Large windscreen bending approach

The bus and special vehicle windscreen business is quite different from the general automotive glass business. The production technology, marketing and logistics involved require an entirely different approach. This article discusses what is involved and looks at how technological developments could drive the process forward in the future.

The LTFBA prior to loading

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Bus windscreens produced are usually sold to local bus manufacturers. The division into OEM and ARG markets is less clear than with glass for cars. The quantities of glass produced are relatively low and there is demand for a wide range of different glass shapes. The windscreen manufacturers are often small units which operate locally. Small orders for large sizes of windscreens in complex shapes are difficult to pack in an economical way and can restrict long transport distances.

The production of bus windscreens is, therefore, divided between smaller and medium-sized production units. However, the average size of a windscreen is increasing and the shapes now required are becoming more difficult to bend. This trend means that substantial resources for the development of proper processing tech-

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nology are becoming necessary, particularly for bending. A certain level of expertise and state-of-the-art production equipment will be needed to achieve realistic production levels.

PROCESS BASICS

In many countries the bus windscreen is still divided into left and right sections. In some models, the windscreen has been divided in two parts horizontally, where the upper screen has more of an incline than the lower screen. In Europe, however, large "monoblocks" are more common, especially for well-equipped charter and long-distance buses. A large monoblock windscreen has more aesthetic appeal and provides better visibility, since there is no central frame. However, this type of windscreen is considerably more expensive to replace. Due to the lower speed that buses travel at, aerodynamics is not a critical factor and the glass is installed in a vertical position. The folds may be bent up to almost 90° to provide a better view.

Due to the fact that most of the large screens are fitted manually and fixed in place with rubber rings, the shape and sag tolerances are generally not very tight. Problems may only arise with larger pieces and spherically bent glasses with deep sagging.

The basic windscreen manufacturing process is the same for bus as for car windscreens. They both go through the same processes of shaping, cutting, grinding, washing, printing, bending, de-airing, autoclaving and quality control. Although there are many stages involved, the most important is the bending process, which enables the manufacturer to achieve high optical quality and an accurate shape. Without perfect bending, the whole process fails. A slightly curved, small half piece is relatively easy to process using traditional laminating and bending equipment, but large monoblocks require more sophisticated production techniques.

TRADITIONAL TECHNIQUES

Bus windscreens have traditionally been bent in slow single chamber furnaces. To create additional capacity, manufacturers have simply added more bending units to the factory floor.

An individual manual furnace is a single- or double-chamber furnace with a closed wagon or

Working in the furnace chamber

chamber. It is suitable for short production runs, it offers good shape control and tooling costs are low. There are, however, some disadvantages: repetition is poor; yield depends on the production mix; it is a labour-intensive operation; considerable floor space is needed to house several furnaces at once.

Due to strict quality requirements for optics, most of the furnaces for bus windscreen bending are electrically heated. The bending of the windscreens is based on gravity and this offers a number of benefits:

- excellent optical quality and shape accuracy can be achieved;
- it is flexible and can be used for long series as well as short series in mixed production;
- the tooling cost is low in mixed production;
- the overall investment and operation cost is low.

THE LTFBA FURNACE RANGE

Type	Capacity (pieces /8-hr shift)	Chamber (mm)	Wagons (pieces)	Power (kW)	Overall size (mm)
140/270 - 8	32-48		8	311	10,280 x 4,000 x 2,900
140/270 - 6	24-36	1,660 x 2,860 x 600	6	263	8,340 x 4,000 x 2,900
140/270 - 4	16-24		4	215	6,400 x 4,000 x 2,900
180/290 - 8	31-47		8	418	12,280 x 4,200 x 2,900
180/290 - 6	23-35	2,060 x 3,060 x 600	6	350	9,940 x 4,200 x 2,900
180/290 - 4	15-23		4	283	7,600 x 4,200 x 2,900
210/330-10	40-56		10	745	16,435 x 4,600 x 2,900
210/330 - 8	30-46		8	550	13,780 x 4,600 x 2,900
210/330 - 6	22-34	2,360 x 3,460 x 600	6	462	11,140 x 4,600 x 2,900
210/330 - 4	14-22		4	374	8,500 x 4,600 x 2,900

