

THE SOLAR COOKER DEVELOPMENT AND APPLICATION IN CHINA

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ABSTRACT

This paper presents the development and application of solar in China. The Chinese experiences are shared including successes and barriers.

Keywords: solar cooker, development, application, China

The Chinese Solar Cooker (SCs) industry has been developed and widely promoted for more than 30 years in China. The development of the solar cooker industry covers SCs design methods, material technology, technical standard/specification formulation, manufacturing, dissemination and promotion, and sales services. China has the technology and experience ranging from SC design and manufacturing to utilization and sales services. During this period it has experienced the change from independent research to national cooperation and the systematic study and research, from laboratory experiment to industrial production, and from governmental subsidy to semi-commercialization. Currently, with a total number of more than 700,000 sets of SCs, China has been the No. 1 in promoting SCs in the world. Almost all the SCs are used for the purpose of food processing and water heating in China. This paper will introduce the development and application of SCs in China over the past 30 years.

1. THE RESEARCH AND DESIGN

The first SC in China was created in Shanghai in 1956. In 1983, the SC research was included in the Science and Technology Key Tasks of “the 7th Five-Years” Plan, and was supported greatly by the government, making it under special management, systematic research and planned promotion. The SC technology had been matured since then. After more than 30 years development, SC research and design has made a fruitful result, including design theory, structure design, test method, shell material and technical process, and reflecting material.

1) Design theory

The presentation of The Three Rounds Calculation Graphing Theory (TRCGT) advanced the method of SC's intercept area design, which changes the qualitative analysis to quantitative analysis, and changes the technical graphing to analytic calculation. In the 7th Five-Year Plan, vast studies were implemented for optimization of the SC design. Based on the TRCGT, studies were implemented for the research of light efficiency and light parameters, including reflection rate, light capture rate and absorbance of the SC as the light inceptor; power, and relation of the light, heat efficiency of the SC as the solar-heat exchanger; and formula of the calculation between light efficiency and heat efficiency. Major parameters were analyzed and calculated to optimize the light efficiency of the SC. Parameter range and calculation methods were developed under the varied demands of the customers. The design program was

developed to complete the designing theory of the SC.

2) Structure design

As the users of the product mainly reside in rural areas, SC is designed in ways of easy manufacture and operation, low cost and competitive with traditional energy on the basic foundation. Because of short time cooking and maintenance cost, most SCs adopted manual modification and tracking. Automatic tracking system has not been widely put into practice because of its high cost and difficulty in maintenance.

3) Testing method

In the 7th Five-Year Plan, the testing method of the SC was listed in the National Standardization Program. This industrial standardization, authorized in 1990, has systematically summarized studies and experience over the last 10 years, therefore, improving designs models, specifications, light and thermal efficiency testing method, and regulating the technical requirements, structure testing method and the heating capacity of the SC.

4) Shell material and technique

The shell of the SC can be made by concrete, cast iron, steel, aluminum, glass steel, gypsum, wood, paper pulp, and grass, etc. The technique of the shelling changes from hand making model to mechanical pressing. After the testing production in different areas, several common techniques were developed by the conclusion of the experience and continuous improvement.

Cast iron SC: The cast iron SC was developed based on the traditional technique for the iron boiler, uses pressure casting technique, making the shell only 3mm's thick. This kind of SC adopts the rotating paraboloid characteristic to produce the two parts by one model, and therefore increases the accuracy of the shell for higher focus temperature. The characteristics of this kind of SC are high accuracy of the shell, small distortion, easy

transportation, and long lifetime, which is also the most mature and commercialized SC product in China. The cast iron SC products have been industrialized and welcomed by customers in different areas.

Anti-alkali glass fibre strengthened concrete (GRC) SC: This is a new construction material, which was used for the testing production in China in 1980. The ER13 product made by this technology has the similar anti-alkali capacity compared with international product, which has been widely implemented in the construction industry as a non-bearing material. The shell of the SC uses the sulfur-aluminum-acid salt quick strengthen concrete with quantitative strengthen additive, retarder, two-tier anti-alkali glass fibre grid in between and steel bars in the midst and around. The GRC SC has good intensity and rigidity, and much lighter than the concrete shell, which can meet the demand of the general transportation. The disadvantage of the GRC SC is the less resistance to breakage.

