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EXPERIMENTAL-THEORETICAL RESEARCH OF THE EFFECT OF MANUFACTURING DEFECTS ON THE STRENGTH OF COMPOSITE STRUCTURES WITH IN-SITU X-RAY MONITORING

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ABSTRACT

This work presents the study of the effects of various manufacturing defects on the strength of composite structures according to the size and location of the defects. The L-shaped composite flanges made of carbon laminate with the use of resin transfer moulding (RTM) technology were taken for the mechanical tests with in-situ X-ray monitoring. The numerical simulation of stress-strain state of this structure under testing load was carried out by finite element method (FEM) with ANSYS Workbench software.

Keywords: polymer composites, microfocus x-ray, testing, finite elements.

INTRODUCTION

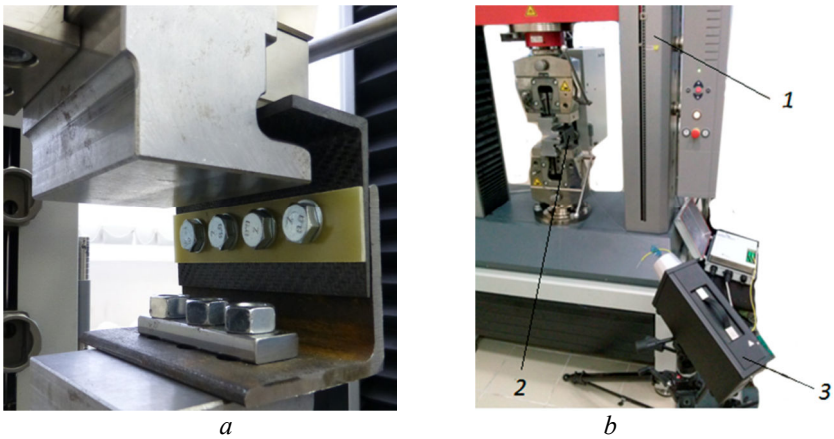
The use of polymer composite materials for advanced aeronautical engineering requires taking into account their high susceptibility to interlayer defects and damage in the form of delamination. Thus, the composite constructions must be inspected for small initial defects and damages before they become catastrophic because of the increase of their number and combination with other damaged areas. Radiography (X-ray monitoring) is one of the most promising techniques for internal defects detection (Brault, 2013; W.J. Na, 2012 and Swygenhoven, 2013).

The main types of manufacturing defects which have been artificially created in the step of samples molding were analyzed: voids, delaminations and curvature of the layers. The mechanical testing of L-shaped flange samples was carried out on Zwick Z100 machine using specially developed fixture (Figure 1).

RESULTS AND CONCLUSIONS

During the samples testing the stress-strain curves and X-ray images with the fixed tensile force were received. The areas of interlayer cracks localization and their estimated sizes values were identified at the various load levels.

The three-dimensional computer models of L-shaped flanges with various defects for stress-strain analysis were created (Figure 2). The numerical simulation of the mechanical testing of these samples was carried out by finite element method (FEM) with ANSYS Workbench software.



a *b*

Fig. 1 - Testing sample in fixture (a) and testing equipment (b): 1 - Zwick Z100; 2 - sample; 3 - X-ray unit.

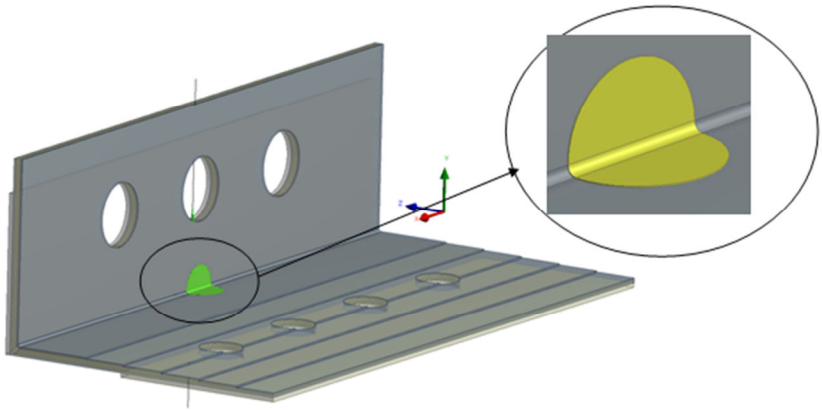


Fig. 2 - 3D model of composite flange with embedded delamination area

The obtained numerical results were compared with the X-ray radiography results and experimental testing data, good qualitative correlation was found.

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