Lehr improvements for solar glass manufacture

Thorsten Seidel describes the successful installation of two solar glass manufacturing lines in Germany, featuring Pennekamp annealing lehrs.

Two solar glass manufacturing lines have been operated at Glas Manufaktur Brandenburg, a branch of Inter Float, for more than a year. Liechtenstein-based Inter Float had decided to move into glass manufacture and acquired the premises of an existing CRT glass plant in Eastern Germany, near the Polish border, close to several German solar panel manufacturers. The basic idea was conceived at the conference table and executed within a year.

A 320 tonnes/day melting capacity was created, requiring the installation of two production lines for high quality solar glass and respective processing operations. Pennekamp was selected to supply two roller annealing lehrs, employing the company's latest technology for flat glass annealing. Pennekamp is an established manufacturer of annealing lehrs for various sectors of the international glass industry. Over 60 years of experience in the annealing process for glass containers, tableware, display, patterned and solar glasses form the basis for the creation of the company's technological innovations.

For this particular contract, most innovations were linked directly to the high glass quality demands of GMB and its requirement for extremely low energy usage. It was agreed for this environmentally-friendly installation that when manufacturing products to generate renewable energies, the process should be executed with the lowest possible energy consumption!

The two identical lines were designed to produce a 2400mm wide glass ribbon, each at a rate of 160 tonnes/day. Glass thickness for solar glass applications is in the range of 2.3mm to 3.2mm but both lines were designed to work at thicknesses down to 1.7mm and up to 8mm, allowing for possible changing demands in the future.

FLEXIBLE DESIGN

The lehr design follows conventional Pennekamp modular standards, each at zone lengths of 2250mm. Their flexible design will accommodate future changes in the client's requirements, featuring zones with eight standardised side slots, four on each side, two below and two above the roller positions. This arrangement accommodates the heaters, indirect, semi indirect and direct coolers.

According to the position and individual requirement of each zone, these slots were to be equipped with heaters and/or the above-mentioned coolers, as well as 'empty' dummy positions. This design does not restrict the purpose of each zone (heat, heat-cool or cool), by maintaining good flexibility due to the simple replacement of 'inserts'.

All internal structures, as well as the outside linings of the first tunnel zones were manufactured from heat-resistant stainless steels. The secondary walls (side panels) are made from polished stainless steel for practical and visual reasons. These side panels are important in the avoidance of interferences caused by draughts within the factory and other air movements. In the past, such air movements influenced the set annealing temperature curves. In addition, this Pennekamp design allowed the heater connector points to be hidden, as well as the individual sets of cooling blowers and accessories. All cabling was also hidden and installed at floor level, not at the top as usual. Keeping the cables away from heat and maintaining easy access is always a good move.

Basically, the lehr was designed with six heating control loops across the width of the glass ribbon, whereas the two central loops are combined in a single assembly. These heaters are equipped with different heating capacities, according to the needs of the zone and individual temperature curve settings. Furthermore, the heaters are installed from the top and from below the ceramic rollers to provide a balance of heat to the glass and therefore, to control flatness.

In addition, the heaters are equipped with electronically movable edge heating in the first zones, compensating for ribbon temperature inhomogeneities at the sides (edges). In traditional lehrs, these heaters are installed within a separate frame and are repositioned manually, according to ribbon width.

The respective indirect and semi-indirect cooling systems in the annealing zones were designed with four individual control loops over the width of the glass ribbon. Each loop is equipped with its own inverter-controlled fan assembly.

Fast cooling remained with the aforementioned four control loops and the inverter-driven fan assemblies. The main differences to cooling in the annealing area are the cooling air quantities required in the fast cooling process. With lower temperature differences from glass to cooling air, higher volumes are required for effective cooling. However, the maximum glass temperature required had to be controlled prior to cutting in the range of 50°C to 70°C.

MINIMAL SURFACE DEFECTS

Because the intention was to produce high quality solar glass, surface conditions were particularly important to the glass producer's customers, the solar panel makers. Scratched and defective surfaces were to be minimised wherever possible.

Looking at previous classic drive mechanisms, several technological disadvantages were evident, including:

- The fixed driving speeds of all rollers, even under the known circumstance that the glass ribbon shrinks during annealing and cooling processes.
- The main shaft design, with problems associated with its length.
- The open gear/sprocket assemblies and their 'open' oil pans.

In addition, traditional lehrs used stainless steel rollers with significantly higher thermal expansion than ceramic materials. This worsened the effect of slippage on the rollers, resulting in movement of the glass on the roller and the likely creation of surface scratching.

