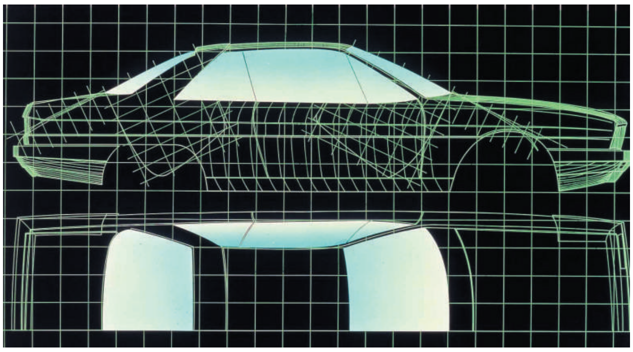
SHAPING AND STRENGTHENING



Glass is a visco-elastic material whose mechanical properties change very rapidly over a small temperature span. Between 500°-600°C its viscosity falls by a factor of 10,000 as it transforms from a brittle solid to a plastic substance. The science of glass bending aims to use this plastic phase to produce shapes which are complex, yet free from wrinkles and other optical aberrations starting from flat float glass. Optical distortion sets the limit for most shaping capability. Computer simulation of the shaping process usually precedes any practical work. (See Modelling and Simulation sheet.)

Automotive windshields are usually relatively simple in shape due to the requirement for a high level of optical integrity. Two basic processes are used to shape windshields. The first is sag bending and is the process most widely used for windshields. A pair of glasses, supported peripherally and heated to the viscoelastic phase (580°C - 640°C), is allowed to sag under its own weight to the desired shape (gravity sag bending). Control is through the pattern of temperature distribution across the sheet.

The second basic process is press bending technology which is used to achieve more precision or complexity into the design. This comes at two levels. The simplest form is where a die is used to press home the shape in selected areas during the final process steps of sag bending (die assist sag bending). Where there is a need for full control of the windshield surface to improve wiper performance and flush glazing, individual pieces of glass are press bent between a full surface male die and a peripheral female die to give a precisely formed surface.

Windshields are of a laminated construction. Laminated glass is made by sandwiching a plastic layer between two sheets of glass. After assembling the glass/plastic/glass sandwich it is heated and pressed under pressure in an autoclave until the laminate is fully bonded and optically clear. This construction gives enhanced safety and security performance as the plastic layer holds the glass splinters in place and resists penetration.

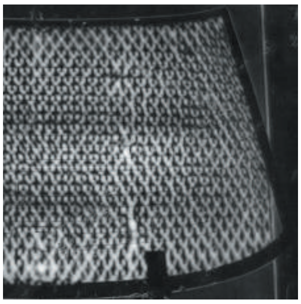
Sideglazings and backlights have traditionally been made of toughened glass although there is an increasing trend towards laminated glass.

Sidelights are generally simple in shape and are made by either sag bending or press bending technology depending upon whether the shape is nominally cylindrical or spherical.

Most backlights require advanced press bending technology in order to create the complex shapes for many of today's cars. The glass is transported through a heating furnace on ceramic rollers to the bending temperature (~650°C). It is then pressed to shape usually using a heated full surface male and peripheral female die and finally transported to the toughening station by a shuttle on a peripheral ring support.

The main purpose of the toughening processes is to introduce compressive stresses into the surface and thereby raise the loads that the glass can be permitted to bear. At the same time the resulting tensile stresses within the core of the glass create many small relatively harmless particles when the glass is broken.

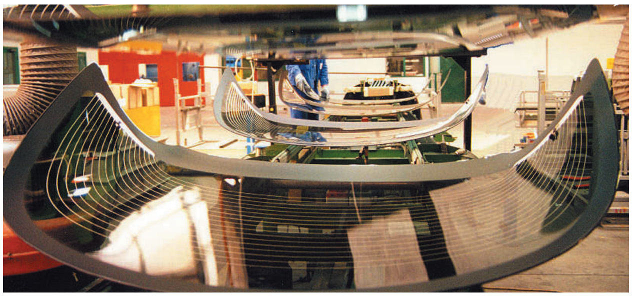
Thermal toughening is the most common way of toughening glass for use in products such as car side and rear windows. Glass is heated to about 650°C, then quenched with air jets so that the surfaces are cooled quickly and the core more slowly. At ambient temperature the core continues to cool and compression stresses develop in the surfaces, balanced by tension in the core.



Chemical toughening is used particularly to strengthen glass to very high levels in specialist applications such as aircraft glazings. It involves an ion exchange reaction which replaces sodium ions at the surface with bigger potassium ions, putting a thin layer of the surface into a high level of compression.

All glazings, whether Automotive or Architectural, require precise control of stress levels to ensure the product meets regulatory or environmental/robustness requirements. Various optical techniques are available to measure surface stresses, interior stresses and area stresses. Sometimes strain gauge technology is used to confirm that the product is able to withstand the thermal or mechanical stresses imposed by the glazing system.

Many products have printing inks applied to them. This can range from simple trademarks to obscuration bands (usually black inks), demisting and antennae circuits (usually silver inks) or decorative effects. The inks are usually ceramic based which means that they are composed of about 50% low melting point glass frit which permanently bonds the pigments etc. to the glass surface during the shaping or toughening process.



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