ICMSSM 2021
7th International Conference on Mechanical Structures and Smart Materials
CHANGSHA, CHINA
14 – 15 June 2021

Tomasz Lusiak[1], Andrej Novák[2] , Michal Janovec[2], Martin Bugaj[2]

[1]Lublin university of Technology, 36 Nadbystrzycka St., 20-618 Lublin, Poland
[2]University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia

Measuring and Testing Composite Materials Used in Aircraft Construction

Abstract

This paper is focused on the use of special composite materials for the construction of aircraft components. It focuses on measuring and testing the strength of reinforced composite materials used in damaged aircraft parts repairs. To determine the layer required to repair a part of the aircraft, it is necessary to know the strength limit of the material and its parts. The article describes experimental measurements of manufactured composite samples that have been subjected to tensile stress. Aim of the performed tensile tests was to determine the maximum tensile stress that the composite materials are able to transmit until they are damaged. Measurement determining the maximum stress level is important to ensure the required safety of the aircraft structure on which the composite structure was repaired.

Introduction

Composite materials are very important materials for the aerospace industry. Compared to metal structures, they provide greater strength to the structure at reduced weight, thus reducing fuel consumption, increasing efficiency and reducing the direct operating costs of the aircraft. From a design point of view, the composite part of the aircraft has a smooth profile, with a low number of riveted or other joints, which provide several advantages. Thanks to the current development progress, we can conclude that composite materials are beginning to be used even in the most stressed structural parts of aircraft. These materials are becoming increasingly used in the secondary construction of aircraft.

Test methods a sample preparation

The tested objects are composite samples produced by the method of manual lamination using epoxy resin MGS L285 / H285. The fabric reinforcement was applied in different arrangements (0/+90° and +/-45°) then an elastic bag attached to the periphery of the mold was applied, and any excess resin and air was extracted with a vacuum pump. The laminate was cured at an atmospheric pressure of 0.9 atm. The next stage of preparation was to subject the samples to the temperature of 60° C for 8 hours. Subsequently, specimens with dimensions according to ASTM D3039 were cut from the resulting plate. The final step in specimen fabrication was to adhere overlays to the edges of the glass-epoxy composite laminate to protect the specimen from damage in the grips of the testing machine. Composite specimens reinforced with ST-IMS modular fabric, series F (Fig. 1), were used for the tests.

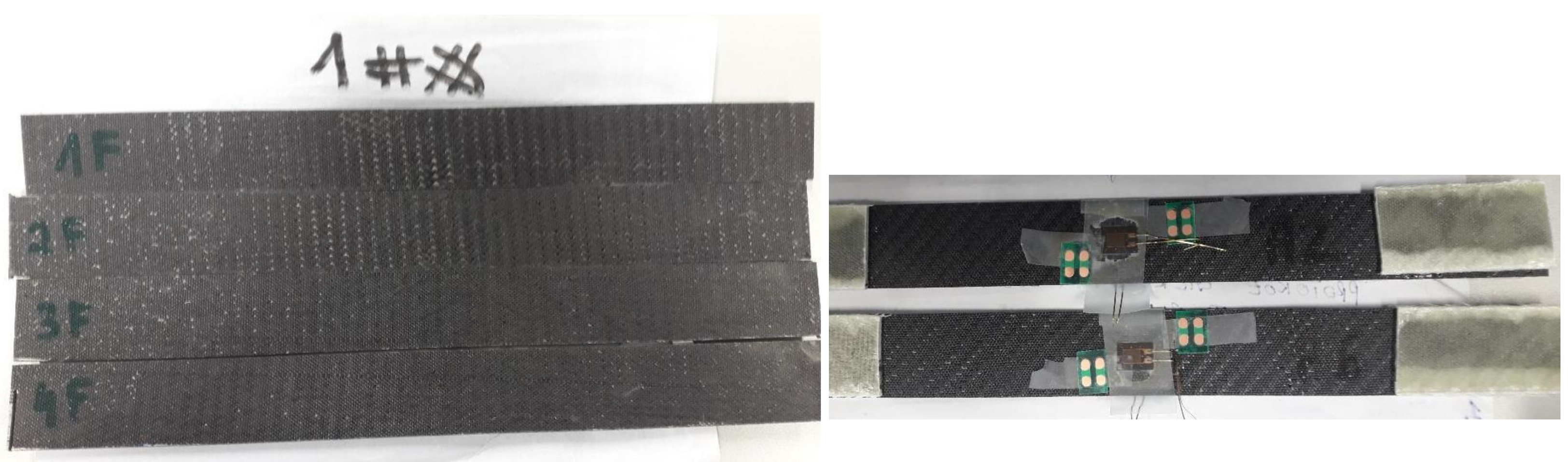

Figure 1 *– a) Photo of composite material samples. b) Strain gauges connected to solder strips.*

Results

The tests were conducted on a tensile testing machine, which is used to perform static tensile tests on any material in different temperature ranges. Tests were performed at a constant strain rate. The data is sent directly from the measuring machine to a specialized software where it is saved as a file. The measured values that are transmitted can be adjusted by a time factor, a change in the magnitude of the force or a shortening / lengthening. The advantages of the Instron testing machine are the ease of use due to automatic closing and opening of the extensometers, an alternative for determining the modulus of elasticity, an innovative control system that allows you to interchange parameters during the test thanks to having two workspaces. The force is recorded for each range not exceeding 5% and the value is recorded with very high accuracy.

