**Convair combined irradiation and convection process**

This article describes the main features of Ianua’s latest innovation in the field of glass tempering machines. The new CONVAIR (Convection And Irradiation) heating system was developed in collaboration with Fintec Engineering Oy from Finland.

Due to increasing quality standards in the automotive and building industries, Ianua has developed a new tempering system called CONVAIR, by which, in the same heating chamber, the concepts of controllable irradiation and convection heating are combined.

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**Fig. 1 HTM with the CONVAIR system**
Heating problems

It is well known that the quality of tempered glass is very much influenced by the heating process used in the furnace: if non-uniform heat distribution occurs, this leads to a deformation of the glass sheet during the quenching process. There can be three different types of deformation which result from overheated edges, overheated midpane and one surface hotter than the other.

In the first case, the glass is recognised by the “oil can effect” or “bistable dish” (the middle part of the glass pane could be pushed from side to side); in the second case, the glass shape is known as “bistable saddle”, caused by the difference in length between the centre and the edges due to the hotter middle part of the glass; while in the third case, as the hotter surface contracts more than the cold side, the result is an arching of the glass sheet.

In traditional radiation or gas-fired furnaces, the heating speed of about 40 seconds for each 1 mm of glass thickness is reached by maintaining a furnace temperature of 700°-720°C, leading to high temperatures in the ceramic rollers.

For this reason, when a sheet of cold glass enters the furnace, the overheating and expansion of the lower surface gives rise to upward curvature of the edges of the glass. In this case, the glass is moving inside the furnace, like a boat with a keel, touching the rollers only along a relatively narrow central strip. This is responsible for damage to the glass surface, together with the so-called “white line” which can be seen in the middle of the glass sheet, and will sometimes cause optical distortion.

Existing remedies

Different numbers of methods could be considered to avoid these kinds of things. For example, the temperature setting of the top heaters could be increased, and the distance between the glass and the upper resistors could be reduced as well. Another possibility is to use heating balance, where heated compressed air can be blown onto the upper surface of the glass in order to equalise the transfer of heat. But there are still many problems with glass optical quality in existing tempering systems.

In addition to this, it must be pointed out that these kinds of problems are critical especially with coated glass, where the heating very much depends on the type of coating applied to the glass.

In order to avoid the above-mentioned problems, some companies have developed plane convection heating furnaces. While these furnaces solve such kinds of problems, others arise because it is not possible to provide the temperature profile inside the furnace, due to the air blow. Furthermore, a high temperature gradient is introduced into the glass because convection heating makes the sheet surface temperature increase more than the sheet core temperature, leading to a great temperature difference between the middle core and its surfaces, causing high tension inside the glass, which sometimes breaks the glass inside the furnace.

The irradiation-convection solution

In the HTM, Ianua’s latest product, all problems of these kinds are now solved thanks to the combination of irradiation and convection heating. The machine consists of :
- a loading station;
- a high-performance combined convection and irradiation furnace;
- a high efficiency quenching unit, with perfect even air distribution;
• an unloading station.

The loading and unloading tables are equipped with a lifting system which helps the operator when large loads are to be carried on it. In addition to this, by pressing a pedal foot switch, the loaded glass is moved towards the furnace of a loading transfer length which can be set through internal software parameters.

The loading length is automatically read through a photosensor installed at the end of the loading table: this is used to calculate the speed and the number of oscillations of the glass loading, from end-to-end of the furnace, in order that the glass receives uniform heating. When the heating time has elapsed, the glass sheet is exactly in the exit position of the furnace, accelerating to reach the quenching station.

The most innovative part of the flat tempering machine lies in the furnace section, where the irradiation effect is combined with convection heating. The irradiation, for the upper part, is provided by traditional individually-controlled electric heaters through radiation plates installed lengthways in narrow sections, while the forced convection is obtained by air blowing through the resistors with nozzles in radiation plates. The air circulation is arranged in such a way that the hot air is taken from the furnace and blown onto the glass surface by small electrically-driven heat resistant blowers.

As regards the bottom part of the furnace, it is also equipped with the same number of controllable electric heaters. However, the hot air is only blown through the heaters and the nozzles.

Heat regulation

Thanks to this, a particular profile for top and bottom heaters can be applied at any moment during heating to ensure uniform heat distribution on the glass. The application of the temperature profile can be used for special loading shapes in the central part of large glass sheets as well as places with cut-outs, notches and holes, for which the breakage rate is significantly reduced.

The top and bottom surface temperatures of the glass can be kept equal to each other by using a separate convection heating system which allows them to be heated at equal rates, avoiding any kind of bending and distortion during the heating period.

The sequence of the hot-air blowers has to be created manually only during the first cycle. After that, this sequence can be stored in the PC memory, filed under the special name of the loading, and re-loaded at any time for use in a completely automatic cycle. If a short part of the automatic sequence has to be modified, this can be done, with the possibility, at the end of the heating period, of saving it or maintaining the old one.

Once the heating time has elapsed, the vane control is opened to reach the correct toughening pressure and the glass exits from the furnace to the quenching station at the specified speed. After tempering, the pressure can be reduced or increased to cooling pressure as set in the parameters. The reduction or elevation of the pressure takes place smoothly and automatically, in order to avoid the breakage that could happen after tempering with too strong cooling, especially with thick glass.

The glass straightness can be controlled by leading more or less air to the glass surface, adding to this a completely even and high efficiency air distribution system all around the quenching section of the machine.

