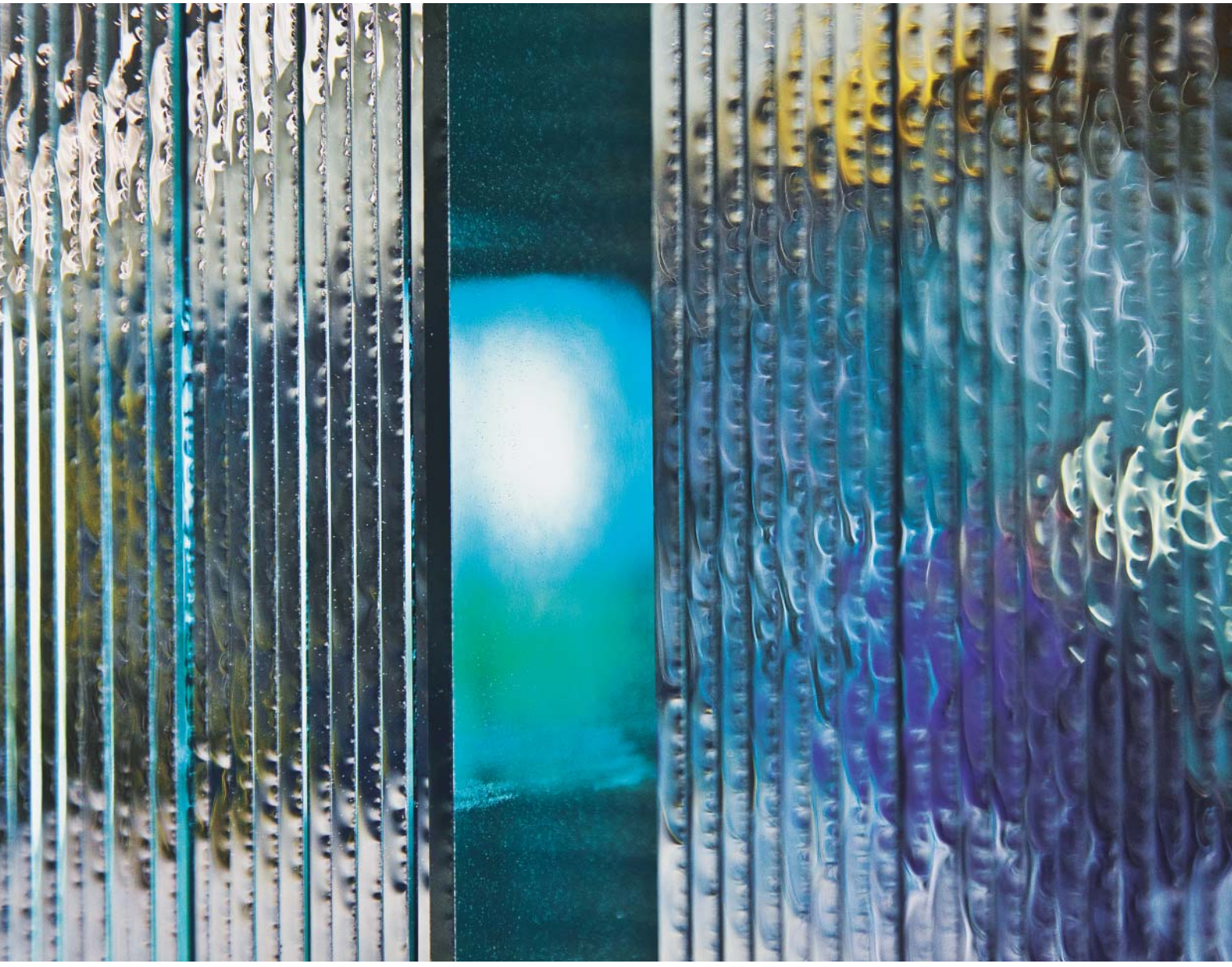
State-of-the-art factory produces 700 tons of flat glass a day



EtherCAT keeps everything under control

f l glass GmbH manufactures high-quality flat glass. The company operates a state-of-the-art production plant at its site in Osterwedding, Germany, producing 700 tons of flat glass a day round the clock. Besides basic glass, the company also produces specialized products such as safety glass or coated glass for thermal insulation and solar control for the window manufacturing and photovoltaic industries. iSATT GmbH was given the task of automating the glass coating unit on the basis of Beckhoff control technology.

