

Development and Application of Solar Cooker in China

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0. Preface

Remarkable progress and significant achievement has been made in Chinese Solar Cooker (SC) industry, especially in designing theory, material technology, technical standard and industrial production, dissemination and sales service after more than 30 years' research and promotion. During this period it has experienced the change from independent research to national cooperation and the systematic study, from laboratory experiment to industrial production, and from governmental support to semi-commercialization. Currently, with a total number of more than 1.4 million sets, China has been the No. 1 in promoting SCs in the world. And the following will give the general review over the past 30 years.

1. Research Progress

The first SC in China was born in Shanghai in 1956. SC began to attract attention as a special technology, only after the workshop held in Shanghai in the year of 1973. After the meeting, SC technology was developed in varied provinces. For example, Heat-box (HB) SC was developed in Anyang, Henan province, and the Light-aggregation Mirror (LAM) SC was developed in Shanghai, Beijing, and Gansu.

In 1983, SC research was covered by the Science and Technology Key Task 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 several years' hard work, the following achievements of SC technology were achieved.

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 was 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 the strike.

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 ponderosity for the transportation and therefore 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

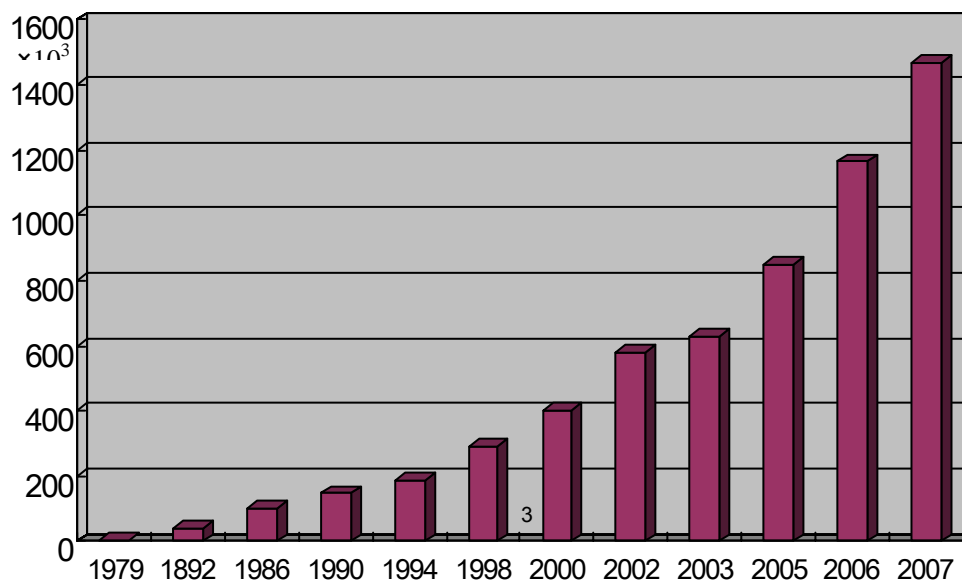
At present time, there are two types of reflection material used for the SC, which are glass mirror and vacuum aluminum film. The early SCs always adopted glass mirror as reflecting material. And nowadays, it is still in use for the thick concrete SC, which has the advantages of good friction resistance, slick surface, reasonable price and 4-5 years of life-span. However, it is vulnerable to erosion, desquamate/metamorphose, and cost time and labor for replacing the stick 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. Development Status

There are mainly three ways of solar cooker production in China.

1) Production on demo-sites

In 1979-1986 the solar cookers are the fastest-growing period, of this number from 2000 to 100,000 (see Figure 1). During this period, Chinese government financed the development of solar cookers. After 1985, the government reduced subsidy for SCs and required commercialization of SC production and sales. Some areas started to develop SC by themselves, for example, with technical support of local rural energy administration departments, many SC manufacturers were established in Lintao County in Gansu and Xiji region in Ningxia. These areas produced nearly 10,000 sets SC annually, and basically realized commercialization of SC production and sales. Recently, Chinese government pays more attention to energy saving and economic development in poor areas, and government is investing large amount of money to



support SC development and promoted about 200,000 sets of SC for using. Obviously the SC development enters a fast development period again.

Figure 1 *Data of the solar cookers used in past years*

2) Industrial production

The industrial production means the SCs were produced by factories with technical capability and equipment basement, 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.

