WHAT KIND OF COATED GLASS CAN BE TEMPERED?

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ABSTRACT

Lately, there has been a great deal of discussion about what kind of coated glass can be tempered. This is understandable because there are many different types of coated glass on the market, and new companies and coatings are entering the market all the time. This has caused confusion among glass processors as well as customers.

Coating capacity, in large scale flat glass producers and processors, has increased more in the past two or three years than during the previous 15 years. This rapid development indicates that the coating industry believes there is great potential in the architectural and automotive industries. I personally believe that within the next 10 years coated glass will be more or less a standard product and clear glass will be used only in special cases.

This paper will give you an idea of what kind of coated glass can be tempered and the reasons why some coatings cannot be tempered at all. It will also give you some information about force convection methods and about how force convection helps us process these products.

INTRODUCTION

During the past two or three years, there has been a notable increase in the use of IG-Unit, especially Low-E coated glass. For example, in Germany the use of low-E glass as window glass has increased from 3-4% to 50%. This is mostly due to new German legislation, but is also due to the fact that consumers have become more and more aware of environmental issues.

The same trend will first spread across Europe, as well as to the USA and Japan, and the rest of the world will follow later.

WHY AND WHERE COATED GLASS IS USED

The right kind of coating on glass protects us, for example, against cold, sunshine, electromagnetic radiation, fire, X-rays etc. and these coatings can be made so thin that we can still see through these windows, doors and glasswalls. Coatings give us plenty of opportunities to create many new products and applications, now and in the near future. They also provide the glass industry with a better opportunity to compete with other materials like plastic, stone, metals etc. All this is made possible just by adding coatings to the surface of the glass.

The new products present a challenge to the glass processing industry: where and how to use them, and from whom to get the latest information in the field. We must be prepared to explain the new possibilities to our customers and to the consumer market. The safe and correct use of glass should be our common interest.

THE COATING ITSELF

Coating means that one or more layers are added to the surface of the glass. The coating can be thick or thin. Ceramic painting is a typical thick coating, and low-E or solar control coatings are examples of thin coatings. In this paper I will focus only on thin coatings.

A typical coating includes two to eight layers and every layer = coating must be done separately. These layers can be of different thickness and different materials. The thickness of coating layers is normally from 100-1000 angtroms thick.

The measure used to describe the thickness of a layer is angstrom (1Å=10 $^{-8}$ mm).

1 Å = 10^{-10} mm or 1 nm nano-meter = 10Å or 1 μm micron-meter = 10.000Å

As a comparison, the size of an atom is typically between 3 and 10 Å.

HOW TO MAKE A COATING ON A GLASS SURFACE

There are several ways to make a coating, the most popular coatings in the flat glass industry are:

On-line CVD Chemical Vapor Deposition, sometimes called hard coating

Off-line PVD Physical Vapor Deposition, evaporation, sputtering, ion plating, sometimes called soft coating

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WHAT ARE THE DIFFERENCE BETWEEN THESE METHODS?

On-line coated glasses are made in a float process. They are partly made inside the tin bath or just after the bath. This process is also called the atmospheric CVD, where the thermal energy of hot glass is used to set off a chemical reaction between the glass and the deposited material. This creates a durable coating on the glass surface (see figure 1). For example solar control, low-E, antistatic coatings, mirrors and transparent conductive coatings etc. In this process, the coating is made just at an high temperature and it is possible to heat up the glass again to tempering temperature (610 - 650°C).

Antelio, Reflectafloat, Reflectasol, Solarcool and Stopsol can be mentioned as examples of solar control coatings, whereas low-E coatings include Comfort, Ekoplus, Energy Advantage, K-glass and Sungate. Of course there are many coatings but these are just examples. However, this process has certain limits. For instance, this method cannot produce different variety of colour shades, or properties that may be required from coatings.

The other main method is the off-line PVD process. This is a vacuum process, and the coating is usually made afterwords in different place than the float-glass factory. Coated glass size can rise up to jumbo size (3210x6000 mm). The most common method currently used in the architectural flat glass business is the sputtering process. In this process the glass is first cleaned, and then transferred to a vacuum chamber where the needed coating layers are deposited onto the glass surface by sputtering in controlled circumstances (vacuum, gas, layer thickness etc.). The glass temperature always remains below 100°C. With the vacuum coating method it is possible to produce a wide range of different coatings, including solar control with different colours, silver (Ag) based low-E and other coatings with special requirements (e.g. Cool-lite, Ipasol Natura, Iplus R, Solarbel, Suncool, Suncool HP, Super-E II etc.).