Resulting from a joint venture between Dutch solar glass manufacturer Scheuten and the German company Interpane, f | glass combines the many years of experience and expertise of two leading manufacturers of glass and photovoltaic modules in. The company has the most advanced facilities and future-oriented production processes. Technological competence in the coating process comes from Interpane Entwicklungs- und Beratungsgesellschaft, which specializes in applications engineering, the development of coating processes, machine construction and plant engineering for the manufacture of special coatings for flat glass.

The highly complex coating process extends over an area of approx. 180 meters (590-ft) long and six meters (20-ft) wide. At the start and end of the coating line is a loading and unloading unit for the glass sheets, which is coupled to the glass production line via a roller conveyor. The format of the flat glass to be coated extends up to 7 x 3.30 m (23 x 10.8-ft).

State-of-the-art coating technology

The coating technology which Interpane has used for years is known as sputtering, whereby a coating is continuously applied in a vacuum. The glass is transported through a system of chambers from the intake sluice via the transfer chamber into the actual coating area, the sputtering chamber. The pressure in the sputtering chamber is reduced to 10-3 mbar, virtually creating a vacuum. To achieve an even coating, the glass is guided under the tools at a constant speed.

During sputtering, high voltage is applied between a cathode and anode under vacuum, which ignites a plasma. This is produced when atoms of the noble gas argon introduced into the chamber collide with the electrons already there and become heavy, positively charged argon ions. The high voltage causes the argon ions to accelerate towards the cathode on which the target is mounted, consisting of the actual coating material (e. g. silver). Encountering the higher voltage, the ions hit the target with high energy and dislocate material from it, which is then deposited on the glass in a thin layer. To create a chemical bond between the sputtered target materials, the reactive gas oxygen is also introduced into the chamber.

Various types of coating can be applied, using this process. Coated in this way, the glass sheets are further processed, for example into insulating glass with excellent thermal insulating properties for windows in buildings.

The total length of the production line is 180 meters (590-ft).

Innovative concept fulfills complex requirements

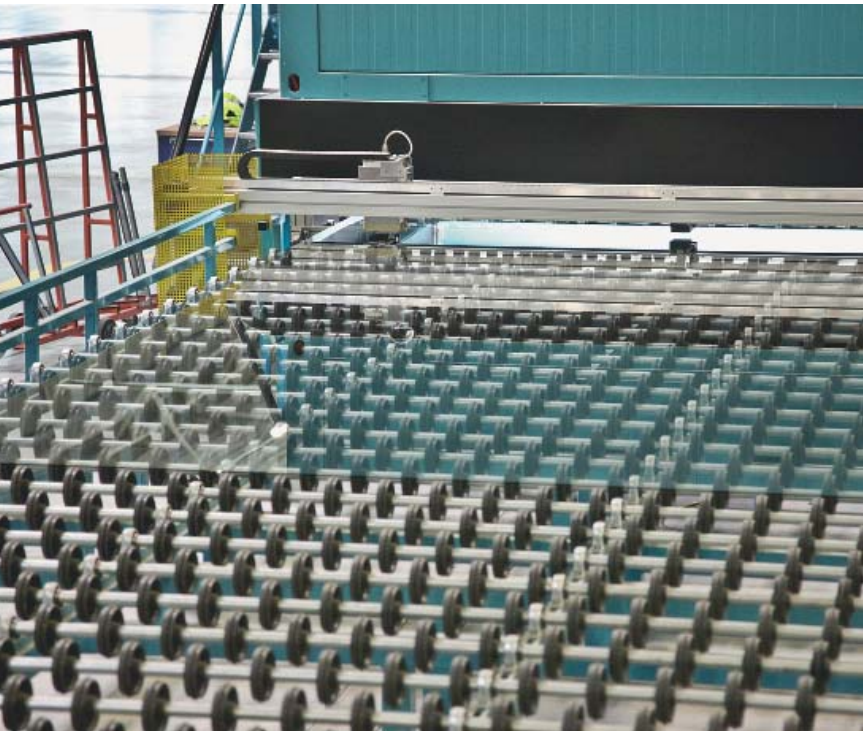
Having worked for Interpane for years and by now thoroughly familiar with the process control of coating systems, iSATT was commissioned to develop a new control concept to fulfill the following requirements:

