

# Present Status and Internationalization Prospect of China Float Glass Technology

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This paper gives a brief account on the development course of China float glass technology accompanied by a detailed introduction of the current status of China float glass technology, covering the respects of production line scale, product variety, product quality, technology & equipment level, etc., and makes prospects for internationalized development trend of China flat glass industry.

*Keywords: Float glass; Technology; Prospect.*

## Estado actual y tendencias en la internacionalización de la industria del vidrio flotado en China

Este trabajo presenta una breve recopilación de los desarrollos en curso de la tecnología de vidrio flotado en China, acompañada por una introducción detallada de la situación de la industria y tecnología del vidrio plano en este país. Se cubren los aspectos de líneas de producción, variedad de productos, calidad de los productos, tecnología y nivel de equipamiento, etc. y se hacen algunas predicciones sobre las tendencias de desarrollo e internacionalización de la industria china de vidrio plano.

*Palabras clave: vidrio flotado; tecnología; prospectiva.*

## 1. DEVELOPMENT OF CHINA FLOAT GLASS TECHNOLOGY

### 1.1. Developing independently to have realized a stride across "from nothing to something"

The Chinese scientific and technical workers began to explore and research float glass process in the early 1960s, who first carried out the research in laboratory and then completed the work from 1963 to 1967; in December 1967, pilot test line was built in Zhuzhou; during 1970 and 1971, continuous semi-industrial test was carried out in Zhuzhou; in 1971, the first industrialized test line for float glass production was established in Luoyang. On April 27 in 1981, this technology passed the state-level technical expertise and was nominated as "China Luoyang Float Process", which enabled China to become the sole country to have invented her own float process technology without purchasing the license for the patent technology from Pilkington, UK. Since then, China float process has been among the three float process technologies worldwide acknowledged, namely Pilkington float process, PPG float process and China float process.

### 1.2. Upgrading "Vertical Drawing" process to have realized a stride across "from old to new"

In 1985, backward vertical drawing flat glass production process was attempted to be upgraded by advanced float glass technology in China. In 1986, it was successful to convert the vertical drawing line with nine machines in Luoyang Glass Factory into a line adopting the float process. During the

upgrading, it made full use of original batch plant, furnace, melting process facility, utilities and the workshop building of the existing production line, which greatly reduced the cost, shortened construction period and created a precedent for converting vertical drawing process into float process at home and abroad. Thereafter, about 20 production lines with vertical drawing process were converted into the float glass production lines early or late in China.

### 1.3. Developing large tonnage float glass production line to have realized a stride across "from small to large"

China float glass technology experienced the development course from small to large, as far as the melting capacity of a unit float furnace is concerned, it saw different stages of initial 90t/d, and then 250d/t, 400t/d, 500t/d, 600t/d and 700t/d. By 2006, the maximum capacity reached 900t/d with glass ribbon width up to 5200mm, which demonstrated that China became one of a few countries in the world able to build super tonnage float glass production line.

### 1.4. Tackling key problem and making innovation to have realized a stride across "from lower to higher"

The progress and growth of China float glass technology

has resulted from arduous efforts and hard work of the great number of scientific and technical workers engaged in the glass field, and from the close cooperation among factories, design and research institutes, colleges and universities, with the forceful support and guidance from the state. At present, China float glass technology can be adopted to manufacture not only automobile glass, mirror glass, but also 0.55~1.1mm super-thin glass, 25mm super-thick glass, on-line low-E glass and on-line self-cleaning glass.

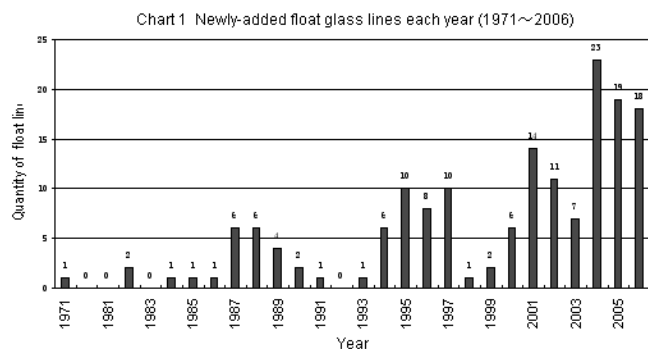
## 2. LEVEL OF CHINA FLOAT GLASS TECHNOLOGY