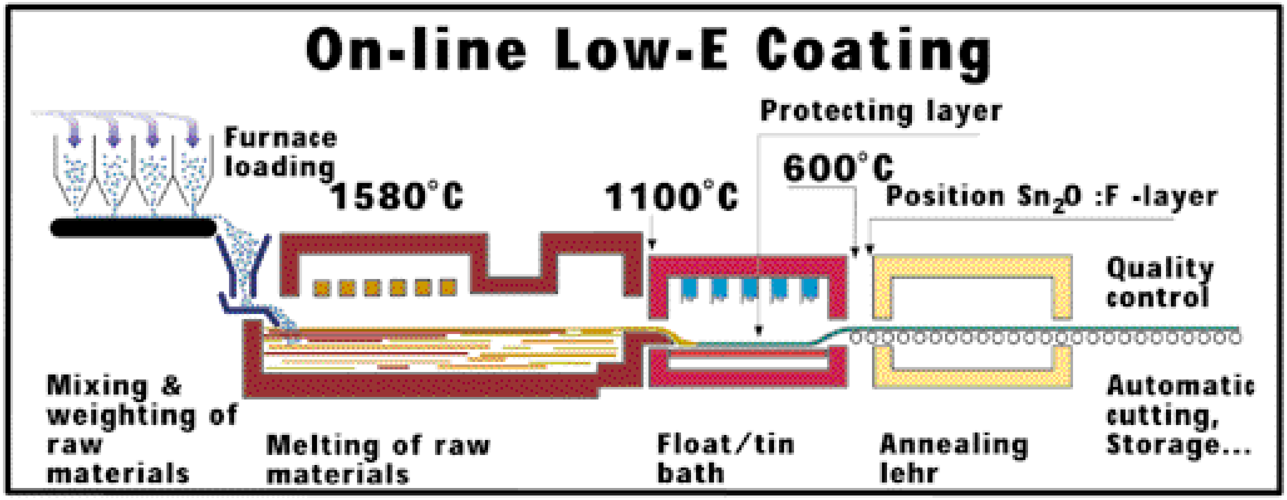

Figure 1: The float and the coating line

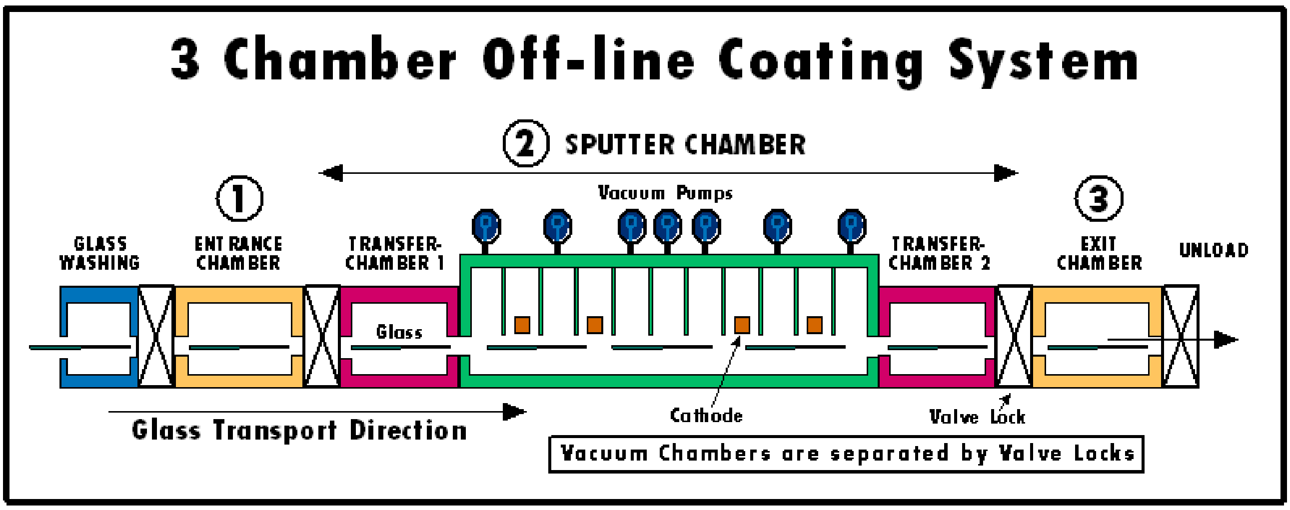

Figure 2: The sputtering line

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However, this method does not usually allow the glass to be reheated in order to temper it after the coating process. If this glass is heated up to the tempering temperature (610-650°), the different thermal expansions of the coating and the glass can make the thin layers crack. The coating may have oxidation, clusterization and/or diffusion. Oxidation means that, for example, the low-E silver (Ag) layer reacts with oxigene(O_2) atoms from the atmosphere or from the glass. This oxidation changes the colour and the properties of the coating layer. Sometimes the Ag atoms become too mobile because of the heat and they start to move and to pack together, that is, to cluster. This means that the low-E properties gradually disappear because the layer is no longer uniform. Different layers can also be mixed with each other during the heating process. These are the main reasons why it is not possible to temper all coated glass.

At the moment, two off-line coated low-E glasses that have been manufactured to allow the re-heating of the glass up to 620-640°C are available on the market. (Planiterm II and High Performance HT)

IS FORCED CONVECTION HEATING THE SOLUTION TO THIS PROBLEM?

By convection heating method it is meant that we can heat up or cooling down the glass by directing forced air flow to the glass surface. This can be done through the blowers or by compressed air. Despite the heating methods used, (radiation/convection) the resistance of the coating depends, at high temperatures, only on the coating manufacturing methods, on the material used and on its structure.

