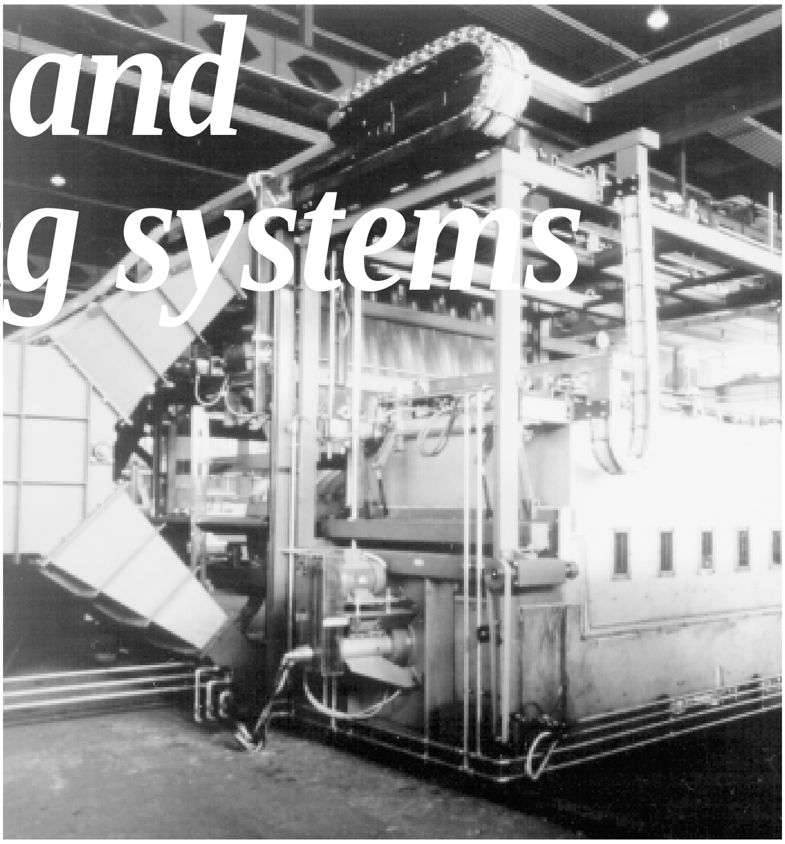
Advanced bending and tempering systems



Since 1993 the technical staff of Fintec and Ianua have been at work perfecting a furnace for tempering complex curvatures, featuring a novel air-support system. The following article details the innovations introduced by this exploration of tempering physics and describes the main features of the BTF model furnace.

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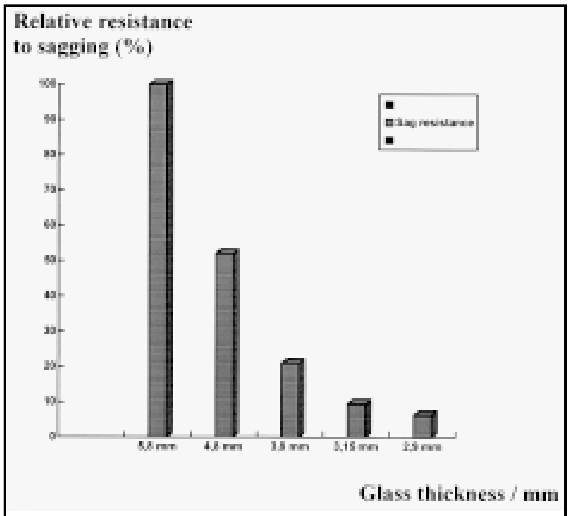
Ianua has been working on furnace development for over two years now; and the prototype furnace is currently under final tests. The machine is a single chamber furnace, but a large one. It can temper a maximum glass size of 1,200 x 2,000 mm.

Fig. 1 Ianua bending and tempering furnace model BTF 120 x 200/1-3.2 E

Background of invention

In bending and tempering the gravity method was possible for only 5-6 mm and thicker glasses, because thinner glasses sag excessively and lead to unacceptable cross curvature. The reasons for



Relative sag resistance of various glass thicknesses in tempering temperature. (5.8 mm glass = 100%)

Fig. 2 Glass bending resistance as a function of glass thickness in tempering temperatures

this are, that bending resistance reduces in square to the glass thickness and thin glasses require a higher tempering temperature. As the glass viscosity reduces exponentially with higher glass temperature, the sag develops quickly at high temperatures. Thinner glasses are naturally lighter weight, but this can compensate for only a very small fraction of the bending resistance and viscosity reductions. Figure 2 illustrates clearly the radical change of sag resistance with glass thicknesses from 6 mm down to 2.9 mm.

The air support method solves this problem in a relatively simple way and makes final heating of thin glasses possible on bending fixture/quench ring combinations. Air support also enables the whole process to be carried out efficiently, as will be explained.

Certain aspects of the glass tempering process

During initial heating, the glass surfaces heat quickly and glass mid-plane temperature is much lower. As the glass temperature rises, the heating speed slows down because glass and furnace temperature difference is now minimal, only some 300°C-100°C. This is advantageous for the process, because the glass temperature starts to homogenise. It is important to finish the heating with a soaking period, during which the following takes place:

1. The glass mid-plane temperature approaches the surface temperature, the glass temperature is homogenised.
2. Due to the high temperature, stresses now relax quite quickly. However, even at tempering temperature this takes a few seconds.