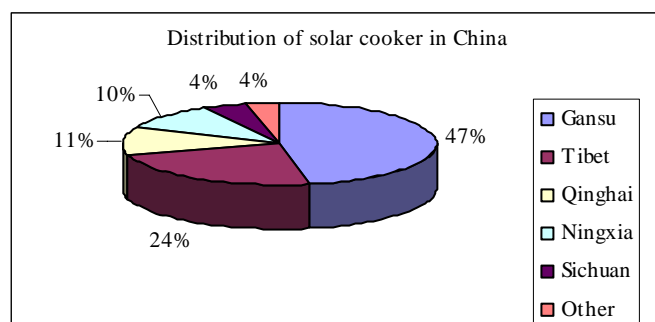
3) Family workshop

Most family workshops aggregated in Gansu, Ningxia and Qinghai provinces. And the products are mainly the thick concrete SC. In addition to their pinch pennies, waste glass mirror 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. Dissemination

1) Dissemination in different areas

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 root and firewood as



fuel. Solar cooker began to populate in this area since 1980s because of its lack of consuming 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 SC were installed in 1980, the diffusion rate was 68.73%. It has been the highest diffusion rate among counties all around the country.

Tibet is short of energy in universal, some places are even worst. 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.

2) Dissemination of varied kinds of Solar Cooker

There are Heat-box cooker, Box focusing cooker and common focusing cooker 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 common focusing cooker. It has advantages such as simple structure, easy operation, reliable performance, cheap price and more functions.



3) The situation of support from the government for promotion of poverty alleviation

In 2006 and 2007, the Ministry of Agriculture has invested 49.7 million RMB for the implementation of “Solar Warmth Project”. The demo station sites included 14 Tibetan counties (out Tibet municipality) in western China including Yushu and Huangnan in Qinghai, Ganzi and Aba in Sichuan, Ganan in Gansu and Diqing in Yunnan. The farmers installed 122,947 solar cookers and solar photovoltaic technology book store was built in 640 off-grid villages. PV book store is the main target of the Tibetan areas in the village without electricity. The program provide for every village with configuration of a solar photovoltaic cells, color television sets, DVD players, satellite TV receivers and CD-ROMs of popular science books, so that farmers can watch the TV, access to knowledge and information.

Due to the reality that SC could only supply 1/3 of cooking energy, the rest 2/3 of cooking energy still relies on straw burning and cattle dung. Since the beginning of 2007, 12120 households started to install high efficient and low emission biomass furnace, which will work together with SC. The high efficient and low emission biomass furnace has more than 3 times higher heat efficiency in comparison with traditional cooking furnace, which will save straw reduce cooking smokes. Through the implementation of the “Solar Warmth Project” it has been an initiative to utilize solar cooker, biomass furnace and photovoltaic technology in the areas of Qinghai, Gansu, Sichuan, Tibetan area in Yunnan and Ningxia. Which has promoted the development of harmonious society in Tibetan areas and it is deeply received by

farmers.

4. Benefit Analysis

1) Income generation

So far few farmers use solar food processing for direct income generation purpose in China. The income generation from solar food processing is mainly indirect cost saving from replacement of fuel utilization, such as coal, natural gas, LPG and firewood. The income generation 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. Few small restaurants use SC to heat water in order to achieve energy saving and labor cost saving, this is also a way for income generation, but it is not widely used by restaurants in China.

In addition, solar drying can be easily found in some western areas in China where people using solar drying oven to dry agriculture products, such as fruits and vegetable, teas, flowers, teas, mushrooms, noodle, fish and shrimps, and so on. Through solar drying the indirect income generation is achieved by saving fuels such as coal and firewood. For examples, farmers use solar drying technology to dry medlar in Ningxia region and farmers use solar drying technology to dry grape in Xinjiang region.



“Solar Drying Box”

2) Social effect

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.

2) Ecological Returns

The maladjusted ecological environment is mostly caused by the human activities. Plants grow slowly in arid area and were destroyed by human, which leads to the vicious circle of nature environment. The straw saved by the SC can be used for the organic fertilizer for the farm 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 neutralized the dissatisfaction for the firewood shortage of the migrations in Ninxia Zhongwei, and therefore developed the local economic.

5. Future Endeavor

1) Taking measures suitable to the local conditions and insisting on disseminations

It is necessary to insist on 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 sits, payment by installment, and perfecting the after sale service system, etc. Only in this way can make the customers confident. As to the high-income area, it is not necessary to develop the SC any more.

2). Investing much more efforts on 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 developed producers of SC. 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 SC for the remote areas, in which 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 life time. And also it is very important to realize the standardization, systematization and the general utilization of the product. Moreover, establishment of testing center to supervise the quality of SCs is indispensable.

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

It is indispensable to assemble with automatic tracing system for the purpose of

advancing the SC technology and enriching the products varieties. It is the high time to accelerate the research of automatic tracing system 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 the cooperation relationship with other developing countries and make technology transfer and business development on the basis of mutual benefits.