When the glass temperature reaches the specified set temperature, cooling is over, the vane control is closed to save energy, the nozzle sections are lifted apart and the glass is transferred from quenching to the unloading table.

System control

The software control of the entire system can be divided, from a theoretical point of view, into four parts, as described below, all connected in a single network.

The first one is the movement part. It
CONVAIR’s automatic convection control panel

Fig. 3

The tempering section and unloading table

Fig. 4

operates on 7 axes, all of them controlled with great accuracy of position and speed, by two Allen Bradley axes controllers, which ensure precision in the application of the movement parameters. Mechanical movement is by means of a toothed belt which ensures that the rollers are rotating all the time in the same phase, something which is not possible in friction driven systems.

The second one consists in the hot part of the system, considering both resistors and hot-air blowers, again using Allen Bradley control equipment.

The third part is an industrial PC, installed in the main cabin of the machine, through which the operator can set all the parameters and manage the memorised data. The PC is also used for monitoring all the process variables at any time, and takes care of the devices connected with the network.

The fourth device consists of a movable pulpit, along the loading table, in which is installed a small monitor, through which the operator can follow all process variables; in addition to this, there are some pushbuttons and potentiometers to create the correct sequence for the hot-air blowers.

The maximum loading size of the furnace, with the smallest one, starts from 100 cm x 220 cm and goes up to 254 cm x 520 cm, with a minimum glass size of 80 mm x 240 mm. The thickness range goes from 2.8 mm to 19 mm.

Comparisons

In this section, the results of the HTM’s CONVAIR will be compared with existing irradiation furnaces, showing the advantages of having the combined effect of irradiation and convection in the same heat chamber.

Heating times

First, what must be cleared up about these final results is that the heating time has been shortened from about 40 seconds per mm in glass thickness (typical of the irradiation furnace) to 28-34 seconds per mm with CONVAIR (depending on the glass size and type of loading), although the temperature setting in an irradiation furnace is higher (about 710°C) compared to the temperature in the CONVAIR system (typically 680°C).

Temperature adjustment times

A great advantage can be achieved in the HTM with the CONVAIR system, which is not available with other well-known irradiation tempering machines: when the glass thickness has to be changed, from thin to thick, no time has to be wasted decreasing the temperature from about 700°C to 670°C in order to avoid glass breakage inside the furnace: in our case, the new type of loading can be sent immediately into the furnace.

In the case of very different production, which is the typical situation of the workplace where the HTM CONVAIR prototype has recently and successfully been installed, this greatly helps the system to obtain and maintain very high capacity. Having thick glass in the quenching station and thin glass ready to be loaded into the furnace can be a common situation.

For this reason, there is the software interlock through the computer, which prevents the thin glass from entering the furnace before the cooling time of the thick glass has elapsed so that its cooling period has finished and the glass is removed from quenching, before thin glass enters the tempering section.

Product yields

During the first months of production, it was found that the production yield
reached as high as 99 per cent with very
difficult glasses, including glass sheets with
cut-outs, notches, holes and bad-edge work
quality.

According to the customer, in the case of
special lamp glasses with big holes and sand-
blasted surfaces, the usual yield with the
existing irradiation furnaces was about 60-65
per cent; with the CONVAIR system, there was
almost no broken glass (yield > 99.5 per cent).

The same situation happened with the
production of figured glass used in shower
walls, thanks to the CONVAIR system which
achieves extremely even temperatures in all
parts of the glass, from the middle to the edges
with no differences. This is not possible with
irradiation furnaces where glass edges are
heated up more than the middle.

**Optical quality**

The optical quality obtained with the
CONVAIR system, measured with specially-
designed equipment, is very high compared to
quite visible optical distortion occurring at both
ends of the glass sheet in irradiation furnaces.
In the case of the CONVAIR system, the
tempered glass is completely distortion-free
and perfectly straight, proved by the fact that
the customer, very often, was not able to
distinguish the float glass sheet from the
tempered one. Very beautiful optical results
were obtained with mirrors, bronze silvered
glass, painted glass and k-glass, for which the
heating time was the same as normal glass
(while in irradiation furnaces it is much longer -
almost double - due to the reflection effect).
Even the previous Glamec furnaces, which
achieved possibly the best optical quality so far,
cannot compete with the CONVAIR quality.

**Other characteristics**

Fragmentation, with the CONVAIR system,
can easily meet all required norms in the
automotive and building industries.

Energy consumption is minimised thanks to
the CONVAIR system and the high-efficiency
nozzles, with two-speed blower motors: the
consumption, for example, of 4 mm glass and 6
mm glass is, respectively, 3.1 kWh/m² and 3.3
kWh/m², with 70 per cent loading efficiency.

The CONVAIR system is almost
maintenance-free and completely automatic:
even people with no experience, not usual with
existing tempering lines (very skilled operators
are needed to guarantee good quality), can
handle the machine and make high-quality
production, thanks to the sophisticated control
system, where all operator parameters are
stored in memory and can be re-called from the
library at any time.

**Conclusions**

What can be realised from the above
observations is that the HTM tempering furnace
with the CONVAIR system approaches the
customer’s dream of tempering machinery
which can make completely distortion-free
and perfectly straight glass sheets which also
display excellent breakage patterns when the
glass has been shattered.

As proof of this, it must be noted that, to the
great satisfaction of Ianua’s HTM CONVAIR
team of technicians and engineers, owners of
well-known irradiation tempering systems are
sending their glass to be tempered with the
CONVAIR system!

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