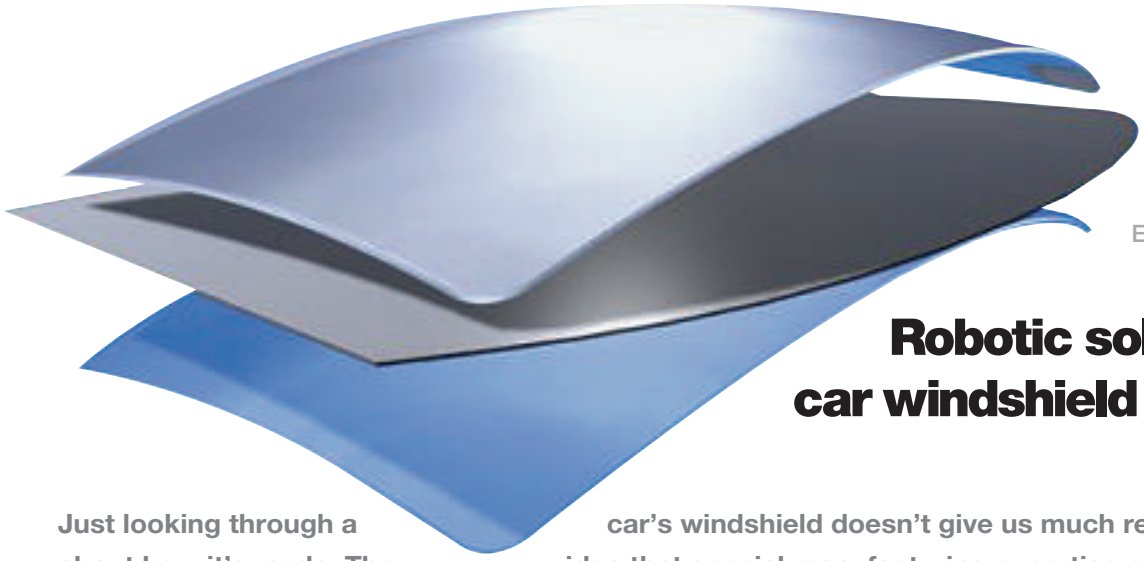
Pane relief



Enrico Mazzocchi

Robotic solutions for car windshield assembly

Just looking through a car's windshield doesn't give us much reason to wonder about how it's made. The idea that special manufacturing expertise might be required can hardly occur to anyone, but that's exactly what *is* needed to ensure crystal-clear visibility, not to mention a perfect fit every time one is pressed into place on a car production line.

Comprising two thin glass sheets joined by a vinyl interlayer, windshields are assembled – usually manually – to very precise product and environmental specifications. To make sure this is done as perfectly as possible, the industry invests heavily in the equipment used for their fabrication. ABB has now developed a robot-based Compact Assembling System for the automatic assembly of laminated windshields that speeds up production and increases cost efficiency.

A typical automobile windshield is a compound pane, made of two thin glass sheets – the *inner glass* (the one on the inside of the car) and the *outer glass* – joined together by a special plastic interlayer made of polyvinylbutyrale, or PVB.

Designed especially for the automobile glass manufacturing industry, the robot-based Compact Assembling System performs all the main windshield assembly steps within an extremely small footprint (not more than 25 square meters) 1.

The main process steps are:

- Absolute and relative squaring of the inner and outer glass sheets
- PVB interlayer peel-off, feed and lay-down
- Assembly of the compound pane
- Removal of the excess vinyl around the glass edge

The Compact Assembling System works like a production line: the inner and outer glass sheets are fed in pairs into one end of the system together with the tray of stacked PVB sheets 2, and assembled windshields come out at the other. The windshields leaving the system – up to five per minute – are then taken to the nipper rolls or vacuum bags, etc, in the next phase by means of conveyors or handling equipment.

An autonomous air-conditioning system ensures constant thermo-hygrometric conditions for the PVB sheets even in harsh industrial environments.

Thanks to the system's compactness, the size of the clean room can be signi-

1 ABB's new compact, robot-based system for assembling laminated windshields

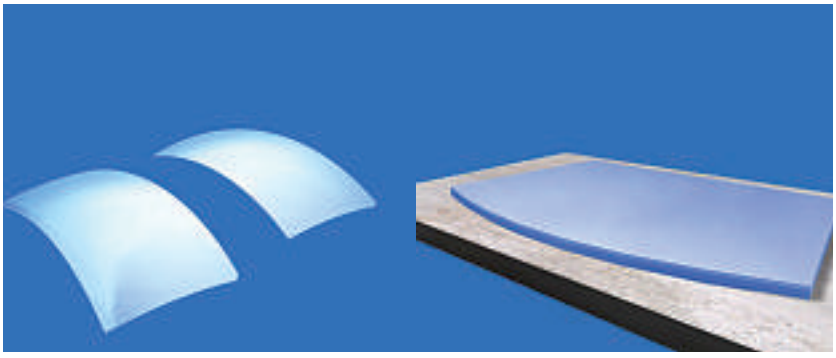
ficantly reduced, allowing a considerable saving in cost.