(figures based on 4+3 mm thickness, average size and shape windscreens)

THE GLASSROBOTS LTFBA

Glassrobots developed a serial bending furnace for large bus windscreens in the late 1980s. The first fully-automatic version was introduced in 1993. With 30 units sold so far, the company has strengthened its position as the leading supplier of serial bending furnaces for large bus and special vehicle windscreens. The reason for this success is simply that the furnaces have so many excellent features and are very user-friendly.

The *LTFBA* furnace combines the benefits of a versatile single chamber furnace with the performance and capacity of a serial bending furnace. The glass is heated up and cooled down in consecutive sections. As greater capacity is needed, more sections can be added. The bending is always completed in a closed, perfectly controlled section. A modular design allows the customer to choose precisely the required capacity and this can be extended even after the initial installation.

The LTFBA furnace is a double-level tunnel furnace, with a pre-heating track above and a cooling track below. Once the glass is loaded, the fully-automatic control conveys the glass through the pre-heating sections to the bending section and then back to the loading/unloading station through the cooling track. Control is based on continuous measurement of the glass temperature by optical IR pyrometer. The standard version features one to four pre-heating sections and one bending section, depending on the capacity required. The lower track has between one and four cooling sections and a loading/unloading station.

The heating is electrical, guaranteeing proper heating in all circumstances. The higher the glass temperature, the more precise heat control it requires to achieve the desired shape. The pre-bending sections are normally one part heating elements and one part controlled elements together, except in the longer versions of the furnace where the last pre-heating section's heating elements can be individually controllable. The heating elements of the bending section are normally divided into three individually controllable parts.

HEAT APPLICATION TECHNOLOGY

Some of today's windscreens are made in such complex shapes that they cannot be bent in

basic furnaces with the traditional heating systems. Wrap-around corners and tight radii require something extra. In gravity bending, the key issue is to focus the heat into the right areas. There are different ways of controlling the radiation and convection in the bending section. Heat covers block the radiation from central areas; heat absorption plates can remove the heat from central areas; heat mirrors can intensify the heat in corner areas; extra heaters on the mould direct the heat in corner areas and local convection can be increased by compressed air.

Automation is necessary to achieve faster cycle times. Glassrobots provides the LTFBA furnace with vertically adjustable heating elements, a temperature balancing system, and also three-part extra heating elements.

The vertically adjustable heating elements improve the focusing of heat into the right areas of the glass as the radiation power increases squared

The vertically adjustable heating elements (*VAHE*™) are divided into three or five individually controllable parts. This proven design dates back to the company's architectural furnaces in the late 1980s and it is cost-effective and reliable. By taking the heating elements down, radiation power can be increased by more than 10 times as much as with a fixed heating element. The scatter radiation is clearly lower with the heating element in the lower position.

The temperature balancing system that consists of one extra pyrometer in the bending section, guarantees symmetrical heating. The glass temperature is symmetrically measured and if variations are noted, the control system automatically balances the heating pattern.

Finally, extra heating elements that are placed on the mould can now be divided into three parts.

COMPUTERIZED CONTROL

Glassrobots has developed a control concept for mixed production, which upgrades the repeatability of the furnace to a different level. The furnace is controlled through a programmable logic controller (PLC). The instrumentation of the furnace, such as heating ele-

ments, thermocouples, IR pyrometers, motors, inverters and limit switches, is connected to the PLC. The personal computer (PC) provides the system with a user-friendly Windows-based graphic operator interface for process control and programming, mass memory for bending programs and process data acquisition for reporting. The operator receives real-time information of the bending process and the functions of the furnace. The control system guarantees excellent repeatability of shape and easy use of the furnace, while allowing the optimization of capacity at the same time. The graphic interface includes the following functions:

- clear and illustrative display for process supervision;
- programming in three different ways: creating new programs, editing old ones, and by recording manually performed bending into the memory of the PC;
- three operating modes: automatic mode for normal production runs, manual mode for correcting and optimizing the bending programs, and step-by-step for maintenance and inspection;
- pre-set start-up timer;
- production reports; and
- a UPS-device and battery back-up to protect the process computer against voltage drop-out and other disturbances in the network.