Tempering should only start when the above has taken place. Otherwise glass breakage in tempering will be high. This is why the invention is considered important. It allows the process to be carried out without any violation of glass tempering physics.

During the tempering process, fully stress relieved glass is quickly cooled on the surface; mid-plane cooling follows later. This causes tempering stresses (especially surface compression) in the glass and increases the strength. With thin glasses actual tempering lasts only a few seconds.

Figure 3 illustrates the glass surface and mid-plane temperatures during the tempering process. Also, it shows how glass viscosity is at a very low level during the last heating stages of at least 20-30 seconds. This is the critical period for sag formation.

BTF bending, heating and tempering technique

As bending takes place by gravity, bending shapes can be quite difficult and deep bending is possible. In this case bending temperatures in sharp bent areas may exceed 640°C. Especially in central areas of the glass the temperature is maintained low enough not to cause unwanted cross

Fig. 3 Glass tempering process changes

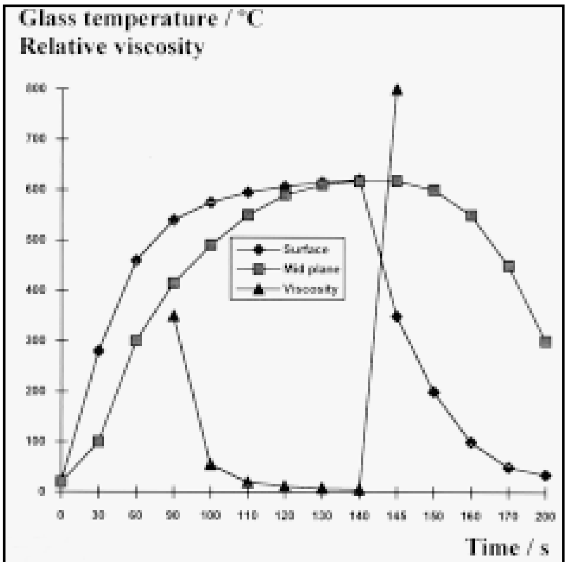


Illustration of glass surface and mid-plane temperature and glass relative viscosity changes during tempering process. Heating time is 140 seconds.

BTF 120 x 200/1-3.2 E BENDING AND TEMPERING FURNACE

The BTF 120 x 200/1-3.2 E, as shown in Figure 1, is equipped with a patented air support system and highly adjustable quench heads, patent is pending. Maximum glass size 1,200 x 2,000 mm. Minimum thickness is 3.2 mm according ECE R 43 fragmentation standards. Bending depth is 150-200 mm, minimum radius is 450 mm with standard adjustable quench head and inexpensive gravity sag bending tools.

curvature. During bending, air support is not used. However, immediately after bending is completed, the collar is brought into contact with the glass and final heating is begun via air support. This ensures that all parts of the glass reach tempering temperature, that temperature is homogenised and stresses are relieved.

After final heating is completed, the collar descends and the glass stays on the bending tool/ quench ring combination to be transferred into the high speed quenching section. Tempering is effected, as usual, by air jets.

BTF technical features

Advanced kinetics and heating systems and controls

At times all of the bending, collar and quench ring movements must be either slow, or fast, but always very accurate and with smooth acceleration and deceleration. Above all, movement of the glass into the quench must take place quickly and accurately without the waste of even a fraction of a second. For this reason CNC control is used for all process kinetics.

The mechanical drive components of the shuttle are located outside the furnace in order to ensure the best possible power transmission. In this way the components may also be high precision components. The system ensures that no slipping, jamming or other malfunctions take place.

Initial glass bending and final heating is effected by manual control. Optimum process parameters are stored in the computer memory for subsequent automatic operation.

The glass temperature during bending and final heating is monitored by optical pyrometer, which ensures that bending and heating cycles are repeated automatically along the same lines from one glass to another. During the final heating stage the heating intensity can be decreased by the so-called duty cycle function to allow for glass soaking and full stress relaxation before tempering.

Adjustable quench shape and size

The quench is adjustable to follow the glass shape down to the minimum radius of 450 mm. The shape can be variable radius, combination of flat or bent shapes, etc. The quench can be used for backlights and two sidelights per batch. When adjusting quench according to glass shape, the proper and ideal quenching pattern would normally be lost. However, with Ianua BTF quench there is a system which automatically maintains the correct quench pattern. Any adjustment in inclination of the individual quench block, (radius adjustment) automatically slides the nozzle block into the new position and maintains a constant quenching pattern. Patents are pending for the system .

Naturally for conical shapes and very small radii the quench shape cannot follow the glass. For them the adjustable quench must be changed to quench heads which are designed according to each individual glass.

Ianua also makes the quench in such a way that parts of the quench area can be closed. In this way remarkable energy savings are possible when processing thin glasses, which are also often small. On the other hand, large thicker glasses can be processed with one and the same quench, quench blower and motor.

The quench head is also adjustable in height, so that it can easily be adjusted for different bending depths. The CNC control allows accurate clam shell function, too.

Quick glass and tool change

BTF is particularly effective for small and medium series, as change over time is very low. The collar is changed by shuttle and a simple tool, which takes the collar into the furnace and locates it accurately in the correct position. The bending fixture quench ring combination is changed manually or by a small lifter located where the glasses are changed.

The glass processing parameters can be called up from the computer memory in a matter of seconds, if the glass has been bent and tempered before and the parameters have been stored in the computer memory.

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