glass mirror panes.

In its basic concept the Scheffler solar cooker consists of a fixed-focus parabolic reflector with its typical elliptical shape and a separate cooking place usually placed inside the house, which receives sideways the concentrated sunlight from the reflector. The latter rotates around an axis parallel to the earth-axis to follow the apparent daily movement of the sun. In fact the reflector is a small lateral even section through a complete rotation paraboloid. The seasonal variations of the incidence angle of the sun (declination) are compensated for by a manual change of the reflector's slope. To maintain its focus although fixed, the reflector changes_slightly its parabolic shape through a controlled deformation of its structure.

Until now several hundred Scheffler-reflectors of different sizes varying from 2 to 50 m^2 have been built in many countries of Europe, Africa, Asia and America. Most of them are used for community kitchens. They can also be used to generate steam or high temperature hot air, which have many possible industrial applications.

3. THE SOLAR COOKER OF CLORINDA

The solar cooker for the marmalade factory had to be installed in an already existing row house. Fortunately, its front and back walls have almost an exact east-west orientation, what is a necessary condition for the Scheffler-system. Otherwise important modifications of the infrastructure would have been necessary. The front part of the house is used as a shop to sell the products. The actual factory is located in the back part of the house, what made it necessary to install the solar cooker in the back yard of the house.

This Scheffler-reflector was the first one_made in Paraguay and probably one of the first worldwide of this size (length: 2.85 m, width: 2.10 m), which corresponds to 75 % of the standard size. It has a reflecting area of 4.5 m^2 and an aperture of 2.6 m^2 to 3.9 m^2 according to the season. Practically all the measures of the parts used to build the reflector and its stand were reduced to scale in relation with the standard size. The reflecting surface is made from 200 rectangular glass mirror facets with a thickness of 2 mm. They are fixed to the structure of the reflector simply with wire, which makes it easy to replace mirror elements in case of accidental breaks. The reflector generates a focus area with a diameter of about 40 cm

Fig. 2. Scheffler-reflector and cooking place jutting out of the wall

The reflector was equipped with a semiautomatic tracking system, which consists in a clockwork made mainly of bicycle parts and a weight generating the rotating movement of the reflector, which is slowed down to the right speed (15º per hour) by the clockwork mechanism. In the morning the reflector has to be turned manually in its right position. Through this manipulation the weight is lifted. Then, during the whole day the reflector follows automatically the apparent movement of the sun until the weight reaches the ground and the clockwork stops.

Due to its location in front of a wall facing the midday sun, the reflector had to be installed in an almost lying position close to the ground, which generated a relatively high positioned focus (see Fig. 2). Therefore, the cooking place had to be installed at a much bigger height than normally (1.6 m from the ground), a fact which complicates considerably the manipulation of the cooking pot and its content. To solve this problem we first considered to build a platform inside the kitchen building, so that the cooking place would have been on a normal height of about 80 cm. The ceiling is sufficiently high for that. But finally the decision was taken for another solution consisting in an elevating system for the cooking pot.

As the concentrated sunlight comes obliquely from downwards to the cooking pot, the cooking place had to be designed in such a way that the pot juts out of the wall, so that its bottom gets most of the concentrated sunlight. The remaining part of it is absorbed by the sidewall, which faces the reflector. Therefore the cooking place, consisting in a steel structure covered with galvanized sheet, had to be fixed to the outside of the wall after having made a corresponding opening in it. An electric fan was integrated into the upper part of the cooking place to extract from the kitchen the steam produced during the cooking process.

Fig. 3. Cooking pot inside its cage with mixer put on the cooking place (without insulating panels)

The cooking pot used for the solar cooker has a capacity of 50 liters and is made of stainless steel. To be able to absorb concentrated sunlight the outside of the pot was painted with a high temperature proof mat black painting. Jams have normally to be cooked during several hours to evaporate part of the water contained in the pulp. To prevent burnings, where the pot receives concentrated sunlight, the pulp has to be stirred constantly. As hand stirring would not have been possible due to the unusual high position of the pot, an electric mixer had to be installed, which not only mixes the content but also scrapes off the pulp from the sidewall and the bottom (see Fig. 3). To get a solid whole between the pot and the mixer, a kind of cage was made for the pot, whose cover with the integrated mixer can be separated to take out the pot for cleaning, etc. To reduce heat lost mainly during solar cooking the three sides of the cage, which don't receive concentrated sunlight from the reflector, were equipped with 5 cm thick insulating panels (see Fig. 4).

The pot lift consists in a kind of travel crane with a 2 m long rail fixed to the ceiling (see Fig. 4). The crab running on this rail has to be moved manually with the help of a rod fixed to it obliquely downwards. The movements of elevation and dropping of the pot have also to be done manually, but a counterweight running along the back wall of the kitchen make these manipulations quite easy.

During the periods with lack of solar radiation, a conventional industrial gas cooker_is used, which is placed near the solar cooking place, but at a normal height. The lift makes it possible to get down the pot together with the mixer from the solar cooking place to a table placed below it and next to the gas cooker. A cart of the size of the pot running on rails makes it possible to move the pot easily from the table to the gas cooker and back.

Fig. 4. Cooking pot in cooking position (with insulating panels) **and elevating system**

On February 12th 2004, a few days after installation_of the solar cooker, an estimation its energy efficiency_was realized. The weather conditions were optimal with a practically clear sky and almost no wind. The ambient air had a temperature of 30ºC. Unfortunately, we didn't have any equipment to measure solar radiation, but through visual observation (total lack of clouds and deep blue sky) direct radiation perpendicular to the incidence angle of the sun was estimated in 700 to 800 W/m^2 during the whole period of the experiment. It started at 10:00 a.m. and finished at 12:10 p.m. The cooking pot was filled with 40 liters of water with an initial temperature of 29ºC and then covered with its lid. To obtain a homogenous water temperature during the heating up process the mixer was running continually. Temperature measurements were realized every 20 min. After 2 h 10 min. the water reached 92ºC. Then a cloud covered the sun for some 5 min. So, the experiment was stopped. The resulting energy efficiency defined as the relation between the estimated incident direct radiation on the aperture area of the reflector (3.65 m^2) and the thermal energy assimilated by the water during the period of the experiment was calculated in 52.7 to 46.1 %, depending on the considered direct solar radiation. These are values slightly lower than those obtained by Scheffler with standard size reflectors under similar conditions in earlier years.

4. CONCLUSION

The experiences made in Clorinda during the two years of functioning of the Scheffler solar cooker are quite positive. It has been successfully used to process different kinds of locally grown tropical and subtropical fruits, like mango, papaya, orange, grapefruit, pineapple, banana, etc., to transform them into jams, marmalades and stewed fruits, and also to preserve vegetables like eggplant, sweet pepper, tomato, etc. The solar cooker not only has made possible for "Hecho en Casa" an important fuel economy (LPG) and therefore of money, but also generated the prestige of being the first and still unique factory in the region using solar energy to produce canned fruits and vegetables. The economy of LPG due to the use of solar energy can be estimated to about 70 % in the average of the year. Considering a normal production capacity this corresponds to approximately 200 kg of LPG per year or in terms of money 150 US$ per year (actual LPG price: 0.75 US$ per kg). Comparing with the total investment cost for the Scheffler solar cooker (reflector, cooking place, elevating system, but without cooking pot and electric mixer) of almost 1.000 US$, the investment will be paid back in about 6 ½ years.