- Large expanse of the plant as a whole, meaning that the fieldbus I/Os would be distributed over a considerable area
- Large number of fieldbus I/Os as well as PROFIBUS and CANopen devices
- Integration of the safe I/Os via a common fieldbus
- Integration of complete drive cabinets with Servo Drives for glass transport
- Modular occupation of the sputtering chambers with independent units at controller runtime without reconfiguration
- Automatic recognition of the occupation status of the sputtering chambers
- Communication link to the loading and unloading mechanisms via PROFIBUS
- Connection to the process control system

iSATT's innovative concept was to replace the existing control system which used several external CPUs with a central control platform. The high performance of the Beckhoff C5102 Industrial PC with Intel® Core™2 Duo CPU, the Beckhoff PLC and Motion Control software TwinCAT PTP and the EtherCAT fieldbus system serving as backbone of the control system was ideal for the job. Jörg Mönnekes, Coating Director at f | glass, adds: "The flexibility and modularity of TwinCAT fulfills the complex requirements of our processes perfectly."

"The following considerations prompted us to opt for this centralized concept," commented iSATT Managing Director, Peter Hennes: "On the one hand, cross communication between the controllers at different locations was no longer necessary. Another advantage is the centralized data management. The operator/maintenance engineer can see all data at a glance at any one time. This means signal tracking, program modifications and system maintenance can all be done in one place. Also, only one central remote access point is required. Furthermore, only one EtherCAT master is necessary to fulfill all the requirements of the fieldbus topology in terms of the distribution and number of I/Os."

The EtherCAT network comprises 20 servo controllers with EtherCAT slave connections, 22 EtherCAT Terminal stations with a total of 1,000 digital and 60 analog I/Os and 57 safety channels, 30 Hot Connect groups with 830 digital I/Os, 41 PROFIBUS and 21 CAN master connections in total. Another 30 Hot Connect groups with similar equipment will be added by the time the expansion of the plant is complete.



Quality control follows the coating process. Optical sensors measure the light reflection and transmission of the glass panes before the electric resistance is measured.

Hot Connect groups enable coupling and uncoupling during runtime

"The Hot Connect groups are especially important here," explains Manfred Czybik, Director of Control Development at Interpane. "One of the key requirements of the automation concept was the flexible occupation of the sputtering chambers with cathodes and/or turbomolecular pumps without reconfiguration during runtime. In addition, the system must enable the operating staff to recognize which occupation takes precedence at the time."

The sputtering chambers are rather like large horizontal type cases into which either a cathode and a target or a turbomolecular pump or both are inserted from above, depending on the type of process. The sputtering chambers are configured to hold 60 'compartments' in total. Every type of cathode requires different processing technology and, in terms of control technology, forms a Hot Connect group comprising a number of I/Os and PROFIBUS/CAN masters, depending on the type of unit. The cathodes communicate with the controller via a centralized plug connection. The advantage lies in the fact that the Hot Connect groups can be coupled and uncoupled within an EtherCAT network at any position during controller runtime.

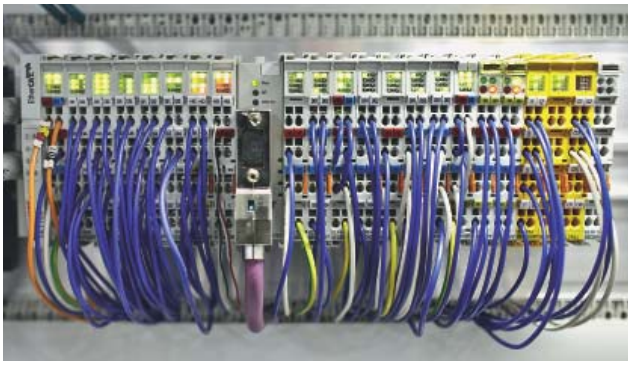
Master and slaves move closer together

A further advantageous point of the EtherCAT Terminal system, which proves to be benefitial within the Hot Connect group, is the integrated fieldbus master or -slave functionality. The high speed and considerable bandwidth of EtherCAT make it possible to move required bus masters out of the PC into the field level via PROFIBUS or CANopen and insert them at any EtherCAT bus station. This means the data from and to one of these fieldbus master-slave terminals is inserted into the EtherCAT protocol transparently – and only logically and physically converted into the relevant fieldbus protocol in the terminal itself. Consequently, almost any number of fieldbus masters distributed within an EtherCAT network can perform their tasks. Another positive spin-off is the shorter cable lengths of the fieldbus devices. Thus the master is brought closer to the slaves as demonstrated in the example of a cathode unit.