### 2.1. Float glass technology becoming major technology for flat glass production in China

By the end of 2006, there were totally 161 float glass production lines in China, of which 135 adopted China float glass technology completely or mainly, accounting for 84% of the total. In 2006, total output of flat glass reached 455 million weight cases approximately, of which float glass was about 85%. Total melting capacity of the float glass production lines all over the country has reached above 71000t/d. The output of flat glass and quantity of float lines, quantity of newly added float lines every year and the total melting capacity of float glass production lines in China are shown in Table 1, Chart 1 and Chart 2 as follows:

TABLE 1. FLAT GLASS OUTPUT AND FLOAT LINE QUANTITY IN CHINA FOR RECENT 5 YEARS.

| Year                               | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|------------------------------------|------|------|------|------|------|------|------|
| Output (100 million weight case)   | 1.82 | 2.04 | 2.28 | 2.52 | 3    | 3.87 | 4.55 |
| Annual growth rate of output (%)   |      | 12.1 | 11.8 | 10.5 | 19.0 | 29.0 | 17.6 |
| Quantity of float line             | 69   | 83   | 94   | 101  | 124  | 143  | 161  |
| Annual growth rate of quantity (%) |      | 20.3 | 13.3 | 7.4  | 22.8 | 15.3 | 12.6 |



### 2.2. Level of China float glass process technology and equipment

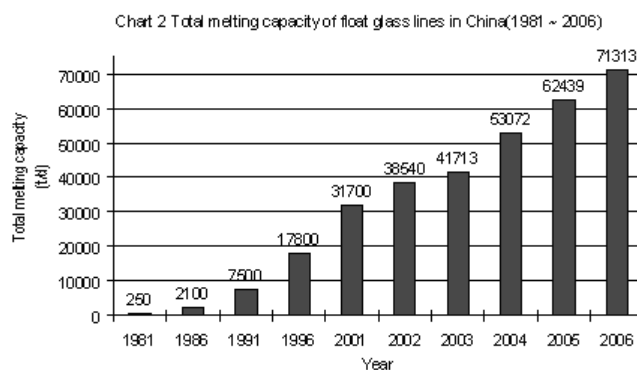
#### 2.2.1. Scale

Melting capacity of unit furnace adopting China float glass

technology has reached 900t/d with glass ribbon width of 5200mm. Now, melting capacity of 1000t/d is under design. In 2001, the quantity of float glass production lines with a capacity of 500t/d and above was only 34%, but up to 2006, it rose to approximately 66%

#### 2.2.2. Variety of products

The thickness of glass products commercially produced by adopting China float technology is 0.55mm~25mm. Super-thick glass of 25mm keeps pace with the present world level. The quality of 0.55mm~1.1mm super-thin glass satisfies the standard of electronic glass substrate; and glass color covers clear and different body tinted glass of blue, green, grey, brown, pink, etc. Function of glass includes transmitted, transparent glass, various modified glass through on-line fabrication, such as heat absorbing glass, reflective glass, one-way perspective, Low-E and self-cleaning glass, etc. Float glass is widely applied to architecture, automobile, mirror, electronic information, etc.



#### 2.2.3. Main technical indexes

**Melting rate:** The melting rate of float glass furnaces adopting China float glass technology can maintain above 2.0t/m<sup>2</sup>·d and preferably can reach 2.4~2.5 t/m<sup>2</sup>·d.

**Energy consumption:** Energy consumption for most of the float glass furnaces adopting China float glass technology can reach 7500~6500kJ/kg molten glass (i.e. 1800~1550kcal/kg molten glass), the minimum heat consumption is 5860kJ/kg molten glass (1400kcal/kg molten glass), up to the international advanced level.

**Furnace campaign (cold repair cycle):** Before 2000, the designed cold repair cycle of most float lines in our country was 5~6 year. In recent years, the designed life of the furnace adopting the China float glass technology has been enhanced to above 8~10 years, and as for actual running, the maximum furnace life is already more than 10 years for some furnaces.

**Tin permeation:** It mainly indicates tin permeation on glass bottom surface. At present, the surface tin permeation of float glass in China is 28~31μg/cm<sup>2</sup>, which satisfies the requirement of no tempering colors during the further fabrication.

#### 2.2.4. Float technology and equipment

In recent years, the technology and equipment level of production line with China float glass technology has been increased continuously, which narrows the gap with the

international advanced level greatly. Aiming at improving product quality, decreasing energy consumption and improving mechanization and automation of the whole production line, a series of technology, equipment and materials have been researched and developed in various sections of batch preparation, melting, forming, annealing and cold end. Total equipment level of mechanization and automation of domestic float glass production lines almost reaches or approaches international advanced level.