'Plug-and-produce'

The Compact Assembling System consists of integrated functional modules, enabling individual production operations to be tuned and tested separately before the system leaves the factory. The system as a whole is also tested prior to shipping, which saves a considerable amount of time on the customer's site.

Delivery of a standard system is usually possible within 13 weeks of ordering. Typically, just five working days are needed to get the system up and running.

2 The glass sheets are fed into the system in pairs (left) with the stacked vinyl sheets



Easy to use, consistent and reliable

The Compact Assembling System is not only installed quickly and producing within days; it also features a whole string of important performance benefits:

- Generous tolerances for the input materials
- Works with a wide range of pane types and sizes
- Long Mean Time Between Failures
- Minimal technical downtime
- Very high product yield

Even very skilled human assemblers would find it extremely difficult to attain the same high performance level, and if they could, it would be impossible for them to maintain it at the system's high production rate.

3 Input end of the Compact Assembling System

4 Glass sheets being transported through stage 1

A seven-stage process

Physically, the Compact Assembling System is a series of adjoining automated cells, enclosed in a hygro-thermostatic tunnel 3. At 9 meters long, 2.4 meters wide and 2.3 meters high (with quick-mount parts removed), the total system can be shipped inside standard freight containers.

The windshields pass through seven process stages in all. (The following descriptions of these stages refer in each case to the basic configuration.)

Stage 1: Loading

This first stage in the system consists of a belt conveyor onto which the inner and outer glass sheets are loaded, and a steel frame above it which carries the tray with the stacked PVB sheets.

The glass sheets can be loaded from a rack (manual or robotic) or by conveyor. Typical line speeds are 10 to 20 meters per minute at the input end and up to 60 meters per minute at the output.

The tray with the PVB sheets can also be loaded manually or automatically (using a flow link conveyor). The stacked sheets are picked up, one at a time, by a 'peel-off' device developed and patented by ABB. Using this technology, single PVB sheets can be peeled off from the top of a stack, even when the adhesion conditions are critical.

The glass sheets pass through stage 1 horizontally and in pairs: first the inner glass and then the outer glass, each 'wings' down and with the long edge leading 4. The sheets can vary in width from 1200 to 1900 mm and in height from 700 to 1250 mm. The sheet thickness can be between 1.5 and 2.5 mm and the depth (curvature) 0 to 150 mm.

5 The squaring module. Squaring is performed by servo-controlled tools designed to handle fragile products.

About 200 PVB sheets, each 0.76 mm thick, can be loaded into the tray above the conveyor. The sheets, which can be trapezoidal, may be larger than the glass sheets by as much as 3 to 120 mm on every side.

Stage 2: Squaring

A high-speed conveyor transports the glass and PVB sheets from the loading station to the squaring module 5. Here, the two glass sheets, first the inner and then the outer, are centered and aligned using a common reference defined by the X and Y directions and the plane angle 6.

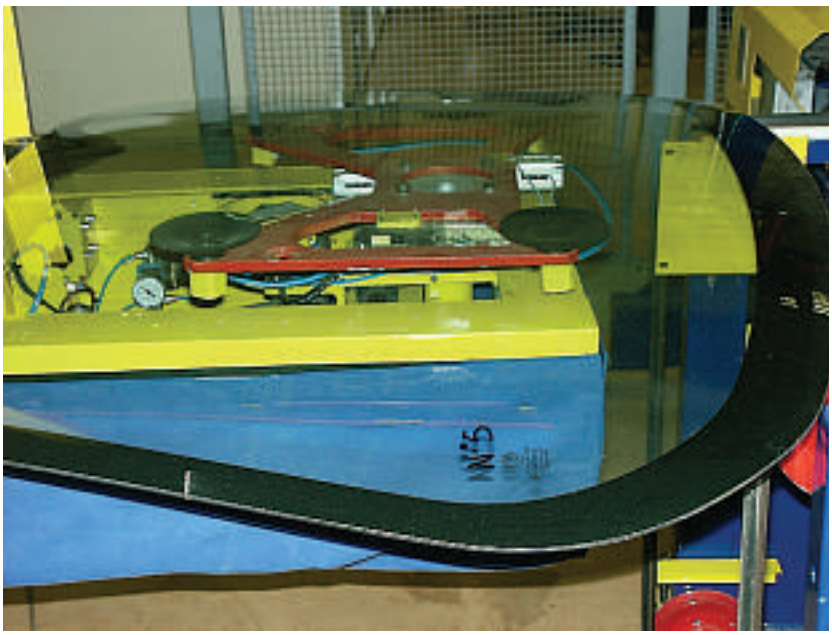
Squaring is performed by servo-controlled tools developed especially to handle fragile products like thin glass sheets. In spite of the delicacy of the operation – the sheets are squared with an accuracy better than 0.5 mm – this operation takes place at high speed.