Generally, convection heating is useful when coated glass is tempered. It is possible to take the glass out of the convection furnace, so that its temperature is slightly lower than it is in the radiation furnace, but the difference is at most only 15-25°C. For some coating types the lower temperature may be useful, but generally the tempering temperature of the off-line coating gets too high and the properties of the coating are destroyed.

WHAT IS THE ADVANTAGE OF CONVECTION TECHNOLOGY?

By means of convection technology it is possible to realise different solutions for heating or cooling glass. Convection has already been used in different glass processes for years. Typical examples of these include autoclaving, windscreen preheating, heat recovery, windscreen prepressing , flat laminated lines, air cushions etc.

Convection has been used in tempering technology since the beginning of the 1980's. In the 1990's, convection became more generally used when the use of the so-called high convection furnace spread. Today's technology can roughly be divided into four main groups:

1. One-stage radiation furnace/with forced convection
2. Two-stage radiation furnace/forced convection
3. One-stage high-convection furnace
4. Two-stage high-convection and radiation/ and convection furnace

All these alternatives are useful when coated glass is tempered. Convection becomes very important when low-E glass is tempered due to its bigger capacity and its capability to heat more evenly.

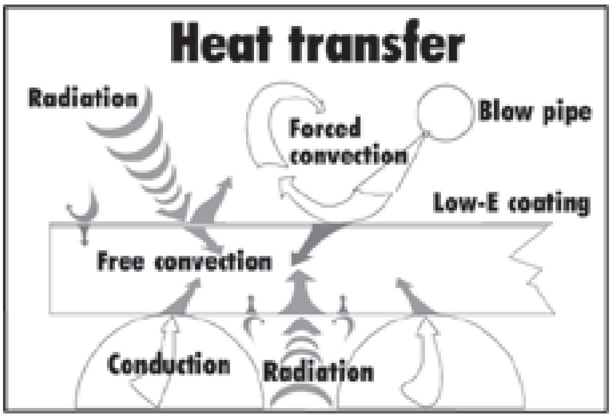

Figure 3: Heat transfer

Particularly when considering radiation furnaces, the importance of convection becomes increasingly emphasised because without upper convection it is impossible to evenly heat Low-E glass. By adjusting the speed of the convection it is possible to heat up the top and the bottom surface of the glass at the same speed without that glass will bend too much in the furnace and thus get a high-quality final product. The typical heating time in radiation furnace for clear glass is 40 sec/mm and for low-E glass is 45-65 sec/mm depending on the coating, glass size and quality requirements.

