Characterization of polymeric interlayer materials in the laminated state using fibre optic sensors

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Abstract

Fibre optic sensing based on the Rayleigh signal analysis supports the investigation of the deformation behaviour of structures in a comprehensive manner. Glass fibre sensors with a diameter of approximately 0.2 mm applicated on the surface of any solid or soft material as well as embedded in composites, provide a high-resolution strain measuring with an effective distance between single measuring points of less than 1 mm. Compared with equidistant strain measurement such as strain gages, the fibre optic sensing enables a smooth progress of strain along the fibre axis with high local resolution. The study shows the applicability of fibre optic sensors on glass surfaces and the determination of the interlaminar behaviour of polymeric interlayer material under static and thermal load. The elastic parameters depending on time, strain and temperature are examined on large-scale specimen in bending tests and compared with standard tests on small scale specimen such as shear tests and tensile tests.

The results show, that the standard tests give proper initial values of the pure interlayer material. However, the structure-related effects of laminated interlayer material like the locking effect or the restraint of lateral extension can be captured more detailed using different large-scale tests on laminated glass specimen. In addition to the small-scale tests the large-scale tests show a decreasing statistical dispersion caused by large effective area of investigation and large amount of data along the measurement section. In conclusion, fibre optic strain sensors provide a powerful method in structural studies on laminated glass, that supplement standard systems for the determination of the thermo-mechanical behaviour of polymeric interlayer materials in the laminated state. Both, the determination of the mechanical behaviour of several polymeric interlayer materials in glass laminates and the evaluation of the numerical model can be used as a basis for computer-aided analysis of building structures on the one hand and the resource saving virtual prototyping on the other hand.

The distributed measuring of surface strain components other methods of characterising interlayer materials such as the dynamic-mechanical thermal analysis (DMTA) as well as small-scale tensile and shear tests. In addition, the distributed measurement of surface strain in a large-scale bending test offers a suitable method for the determination of material parameters such as the elastic modulus and the shear modulus. The measurement applied is mainly used for the examination of the load bearing behaviour of laminated glass panes. It does not replace methods like DMTA or temperature- and time-controlled tensile test which are also useful to describe the rheological behaviour of polymeric materials. Furthermore, the application limits of different analytical methods for investigating the behaviour under thermal- and force-induced loading by measuring the strains between the layers in the laminated state are shown. In particular, high interlayer thicknesses compared to the glass sheets lead to nonlinear shear deformations, which can be detected by a comprehensive strain measurement, such as distributed measuring fibre optic sensors.