Concrete SC: The concrete has good water resistance, shape maintenance and resistance to the natural erosion. This kind of SC was widely used with the longest history and biggest number, especially for the cheap price, easy shaping, and simple technique. The disadvantage is the heavy weight for the transportation and therefore these need to be produced and sold on the spot.

Glass fiber SC: The glass steel SC is light, easily shaped and simple produced, but easily distorted and aged. Recently, aging resistance was improved by changing the material composition and testing, distortion was under certain control by the modification of the bearing structure, too.

5) Reflecting material

At present time, there are two types of reflection material used for the SC, which are glass mirror and vacuum aluminum film. The early SCs always adopted glass mirror as reflecting material. And nowadays, it is still in use for the thick concrete SC, which has the advantages of good friction resistance, shiny surface, reasonable

price and 4-5 years of life-span. However, it is vulnerable to erosion, peeling off, and costs of time and labor for replacing the shiny surface. The aluminum film, with characteristics of high reflectance and easy replacement, were used for the commercialized SC product recently. Generally speaking, the lifetime of the aluminum film is 2-3 years.

2. PRODUCTION

China has gained advanced SC production experience. Basically there are three types of SC production models in China:

1) Production at demonstration sites

The number of SCs installations increased from 2000 sets in 1979 to 10,000 sets in 1986 in China. During this period, most of the SCs were financially supported by the central government and developed by the guide of the local government on the demonstration sites. In the early stage, the users only needed to pay 10-30 RMB to buy a concrete SC with the price of 40-60 RMB. After 1985, the central government reduced the subsidy for SCs, and commercialized sales replaced them gradually.

2) Industrial production

The industrial production means the SCs were produced by factories with technical capability and equipment capacity, in which the raw materials are mainly cast iron, GRC, glass steel and glazed steel. Mostly, products were sold in many provinces. These factories are mainly distributed in Jiangsu, Hebei, Henan, Gansu and Beijing.

3) Family workshop

Most family workshops are aggregated in Gansu and Hebei Provinces. And the products are mainly the thick concrete SC. In addition, to pinch pennies, waste glass mirrors were always used as reflected material, hence, cost was low. Furthermore, the producers paid much attention to the quality and credit, and sold their products on the spot, which made the SCs welcomed by the local customers. All of the above shows the market potential of the SCs in the rural area.

3. PROMOTION AND APPLICATION

Solar cookers have swiftly gained a vast ground in the areas where there is lack of firewood and other traditional fuel. Because of natural conditions and varied historical reasons, Gansu suffered a lot from the shortage of traditional fuel. For many years, farmers had to grub grass, tree roots and cut woods inordinately to make up the insufficient living energy. Therefore, the local farmers are eager to have SCs, which can take place 15% of the total energy for living purpose. For example, Yongqing, a county of Gansu province disseminated 18,371 sets of SCs within only 3 years and the diffusion rate has reached to 68.73%, on the top of the nation. Tibet takes the second and the next two provinces are Qinghai and Hebei.

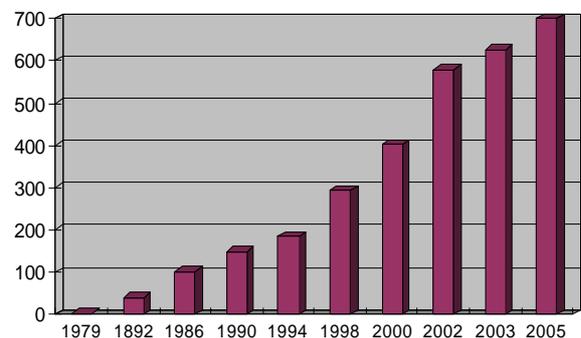


Figure 1 Data of the solar cookers used in past years (unit: 1,000)