**Complete set of technology and equipment for batch preparation:** Integral technology and equipment for raw material delivery, storage, weighing, mixing, control and quality monitoring has reached international level. Static precision of independently-developed electronic scale system is over 1/2000 while its dynamic precision is more than 1/1000. Now, batch preparation technology and equipment has been sold to Taiwan, and AGC 700t/d float glass production line in Suzhou also adopted domestically complete set of technology and equipment for batch preparation

**Furnace and melting technology:** China float glass technology has brought about new type of energy saving glass furnace with its own characteristics. For melting, the technologies adopted for the combustion system and burner suitable to the property of heavy oil available in China, reduction sulfur refining technology, glass furnace boosting technology, bubbler technology, oxy-fuel technology (i.e. 0# port oxy-fuel melting technology) and oxygen enrich-combustion technology and so on, have not only raised the thermal efficiency of flat glass furnace, but also improved the homogenization of molten glass and perfected molten glass quality. Melting quality and consumption index have reached or approached international level. Some production lines with imported technology have adopted China float glass furnace in cold repair.

**Tin bath and forming technology:** Domestic production of the bottom block and combined roof cover of tin bath etc. have been realized and the product can meet the requirement of high quality and long working life; the construction of tin bath is more reasonable with better sealing and the pressure in the bath can generally reach 20~40Pa, thus ensuring basically that no tempering iridescence will occur during the course of further process; application of fully automatic top rollers has improved the glass forming quality and production stability; and application of homemade linear electric motor and skimming device has improved the forming environment and reduced glass defects.

**Annealing Lehr:** Domestically-made annealing Lehr suitable for big tonnage, wide glass sheet and multi-thick varieties has been applied and promoted.

**Cold end equipment:** Domestic production of main equipment in cold end has been reached basically, cutting precision of new type cross cutter has been improved greatly, with its long size error reduced from original  $\pm 1.5\text{mm}$  to  $\pm 0.5\text{mm}$ , and diagonal error from 3mm to 1mm.

**Float production line controlling level:** DCS system or PLC system have been popularly used for control of the production lines adopting China float glass technology; the specific software package developed by ourselves are adopted for controlling strategy of the control system and the controlling arithmetic method. In a word, the overall equipment level of domestic float glass production line in terms of mechanization and automation has basically reached or is close to the international advanced level.

**Investment level of float glass production line:** Domestic production of core equipment and key materials has been realized, which decreases greatly the investment of production line adopting China float glass technology and strongly drives the further popularization and development of China float glass technology, and consequently makes it more competitive in the international market. On the premise of the same scale and same quality requirement, the total cost for constructing a float line adopting China float glass technology will be 50% plus lower than that using foreign company's technology.

In recent years, the fact that some large glass groups at home and abroad have constructed their plants in China by adopting China float glass technology demonstrates that comprehensive competitive power of China float glass technology has become stronger and stronger. Taiwan Glass Group originally only adopted Pilkington float glass technology, however, a 350t/d float glass production line in operation in October 2004 by TG Donghai Glass Co., Ltd. was initially built up by adopting China float glass technology and its main line was domestically general contracted with its product quality indexes all up to those of TG Qingdao Glass Co., Ltd. At present, 2 float glass lines with a capacity of 900t/d under construction in China by Taiwan Glass Group also adopts China float glass technology. China Southern Glass Group is one of the earliest listed companies in the Chinese mainland, one of the enterprises in China with the largest scale and complete industrial chain in glass manufacturing and fabricating aspect and also one of the biggest high quality float glass manufacturers in China. When the Group constructed the first float glass line, the technology and equipment was all imported, but for the second, third and fourth line, only key technology and equipment was introduced, for the fifth line with a capacity of 550t/d and the sixth line of 700t/d, China float glass technology and equipment is adopted, i.e. furnace, tin bath and annealing Lehr are all with China float glass technology and general contracted by the domestic company.

### 2.3. Product quality standard and reachable quality level

In 1980s, the Chinese government established float glass quality standard: GB11614-1989, the super-grade product specified in the standard can meet the productive needs of automobile glass, mirror glass and other fabricated glass at home and was exported partially. In 1999, the float glass national standard GB11614-1999 was revised to further raise the quality standard of product and made it equal to the international level. The national standard is the lowest quality target for the float glass industry to follow, more and more enterprises take as the reference the actual product quality in Sino-foreign joint ventures with foreign advanced float technology and take it as the final object to satisfy the market demands on high quality glass products.

At present, the product quality of part domestic float glass production lines with China float glass technology is as follows and please see Table 2-4.

