Volume deformations and viscoelasticity in laminated glass which contains plastic materials such as PVB were studied by the authors of this article who conducted an experimental analysis in an attempt to gain greater insight. In the course of their study, an FEM 3D model was created to evaluate stress formation, the observations and results of which are described in the text.

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Introduction: problems and tasks

In evaluating the performance of stratified glasses with PVB as an adhesive, two kinds of problems can be verified, depending on the lamination process: (a) in normal stratified glass, the presence of residual stresses which can induce - especially in glazings with complex and deep curvatures - delamination and crack formation and propagation; (b) the growth of internal stresses which favour wrinkling formation in stratified glasses by embedding a thin PET metallised film to obtain heatable glazing with solar control properties. ‘Wrinkling’ means waveform planarity deviations in the PET film which produce optical distortions.

In order to reduce the stress state present, we decided to investigate the role of plastic materials such as PVB employed in stratified glass. Profound knowledge of their properties and their behaviour during the lamination process can provide useful information on methods of optimising production parameters to achieve glazings with higher quality levels.

PVB behaviour during lamination

The PVB sheets for lamination are produced by the extrusion process, and material stretching to obtain film causes molecular orientation. Consequently, heating the film above the softening temperature creates the tendency of the molecular structure to arrange itself in a disordered state, causing shrinkage which results in differences between the flow and the transverse direction; in the machine direction the film is contracted, in the transversal direction it enlarges. The effects of such deformation are dependent on the film’s thickness, the type of polymer employed, on its polymerisation degree, and on other process parameters such as temperature and pressure. At times, these effects are so extensive they mask thermal expansion, as shown in Figure 1, wherein experimental results on the film’s free deformation during the typical long autoclave’s temperature cycle are illustrated. Based on these considerations, it is hardly difficult to understand PVB shrinkage contribution towards the growth of stress states in stratified glasses during the lamination process. Because of PVB’s viscoelastic properties, which determine molecular mobility, shrinking depends on the characteristics of production phases: pressure - temperature rise, maintenance and then decrease.

Laboratory activity

The role played by volume deformations and viscoelasticity is essential in the lamination process: because of the coupling of materials with different thermal behaviour, some stresses can originate at the contact interface and propagate towards the inside, thus compromising the glass’ optical quality and mechanical performance.

An analysis methodology has been set up to obtain useful suggestions to the problem of wrinkling. Experimental tests and an FEM model have been done to evalu-
...PVB

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...PVB
Conclusions

The properties of plastic materials, and in particular, PVB’s thermal behaviour, assume an important role in stress state growth in stratified glasses. Knowledge of dimensional thermal instabilities and viscoelasticity of these plastic materials, leading to greater comprehension of lamination, can furnish considerable support in dealing with product performance problems. Performing experimental tests and with an FEM model, we have gained indications on the method of selecting the appropriate materials, and on how to adjust the process parameters to improve product quality.

References:


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Fig. 1
Experimental results on PVB film free deformation during autoclave temperature cycle.

Fig. 2
Shear Modulus Relaxation for PVB at different temperatures.

VIRACON INTRODUCES
HURRICANE-RESISTANT GLASS

In order to meet the safety requirements of the strict new South Florida building code, US company Viracon, has introduced Viracon Hurricane-Resistant Glass consisting of standard Viracon annealed or heat-strengthened glass laminated with DuPont SentryGlass® composite. The SentryGlass composite combines an interlayer of Butacite® PVB with a strong exterior layer of clear polyester film, which has a hard, abrasion-resistant coating. The new South Florida building code requires that all window systems in commercial and residential buildings pass debris impact and cyclic pressure tests that replicate the effects of a hurricane.

In the "large missile test," three identical window systems must survive two head-on impacts from a shot fired from a specially designed missile cannon at 35 miles per hour. Next, in the "small missile test," the same window systems must withstand the impact of 2 grammes of roof gravel shot from the test cannon 30 consecutive times at 55 miles per hour. If the glazed assemblies pass both the large and small missile tests without penetration, each window then undergoes "cyclic pressure" tests to simulate hurricane winds. The 4,500 positive cycles inward and the 4,500 negative cycles outward create an intense vacuum behind the window. To pass this tough series of tests, the glass cannot exhibit a tear or crack longer than 5 inches or an opening through which a 3-inch sphere could pass.

Viracon Hurricane-Resistant Glass protects building interiors from hurricane winds and flying debris propelled by the winds. According to Steve Wetzel, Viracon’s manager of specialty products, the most severe damage to buildings during hurricanes happens when an opening is breached. Once windows are broken, it is much more likely that the roof will be blown off, resulting in extensive interior water and wind damage. Hurricane-Resistant Glass also prevents glass spalling, the release of glass shards or slivers, which happens when glass is impacted from the opposite side. On the security front, Viracon Hurricane-Resistant Glass passes burglar-resistant tests, offering smash-and-grab security protection while providing excellent clarity and optical performance. Viracon Hurricane-Resistant Glass has a 3-year warranty against delamination. Completed and in-process installations of Viracon Hurricane-Resistant Glass in South Florida include a US car rental company building at the Fort Lauderdale Hollywood Airport, Nova Southeastern University in Fort Lauderdale, the Helman International building in Miami, and several other buildings in the US.

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