1) Application in different areas

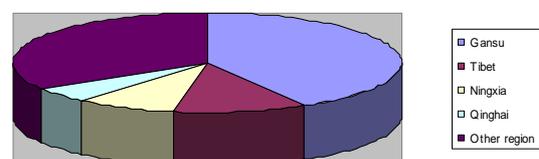


Figure 2 Distribution of solar cooker in China (unit: 1,000)

The widespread distribution of solar cooker in Gansu province is admittedly associated with the good sunshine condition, but more importantly is the strong demand for the solar cooker since the lack of energy source. For decades, farmers had to use sod, grass, roots and firewood as fuel. Solar cookers began to populate in this area since 1980s because it doesn't consume conventional energy. According to the practical usage, SC can substitute 15% of farmer's annual fuel requirement, meaning 50-100 acre of firewood. In Yongjing County with the fastest development of SC, 18,371 SCs were installed in 1980, and the diffusion rate was 68.73%. It has been the highest diffusion rate among counties all around the country.

All of Tibet is short of energy, but some places are even worse. Because of the long distance from the railway and the energy base, transporting coal is very difficult. Solar energy can solve this problem with its abundance and wide spread. Nowadays, cast iron SC is sold mainly in Tibet, around 50,000 a year. With the diffusion rate of 10% it has the most SC among provinces around the country.

Sichuan is another provincactively promoting SCs. Under the national bond program of the Ministry of Agriculture, in 2006 the government finances 3/4 of a SC and the farmer himself pays 1/4 only in Sichuan Province. The price of a SC is around RMB400; the farmer only needs to pay RMB100 to install a SC under this program. There will be 10,000 sets of SCs to be installed in Sichuan Province in 2006.

2) Dissemination of varied kinds of Solar Cooker

There are Heat-box cookers, Box focusing cookers and common focusing cookers used in China.

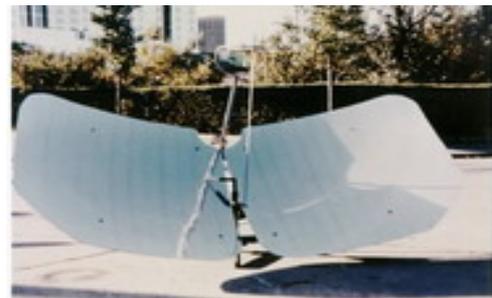
Heat-box cooker is easy in producing, drawing materials and cheap, but its disadvantages of low temperature and limited specific heat capacity make it less developed.



Box focusing cooker has relative delicate design. It is a solar cooker when it was open and is a box when it closed, making transporting and storing convenient. But because of its complicated structure and costly price, it is not widely installed.



The most common type of SC in appliance is a **common focusing cooker**. It has advantages such as simple structure, easy operation, reliable performance, cheap price and more functions.



4. BENEFITS FROM SCS APPLICATION

Chinese people have been gaining benefits from using of SCs from the aspects of economic benefits, social benefits and ecological benefits.

1) Economic benefits

The economic impact of the SC varies a lot for different areas, users, and living customs. Based on the investigation in '90s, the case study of Hebei Xinglong shows that the annual saving of 1,000 SCs is more than 75,000 RMB (each SC saves 750-1000 firewood kg/year, and 100 kg firewood equal to 10 RMB). In Gansu Yongjing, SC saves 824,200 RMB from the annual fuel cost. Investigation shows that each SC saves fire-straw 562.5 kg/year, 15.4% of the cooking energy, and 1 kg equals to 0.8 RMB, saves 45 RMB. In Qinghai Hualong, 18,500 SCs save straw 7,741 ton/year, 620,000 RMB/year. Based on the investigation in some areas, the annual saving of a SC is 600-1000 kg of the firewood. In Tibet, since the normal energy is very expensive, each SC may save 600 RMB/year.