### 2.4. Centralization of float glass production

In recent years, the Chinese float glass production has become more and more centralized, which promotes the optimization and upgrading of the flat glass industry structure, brings the whole industry level to a new high and forms the

TABLE II. INSPECTION DATA OF FLOAT GLASS PRODUCT QUALITY OF LINE A (MELTING CAPACITY: 600T/D, CLEAR GLASS).

| Variety (mm)                               | 3         | 5         | 10        | 15          |
|--|-----------|-----------|-----------|-------------|
| Thickness (mm)                             | 2.87~2.92 | 4.85~4.88 | 9.82~9.98 | 14.78~15.06 |
| Difference of thickness (mm)               | 0.05      | 0.03      | 0.16      | 0.23        |
| Optical distortion (°)                     | 62        | 68        | 63        | 63          |
| Bubble (pc/10m <sup>2</sup> )<br>0.1~1.5mm | 1.47      | 2.92      | 1.0       | 2.2         |

TABLE III. CONTINUOUS ON-LINE INSPECTION DATA OF POINT DEFECT OF LINE B (MELTING CAPACITY: 600T/D, CLEAR GLASS).

| Time | Thickness (mm) | Point Defect          |       |        |      |      |      |      |      |
|------|----------------|-----------------------|-------|--------|------|------|------|------|------|
|      |                | Total                 | Stone | Bubble | Knot | Tin  | Drip | Ream | Etc. |
|      |                | pcs./10m <sup>2</sup> |       |        |      |      |      |      |      |
| 1    | 5.0            | 9.99                  | 1.13  | 1.29   | 0.48 | 0.01 | 0.02 | 0.01 | 7.04 |
| 2    | 5.0/6.0☆       | 2.27                  | 0.81  | 0.63   | 0.45 | 0.01 | 0.02 | 0.00 | 0.36 |
| 3    | 6.0            | 3.92                  | 0.73  | 0.79   | 0.38 | 0.03 | 0.09 | 0.05 | 1.85 |
| 4    | 6.0/7.2☆       | 5.64                  | 0.92  | 1.13   | 0.44 | 0.01 | 0.02 | 0.00 | 3.13 |
| 5    | 7.2            | 3.72                  | 0.64  | 0.86   | 0.21 | 0.10 | 0.23 | 0.20 | 1.48 |
| 6    | 7.2            | 4.29                  | 0.44  | 1.22   | 0.06 | 0.01 | 0.19 | 0.06 | 2.29 |
| 7    | 7.2            | 2.15                  | 0.39  | 0.78   | 0.06 | 0.04 | 0.16 | 0.11 | 0.60 |
| 8    | 7.2            | 2.82                  | 0.39  | 1.03   | 0.06 | 0.00 | 0.04 | 0.01 | 1.29 |
| 9    | 7.2/5.0☆       | 2.44                  | 0.58  | 0.89   | 0.10 | 0.02 | 0.79 | 0.22 | 1.25 |

Notes:

1. Average inspection data in 9 successive days.

2. ☆ means thickness change on that day.

TABLE IV. INSPECTION DATA OF 1.1MM THICK FLOAT GLASS QUALITY OF LINE C (CLEAR GLASS)

| Item                        | True value       |
|-----------------------------|------------------|
| Optical distortion          | 60~64°           |
| Bubble (pc/m <sup>2</sup> ) | ≥0.3mm Not found |
| Impurity                    | ≥0.3mm Not found |
| Density of point defect     | Not found        |
| Line                        | Not found        |
| Scratch                     | Not found        |
| Face crack                  | Not found        |
| Section defect              | Not found        |
| Thickness difference        | 0.04 mm          |
| Visible transmission ratio  | 91%              |
| Micro-wave                  | 0.07~0.1μm       |

situation of “from large to strong” in flat glass industry. By the end of 2006, the output of 12 large enterprises with their annual output more than 10 million weight cases (500,000 tons) accounts for nearly 50% of the total flat glass quantity.

### 3. INTERNATIONALIZATION OF CHINA FLAT GLASS INDUSTRY

Internationalization of China flat glass industry means both “Go out” (exporting technology & talents, building up plants abroad, transnational operation) and “Invite in” (introducing capital, technology and talents).

#### 3.1. Export of China float glass production technology and equipment.

At the end of 1980s, the first float glass production line with

a capacity of 300t/d built up in Indonesia by adopting complete set of China float glass technology and equipment took the lead in exporting the technology and equipment. Following this, China exported successively complete set of technology and equipment to Indonesia, India, Iran, Bangladesh, Vietnam, North Korean, etc., with 9 float glass lines already in operation and 6 lines under construction, among which the maximum capacity is 900t/d. The construction of these float glass lines is based on international project general contracting mode

and has achieved success, which promotes China float glass technology further to the world.

Overseas float glass production lines completed on the basis of general contracting in recent years are shown as Table 5 below.