The patented *FuzzyBend*™ control system gives clear advantages in 8-10 wagon systems. It practically eliminates the effects of changing production mix, heat balance of the furnace, external conditions and variations in the supply voltage.

EASY, EFFICIENT OPERATIONS

Glassrobots furnaces are designed with the furnace user in mind. The graphic operator interface makes operation of the furnace as easy as using the office computer.

Loading/unloading devices facilitate glass handling and cut down on the amount of heavy manual lifting required, reducing health problems among operators. The most used loading device is a piece of equipment which allows the operator to lift and flip the windscreen completely out of the wagons. It consists of four lifting pins in a pit under the loading/unloading area and a manual glass "flipping" device with horizontal roller arms, the *FlipFlap*™.

The condition monitoring and maintenance system (*CMMS*™) minimizes the downtime and maximizes the hours of operation. The system supports preventive maintenance by giving maintenance schedules based on operating hours and by giving information about failures in the functions of the furnace.

Glassrobots technicians can comfortably communicate with the process computer via modem by means of the *GlassButler*™ remote diagnostic software.

COST-EFFECTIVE OPERATIONS

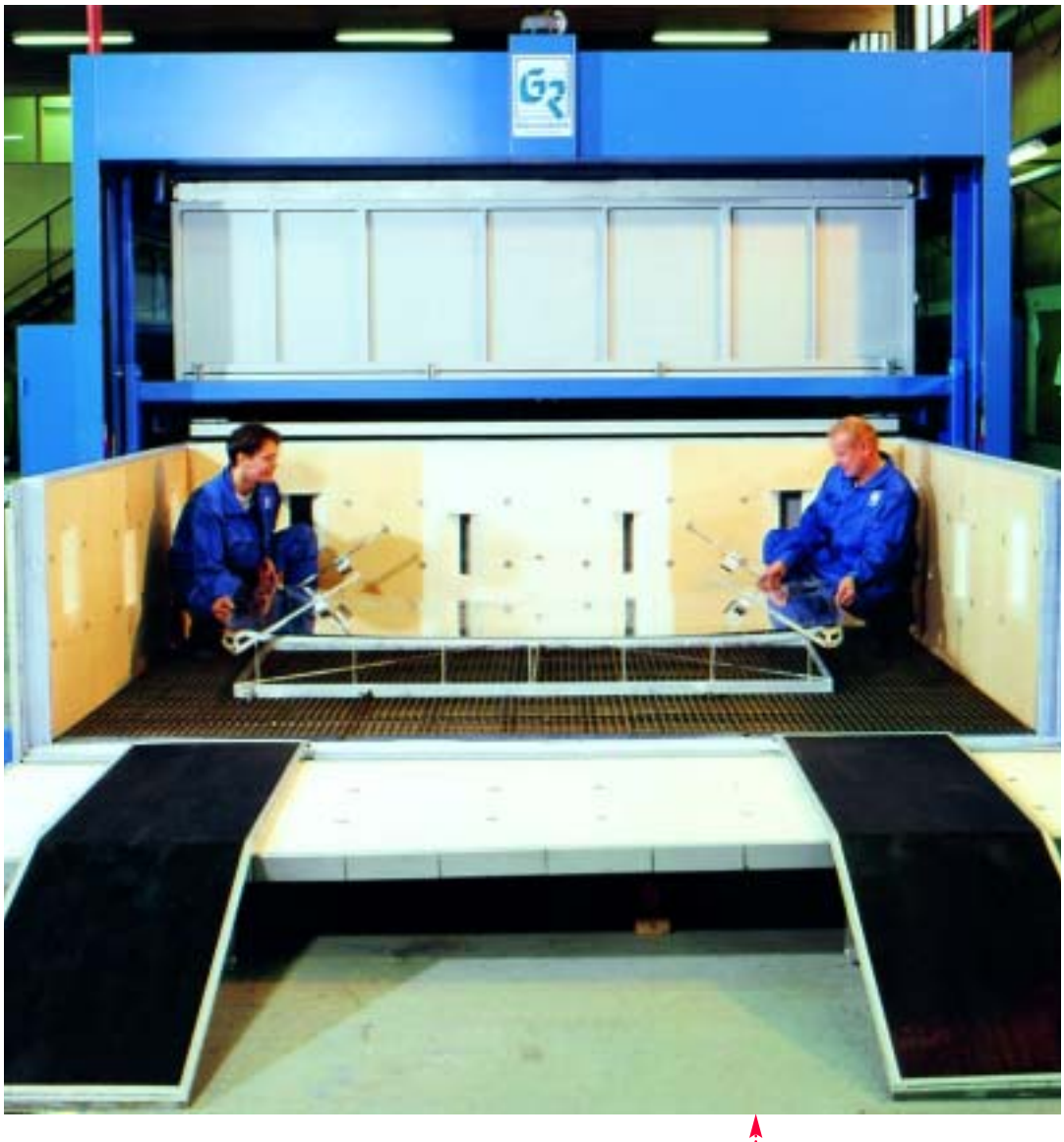
The serial bending furnace was initially developed to be affordable, with low operation costs. Its tunnel construction guaranteed low energy consumption and made it possible to run short series in mixed production, for example with different windscreens in each wagon. Automation means that the furnace does not constantly need to be attended by an operator, which means that other tasks can be performed while the furnace bends the glass.