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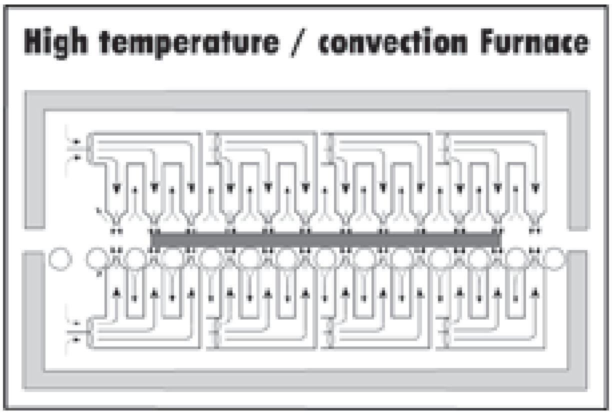

Figure 4: High temperature/convection furnace

In the high convection furnace, glass is mainly heated by blowing air, but we need to take into account also heat flow by radiation as furnace temperature is 680°C. Convection heat transfer makes possible to heat up glass faster speed, (29-35 sec/millimetre) is reached, which is useful for thin glass. The evenness and adjustment of the convection set high requirements for the control system of the furnace.

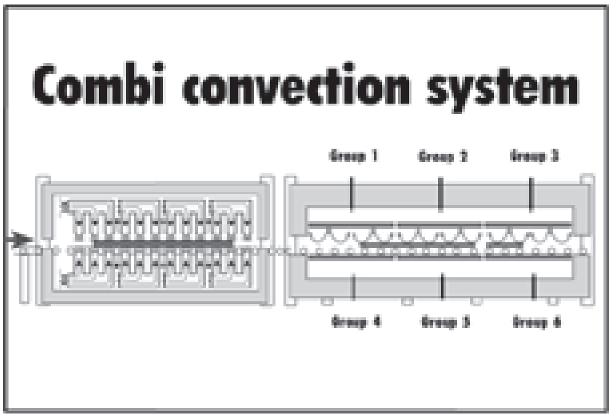

Figure 5: Combi Convection

In the Combi Convection furnace, heating takes place in two stages. In the first furnace, heating takes place only by means of convection at a lower temperature of 350-450°C. Because of this lower temperature the radiation heat transfer factor is minimised.

In the second stage, in the radiation and convection furnace (680-710°C) heating usually takes place by means of radiation, but the evenness of heating is further secured by convection. The advantage of this method is that at the first stage (which is the most difficult part of the heating) the glass is heated at relatively low temperatures, which makes the controlling of heating easier. At the second stage, it is still possible to adjust the heating by means of radiation (heater profile) and thus secure the even uniform heating of the glass sheet.

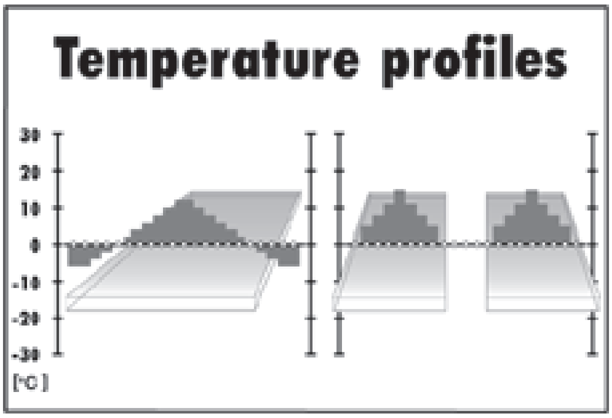

Figure 6: Profile

However, regardless of the heating method, the structure and the adjustment possibilities of the cooling section also essentially affect the quality of the final product.

CONCLUSION

The future use of different coatings presents new challenges to all of us, especially to glass manufacturers and processors. By correct and safe use of coated glass, it is possible to create new applications and markets for glass, and thus to increase both the uses and the competitiveness of glass against with competing materials.

For the successful processing of coated glass, it is important to know the properties of the product, concerning its storage, pre- and post-treatment, washing and heat treatment. Without proper treatment the quality and the properties of the final product cannot be guaranteed.

The use of convection technology improves the quality of coated safety glass, but also the heat resistance properties of the coating must always be known in order to guarantee good quality.

More detailed information on the advantages of the convection technology is available in the previous papers by the author.

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