Therefore, for glass transport, Pennekamp selected ceramic rollers in combination with individual drives (one drive per roller). This design compensated for thermal shrinkage of the glass ribbon during the annealing and fast cooling processes. By pre-calculating the thermal shrinkage of the glass, roller speeds were set up accordingly, thereby >

D zone with air extraction system.

avoiding glass/roller slippage. The individual roller drives (motor/gear unit assemblies) are enclosed, filled with oil for life, maintenance-free and synchronised electronically by the master/slave arrangement, maintaining the 'speed offset' feature. Electronically, they are equipped with a full backup system (backup inverters), which are arranged in roller groups. In the unlikely event of a mechanical stoppage or damage, they are simply lowered from the glass contact position and are easily replaced.

The ceramic rollers provide several key advantages, including their considerable mechanical hardness, almost zero thermal expansion at the operational temperature range, smooth surfaces with good properties towards glass and the fact that they exhibit no distortion or damage when stopped under thermal load.

Furthermore, the ceramic material has low thermal conductivity (low heat emission through the shaft), rated at 15 times lower than stainless steel, thereby assisting in minimising energy use.

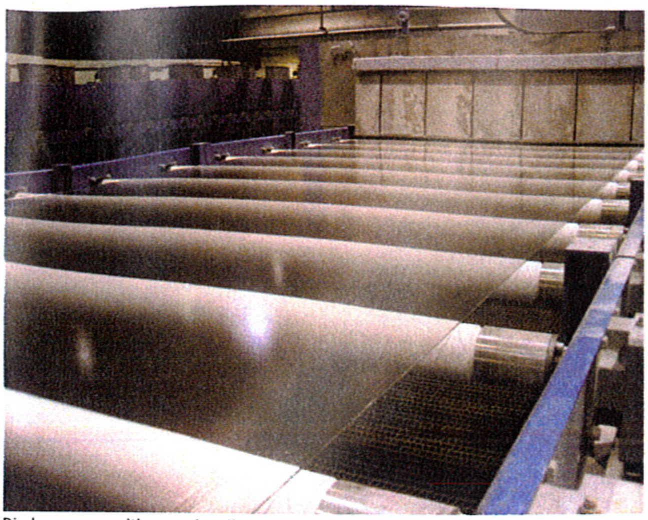
REDUCED ENERGY USE

After initial start-up and continuous operation of the solar glass lines, energy consumption for heating was brought down to almost zero. The only electrical usage was for the rollers driving and cooling the glass itself. These levels are approximately 50% of traditional lines because of the decentralised and more economic cooling fan arrangement employed. In addition, this system provides enhanced production safety. The task of minimal energy consumption as stated above was achieved.

Roller support was another issue that required modernisation and improvement. Instead of separate steel structures and foundations to support the rollers, the precisely machined support rails are mounted directly on the lehr structure, allowing easy and repeatable alignment of the rollers, zone by zone. However, each roller may be lowered individually for cleaning and replacement if required.

Cleanliness of the internal atmosphere is another critical factor for the high quality manufacture of solar glass. Therefore, Pennekamp designed the lehr to be operated with controlled overpressure, while all cooling air intakes are filtered. Special attention was paid to the seams of inner structural stainless steel materials by the use of sealants, as well as the openings at rollers and thermocouples.

In terms of temperature control, Pennekamp closely monitored the requirements of the solar glass process to find an optimised solution. One major factor was the effect of changes in the annealing curve due to draught changes within the building itself. Another issue required by operators was the repeatability of process temperatures and conditions, as well as heat/cool flexibility over the entire length of the tunnel (annealing zones).



Discharge area with ceramic rollers.

Therefore, Pennekamp introduced a combination of infrared scanning temperature measurement, alongside various thermocouples across ribbon width. These thermocouples are installed above and below the glass ribbon where needed. The combination of these two temperature measurement principles demonstrated the improved repeatability and control of the annealing curve.

The avoidance of external influences (factory draught) was achieved by the consequent minimisation of bottom, side wall and roof lining leakages on the annealing lehr itself, as well as structured internal pressure control. In traditional lehrs, such 'air in' leakages can only be alleviated by excessive loads of unnecessary electrical heating. The slightly pressurised lehr chamber assisted in the achievement of this goal.

CULLET REMOVAL

The traditional method of cullet and debris removal is by the use of steel hooks and operators opening the side doors to gain access. While opening the side doors in the tunnel zones, cold air will be introduced, thereby disturbing the annealing temperature curve. In addition, there is always the risk of the operator damaging a roller with the steel hook. Innovative technologies were required to improve the system.

Pennekamp's solution was to develop an automatic cullet removal system, based on the use of a stainless steel cullet conveyor throughout the entire lehr. This cullet conveyor operates during start up and glass design changes at higher speeds and idles during normal production. The conveyor serves not only for cullet removal but also for the protection of the heater and cooler banks installed below the rollers. Any cullet or debris will be removed automatically towards a specific cullet chute at the lehr end. This interfacing and positioning of the cullet chute position needs clarification with the solar glass manufacturer.

The abovementioned improvements are just a few of the developments introduced to Pennekamp solar glass lehrs, as the industry enters the next era of high quality solar glass manufacture. ■

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