Glass breakage during pre-heating was previously a problem in bending. However, in

NEW GROUP PREMISES

Glassrobots was planning to relocate to new 6,300-square-metre premises close to Tampere-Pirkkala airport in Finland by July this year. The premises will also house *Tambest*, Glassrobots' partner in the *Tambest Group*. Tambest manufactures bent glass for the construction industry and supplies a broad range of premium-quality bent architectural glass. Glass installations include the Royal Opera House in London, United Kingdom; the headquarters of the Bank of China in Beijing, China; Expo 2000 in Hannover, Germany; the Audi headquarters in Ingolstadt, Germany; and the Siemens Forum in Munich, also in Germany.

The Tampere-Pirkkala site will house the product development, manufacturing and office facilities of both companies. "Operating with Tambest under the same roof provides synergies and gives an additional boost to product development," said Juha Karisola, Glassrobots' Managing Director.



An openable, spring-balanced front door guarantees easy access to the wagon and easy loading of the glass and mould

most cases this can be avoided by supporting larger windscreens during the pre-heating process. The support should then be removed, or lowered manually or automatically, before the bending process begins.

An automatic central support consists of two motors outside the furnace in the bending section and a mechanical support system in each wagon. It can support the glass or the mould, depending on the system the client is using. The function of the support is based on the pyrometer reading of the glass.

INNOVATION AND SUCCESS

Future bus windscreen models are likely to display a number of innovations, which set further standards for the windscreen bending and laminating process. In the future, the windscreen processor will have to become accustomed to using modern technology to improve the functional properties of the windscreen. Research and development is being conducted on issues such as solar control glasses, micro-wires and coatings used in heated windscreens, integrated antenna systems and sensors. Only through a process of continuous development and by striving to adapt to the technology of the future will the windscreen processor and the furnace manufacturer be able to secure their positions in this competitive industry. The key factors which will bring success are, as always, cost efficiency, process quality and product quality. ■

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