TABLE V. FLOAT GLASS PRODUCTION LINES WITH COMPLETE SET OF TECHNOLOGY AND EQUIPMENT EXPORTED

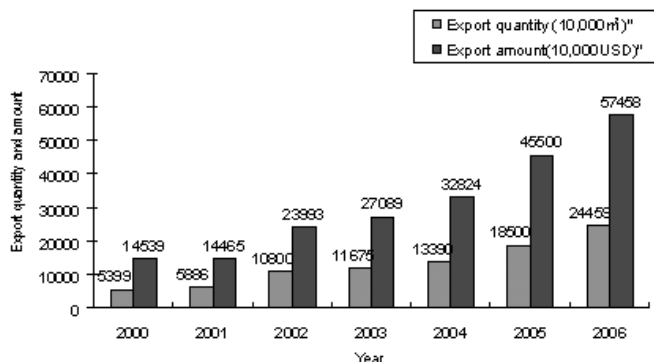
| No. | Item                              | Scale (t/d) | Time of operation |
|-----|-----------------------------------|-------------|-------------------|
| 1   | Indonesia ARB float glass line    | 300         | 1991.1            |
| 2   | Vietnam VIFG float glass line     | 350         | 2002.10           |
| 3   | Iran AZAR float glass line        | 300         | 2004.10           |
| 4   | Bangladesh PHP float glass line   | 150         | 2005.6            |
| 5   | Bangladesh float glass line       | 300         | 2005.9            |
| 6   | North Korea Daan float glass line | 300         | 2005.10           |
| 7   | India float glass line            | 250         | 1996              |
| 8   | Indonesia TS-3 float glass line   | 500         | 1996.9            |
| 9   | Indonesia TG-2 float glass line   | 900         | 2007.2            |

#### 3.2. Export of China float glass product

At present, China flat glass product has stronger competitive power in the market of developing countries and international medium level product and has maintained vigorous export trend in recent years. Please refer to Chart 3 below for 2000-2006 export of China float glass.

Chart 3 2000~2006 China float glass export.





### 3.3. Entry of foreign float glass technology and equipment manufacture.

To date, 14 float glass production lines have been constructed and put into operation in China by Pilkington, UK; Saint Gobain, France; Asahi and Nippon Sheet Glass, Japan; etc.. In addition, 10 plus float glass production lines have been built up in China by American PPG, French Saint, etc, in the mode of selling float glass technology.

The competition of the three major world float glass technologies in the Chinese market represents the fact that the competition setup of "Internationalization of domestic market and domesticalization of international competition" has already formed.

Furthermore, some world famous companies related to float glass machinery and refractory also come to China one after another to construct plants or set up joint ventures so as to satisfy market demand at home and abroad, such as Italian Bottero, German Grenzebach, etc.

### 3.4. Prospects of China flat glass industry's internationalization.

At present, the export of complete set of float glass technology and equipment appears in favorable momentum, together with a good tendency of export concerning technology related to horizontal drawing and rolled glass as well as technology and equipment related to glass fabrication. However it has only just begun for the Chinese flat glass enterprises to construct float glass line directly abroad.

It is a general trend of development to "Go out" for setting up plant abroad and having transnational operation if the Chinese flat glass enterprises want to be internationalized.

Presently, China has become a world flat glass manufacture base and productivity is somewhat surplus corresponding to domestic demand. Meanwhile, with the development of these years, some enterprises in flat glass industry have developed into stronger ones through integration. With the progress of economic globalization, the boundary of domestic and international market is gradually turning vague and all enterprises face a common market at home and abroad. Therefore, it is a general trend of development for flat glass enterprises to allocate capital, production and market resources worldwide by opening up international market and carrying out the strategy of "Go out" and also it is a necessity for them to survive and further develop. Since complete set of China float glass technology and equipment entered the world market many years ago, it is the right time with mature condition for the Chinese enterprises to set up float glass plants abroad.

China float glass technology with independent intellectual property rights has advanced the development of the Chinese flat glass industry and is also making contributions to the development of the world flat glass industry. For the future, the Chinese flat glass industry shall focus on resource/energy conservation and environment protection, aim at increasing the utilization rate of resources, reducing pollutant discharge and maintaining the sustainable development. At present, the Chinese government has put forth related policies and very soon some related documents such as "Access Conditions for Flat Glass Industry" and "Guidelines on Flat Glass Industry Development during the Eleventh-five Plan", etc. shall be issued, which shall further the improvement and development of China float glass technology and enable the industry into the stage of quantity control, structure optimization and stable development both for quality and efficiency.

## REFERENCES

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