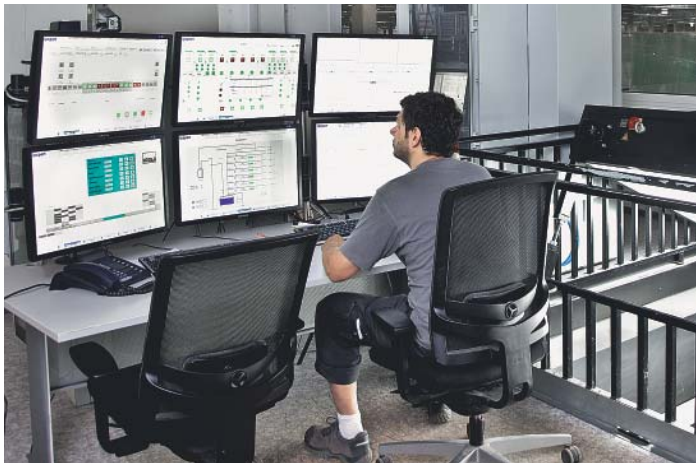
The fact that an ID switch allocates the address in the EK1101 EtherCAT Coupler means not only that operations can be performed at almost any point inside the sputtering chamber, but also that the type of cathode is identified. An address range is allocated to every type of cathode, which is imported into the PLC program and integrated into the control technology as required.

Motion Control ensures uniform glass transport

Glass transport in and out of the sputtering chambers is enabled by Servo Drives. The centrally calculated set values are transmitted cyclically to the Servo Drives via EtherCAT. First, the glass sheets produced on site are fed onto the roller conveyors in the line by material handling robots. The sheets pass through a washing unit which removes the separator ap-



All the safety devices in the line, together with all the emergency stop buttons along the transfer route, are operated via the TwinSAFE terminals integrated into the Beckhoff I/O system.



Control room

The final step is done by a material handling robot which takes the finished panes off the line and places them on transport racks. During a normal shift, one finished glass sheet is removed from the line every minute.

plied to the sheets when they are stored to prevent them from adhering. They are then conveyed through three chambers in which the necessary vacuum is gradually increased. Positioned at an interval of 10 cm (4-in) for example, the glass sheets enter the sputtering chamber where the coating process described above takes place. To ensure the material is applied evenly, it is extremely important that the glass transport does not fluctuate.

Once the glass is out in the atmosphere of the shop floor again, the coating is checked. Optical sensors measure the reflections and transmission of the glass panes and their electric resistance is measured, which is also an indication of coating quality. The final step is done by a material handling robot which takes the finished panes off the line and places them on transport racks. During a normal shift, one finished glass sheet is removed from the line every minute.

Integrated safety technology

All the safety devices in the line, together with all the emergency stop buttons along the transfer route, are operated via the integrated Beckhoff TwinSAFE system. If an emergency stop button is activated, all the drives, valves and power units for generating the plasma switch off. Four KL6904 TwinSAFE logic terminals evaluate the safe inputs and shut down the outputs. Communication between the TwinSAFE terminals, together with the exchange of the process data at controller and I/O level is done via EtherCAT.

Centralized control concept

Despite the complexity of the system, f | glass opted for a centralized control system. "We feel this has obvious advantages," explained Alexander Kick, automation expert at f | glass: "On the one hand, there is no need for cross communication between controllers as with a decentralized control system; on the other, central data management gives the operator or developer all the information at a glance. Moreover, the administrative costs for signal tracking, program modifications, system management and archiving as well as for centralized remote access are far less.

Easy to operate despite complex control technology

The visualization and master control of the coating line is coupled to TwinCAT via Beckhoff's ADS interface. Over 5,000 variables are exchanged between the control PC and the master computer via Ethernet. Ethernet TCP/IP forms the physical interface between the control system and controller.

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