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QUANTITATIVE DETERMINATION OF GLASS FIBER CONTENT IN FIBER-REINFORCED COMPOSITE MATERIALS

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1. Introduction

During the operational use of fibre-reinforced composite components, structural defects such as cracks, delamination, or fibre breakage may develop due to mechanical overload, cyclic fatigue, environmental degradation, or manufacturing imperfections [1,2]. These defects can compromise the integrity of the load-bearing structure, resulting in a reduction of stiffness, strength, and overall performance. The propagation of such damage under service conditions not only shortens the component's lifespan but also increases the risk of sudden failure, which can have severe safety and economic consequences [1]. Understanding the underlying causes and mechanisms of crack formation is therefore essential for implementing effective preventive measures and improving the durability of composite structures [2].

"Burn-off" and resin removal techniques are widely applied in composite characterization to evaluate fibre–matrix ratios and detect potential structural inconsistencies [3-5]. The results provide insight into material uniformity and support the evaluation of possible links between fibre content and the occurrence of structural defects [4]. In this study, the mass fraction of glass fibres in a composite door panel was determined to assess whether material composition differences exist in defect-prone zones compared to unaffected areas.

2. Materials and methodology

The experimental procedure followed [3]. Mass measurements before and after combustion, as described in [3], enable precise quantification of the glass fibre content. Five specimens were prepared from the crack formation zone (Fig. 1), along with five control specimens intended to represent the characteristics of other areas of the panel (Fig. 2). The geometry of each specimen was precisely digitized using the ATOS optical measurement system [6] (Fig. 3a). This measurement and the resulting model enable accurate determination of the volume of each specimen.

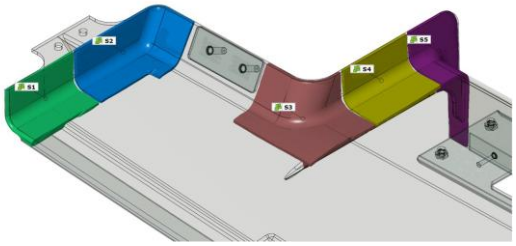

Fig. 1. Test pieces from the crack-affected zone.

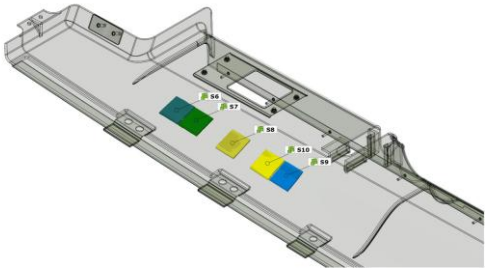

Fig. 2. Specimens made outside the crack formation zone – control specimens.

The mass of each sample before and after the test was precisely measured with an analytical balance (Figure 3b). The furnace with high-temperature combustion at 600 °C is used to remove the polymer matrix in the specimens (Fig. 3c). The specimens after burning contained a certain amount of powdered base material, so they were separated from the glass fibres (Figure 4).

3. Results

Figure 5 shows the density of the specimens, while Figure 6 shows the fiber glass content in the composite material.

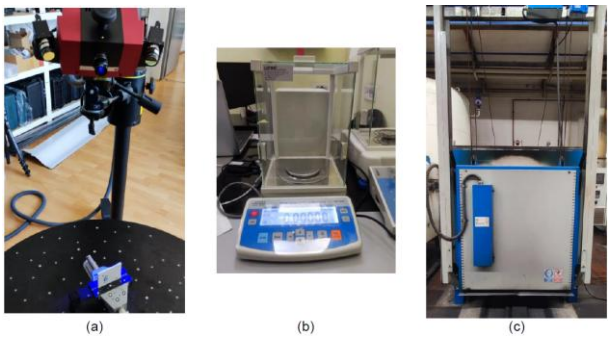

Fig. 3. Equipment used during testing:
(a) Optical measurement device ATOS,
(b) Analytical balance RADWAG,
(c) High temperature furnace Grejač Komerc.

Fig. 4. Specimens after exposing to high temperature, cleaned of base material and prepared for measurement.

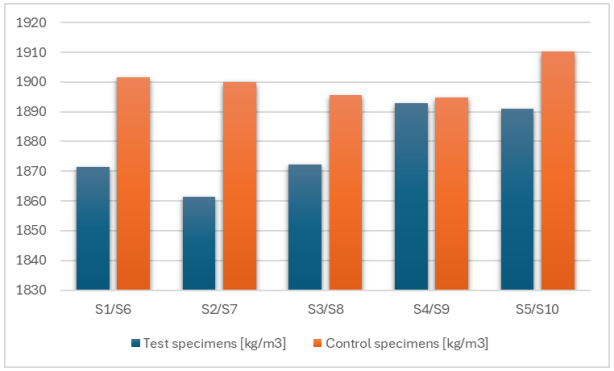

Fig. 5. Density of specimens

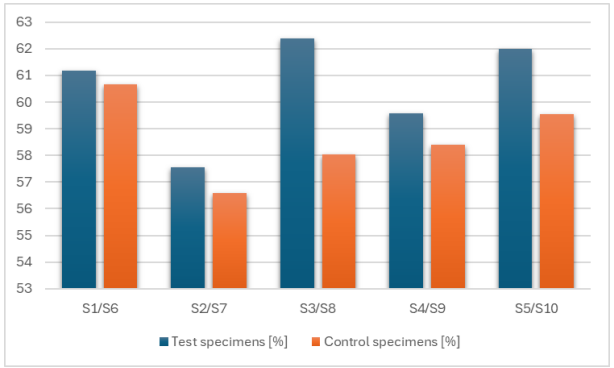

Fig. 6. Fiber Glass Content in the Composite Material

4. Conclusions

The results revealed a slightly higher average fibre mass fraction in the defect-prone zone compared to control areas, accompanied by a marginal decrease in density. This indicates potential microstructural irregularities such as voids, resin-rich areas, or incomplete fibre impregnation, which could influence local stiffness, stress distribution, and crack initiation mechanisms. These findings highlight the importance of combining compositional analysis with volumetric quality control to ensure consistent manufacturing quality and to improve the structural reliability of composite components in demanding operational environments.

The integration of [6] with high-precision optical 3D digitization and analytical mass measurement proved to be an effective approach for accurately determining the glass fibre content in fibre-reinforced composite panels.

Acknowledgments

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