2) Social Benefits

The social effects of the SC are: 1) Labor saving: Using the SC saves the labor for the firewood collection in Gansu, Qinghai, Xinjiang, where the household needs one person for the firewood collection due to the shortage of the energy resource. 2) Coal saving: SC saves the coal consumption and transportation in some areas. 3) Improvement of living level and the health conditions: Due to the energy shortage, people in the poverty regions usually have rice in cold water for lunch, and therefore badly damaging them physically. SC can be used for cooking food, heating water, and preparing food for livestock, and also for bathing, therefore it improves the local health level and sanitation conditions.

3) Ecological Returns

The maladjusted ecological environment is mostly caused by the human activities. Plants grow slowly in arid areas and, when destroyed by humans, this leads to the vicious circle of natural environmental decline. The straw saved by the SC can be used for organic fertilizer for the farms to increase the land saving ability there. For example, thanks to the application of the SCs, Xiaoling county of Yongjing, became the model village of

greening in the region in 1984. The use of the SCs reduced migrations due to the dissatisfaction for the firewood shortages, in Ninxia Zhongwei, and therefore developed the local economy.

5. NEW DEVELOPMENT ON SOLAR COOKER PROMOTION

At present, the Chinese government is formulating the national plan to promote the solar energy in China. SC promotion will be part of the solar energy promotion program to be promoted in poor regions with good solar radiation conditions. In this plan, 100,000 sets of SCs will be installed at 1000 villages; each SC will receive RMB 300 as subsidy and the farmer pays RMB 100 himself. So far, this program is not yet approved and implemented, this is just a plan proposed.

6. CONCLUSIONS

By the end of 2005, around 700,000 sets of SCs have been installed in China. The main type of SC used in China is the solar paraboloid concentrator which is mainly produced locally and distributed locally. SCs have been promoted in China for more than 30 years. The experiences in China are that it is very difficult to promote SCs in the way of commercialization. The promotion of SC in sun-rich and poor areas needs the financial support from government and international financing organizations, NGOs and other institutions.

The financial support from the government is insufficient and very limited. The constraint for promotion of SCs in China is lack of financing for training and capacity building. After the economic transition, the financial support from the government for SC promotion is becoming less and less. But the need for SCs in western areas is still very high. Therefore, China also needs the support from NGOs and other international institutions to promote SCs in western China which has rich sunshine. The promotion of SCs in western China is slowing down and the poor people lack of money to buy a SC.

Meanwhile, SC capacity building is an urgent need in western China.

7. SUGGESTIONS

1). Taking suitable measures according to the local conditions and continue with disseminations

It is necessary to continue with the promotion of the SC as an important method to alleviate energy shortage and ecological environment. Different regions should take different methods in ways of dissemination and sales depending on the local situations. In the low-income areas, it is hard to realize the commercialized sales completely. And in such case, local government should give subsidy to the SC promotion. In the middle-level-income areas, the government should encourage the costumers make purchase of the SCs in varied sales strategies, such as establishing commission sites, payment by installment, and perfecting the after sale service system, etc. Only in this way can make the customers confident. As in high-income area, it is not necessary to develop the SC any more.

2). Investing much more efforts in research and supporting the SCs industry

It is suggested to keep an essential budget and organize an efficient team on the technology research of SC in order to maintain the leading place in this field of the world. The government should support producers of SCs. Since the profit of the SC product is limited and the target customers are low-income farmers, it is necessary

for the government to stimulate the industry by the financing support and tax reduction to lower the cost of SC. It is a good option to set up the local factories for the production and sale of the SCs for the remote areas, and the local government should give technical support in the quality control.

3). Perfecting the technology and insuring the quality

Efforts should be made on the stability of reflecting material to improve its lifetime. And also it is very important to realize the standardization, systematization and the general utilization of the product. Moreover, establishment of a testing center to supervise the quality of SCs is indispensable.

4). Enhancing the grade of products and enriching the varieties

It is essential to assemble SCs with automatic tracking systems for the purpose of advancing the SC technology and enriching the products varieties. It is the high time to accelerate the research of automatic tracking systems with attention on economic and practical use, and to develop the easier carrying and clean box-style SCs.

5). Strengthening co-operation and promoting communication

It is essential to set up cooperation relationships with other developing countries and make technology transfers and business developments on the basis of mutual benefits.