The peeled-off PVB sheet is dropped here onto a special tape which acts as a background for the vision system (CCD cameras) that is used to locate the PVB sheet. The cameras determine its position, which is affected by the original stacking accuracy, the peel-off operation and the drop-off cycle, with respect to an absolute reference (X, Y, plane angle).

Stage 3: Shuttle service

In this stage, shuttles fitted with vacuum cups transfer the two squared glass sheets (one shuttle for the inner and one for the outer sheet) to the assembly station.

6 Squaring a glass sheet to get it ready for assembly



The first sheet to arrive – the inner glass – is picked up and transferred by the lower of the two shuttles, which moves between the conveyor belts.

The outer glass is picked up by the overhead shuttle, which runs under the PVB peel-off machine and above the conveyor line.

After they have released the glass sheets, the shuttles travel straight back to their start positions to pick up the next pair.

Stage 4: Final check

This is where any necessary correction is made to the drop-off position of the PVB sheet over the convex surface of the inner glass. Correction may be needed to ensure a perfect match between the X,Y center of the PVB sheet and glass sheet and their identical orientation about this center.

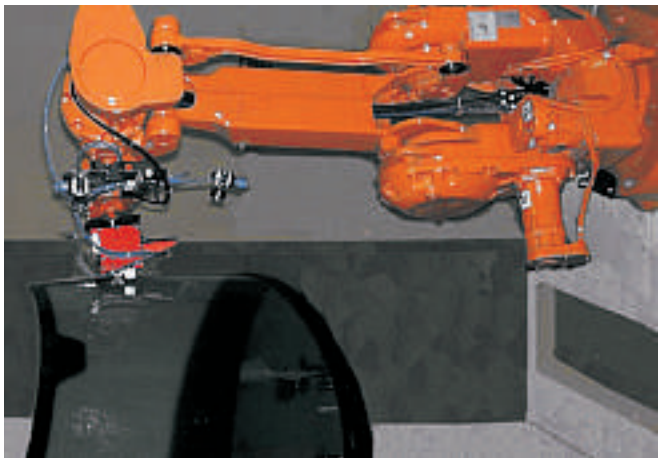
The manipulator that transfers the PVB sheet to the glass sheet works with four degrees of freedom and therefore has all the freedom of movement it needs to ensure perfect positioning of the PVB and glass sheets in the assembly station. Vision systems detect the actual position and orientation of the PVB sheet before any handling by the manipulator.

Stage 5: Assembly

In this stage, the two glass sheets and PVB sheet interlayer are assembled to form the finished laminate. The sequence of operations is as follows:

■ The inner glass is released by the lower shuttle onto a device fitted with vacuum cups.

7 One of the ABB 6-axis robots used for cutting



8 Protruding PVB is cut away

■ The PVB sheet is laid over the convex surface of the inner glass by the manipulator.
■ The outer glass is lowered onto the PVB sheet by the upper shuttle.

Each of these operations is carried out with the utmost precision. Misalignment of the two glass sheets is no more than 0.5 mm at any point on the glass edge, while the maximum possible mismatch between the glass edge and the PVB sheet edge is 3 mm.

Stage 6: Last shuttle

The assembled windshield is now transferred by another shuttle from the assembling area to the PVB cutting station. This shuttle movement is absolutely rigid to ensure that the squared windshield does not change position as it passes into the cutting station.

The motors that drive the shuttles' transfer movements all feature built-in closed-loop control of the end stops, speed and acceleration.

Stage 7: Cutting

In this last stage, the excess PVB sheet protruding from the glass edges is cut away 7.

Two 6-axis programmable robots are used for this. They enable the amount of PVB that needs to be cut away to be defined individually for different windshield models 8. A minimum amount of PVB can be left all around the contour when a further process is planned, such as autoclaving, which usually causes the PVB to shrink. It is also possible to trim down to zero when there is no risk of shrinkage but folding could be a problem.

Clear-cut advantages

The ABB Compact Assembling System offers some very attractive benefits for car windshield manufacturers:

■ Compact, space-saving set-up
■ Fully tested and tuned before delivery
■ Easy to transport (container shipment)
■ Delivery of standard systems within 13 weeks
■ Fast completion of on-site installation and commissioning
■ Low lifetime costs

These are major advantages that automobile glass manufacturers will not be able to ignore. Benefits such as faster production and increased cost-efficiency are factors that will help decide which companies succeed in this highly competitive sector.

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