Number	Width [mm]	Length [mm]	Thickness [mm]	Area [mm²]	Tensile strength [Mpa]	Maximum deformation [%]
1	25.1	150	2.60	65.3	468	1.35
2	25.2	150	2.64	66.7	399	1.12
3	25.2	150	2.60	65.5	351	1.03
4	25.2	150	2.65	66.9	447	1.26
5	25.2	135	2.56	64.6	414	1.05
6	25.3	150	2.65	66.9	453	1.24
7	25.2	135	2.55	64.1	400	1.05
Average	25.2	146	2.61	65.7	419	1.16

Table 2 *– Analysis of test results obtained for composite laminate reinforced with Aspro A80 symmetric fabric, weave 0/90°.*

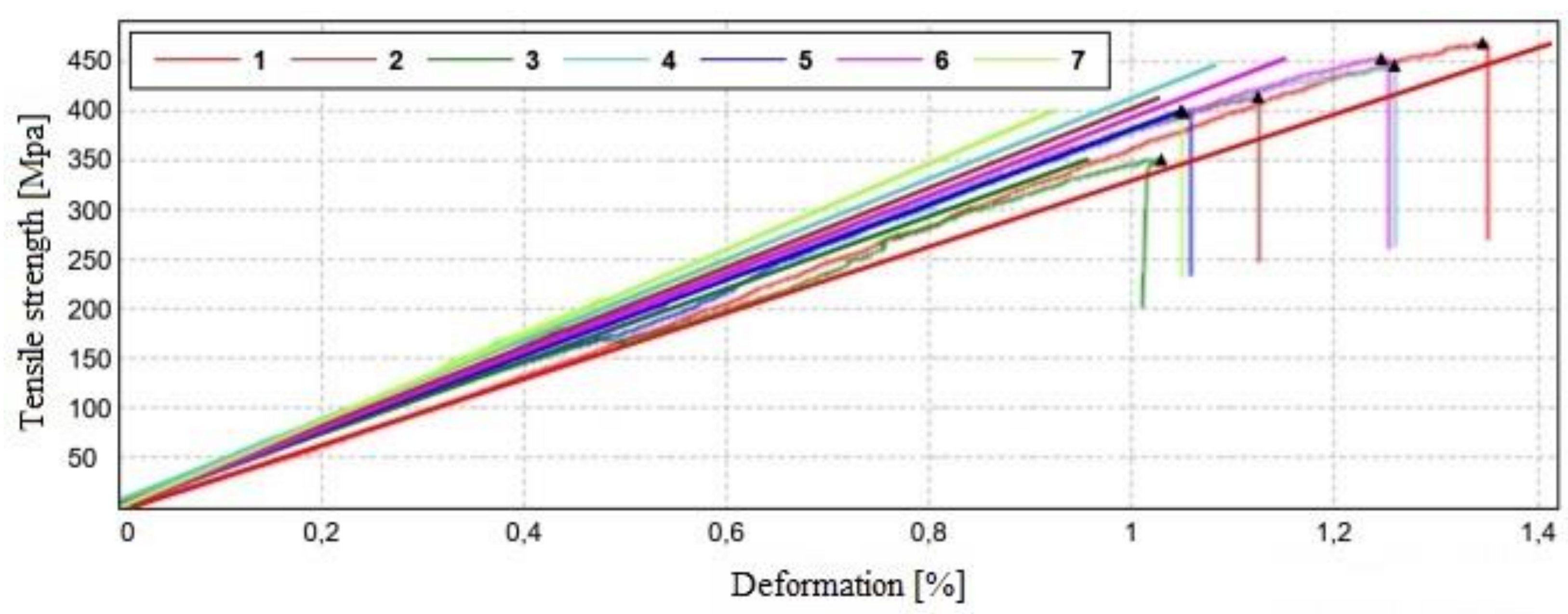

Figure 2 *– Diagram showing tensile strength and strain of laminate reinforced with Aspro A80 symmetric fabric 0/90° weave.*

The maximum values of tensile stress ranged from 351 to 468 MPa. The apparent difference in maximum strain ranged from 1.03 to 1.35 % (Tab. 2). The specimens marked 3 and 4 delaminated much faster than the other specimens after exceeding 150 MPa, a phenomenon that may have been caused by previous microcracks in the structure of the specimens. The obtained dependence is characteristic for brittle materials, because the maximum loading force destroys the sample. The tensile strength value of the composite laminate R_m is equal to 419 ± 29.7 MPa.

Acknowledgement

This work was supported under the project of Operational Programme Integrated Infrastructure: Research and development of contactless methods for obtaining geospatial data for forest monitoring to improve forest management and enhance forest protection, ITMS code 313011V465. The project is co-funded by European Regional Development Fund.

Conclusion

Composites that use polymeric fibers reinforcements in their construction initiated a further search for newer and better construction materials. Especially with attention to their strength. Attributes resulting from the structure of plastics such as lightness, vibration damping and resistance to external factors significantly contributed to their expanded use in aviation. It was these aspects that led to further search for better and better materials. At a time when the economy is playing a major role in aircraft manufacturing, there is a need to develop new hybrid materials that provide better properties than those currently used. Composite materials provide a more suitable solution for the production of aircraft components. They reduce the weight of the aircraft, require less maintenance, have a longer service life and provide a smooth surface without the need for joints, resulting in reduced fuel consumption. In the case of damage to composite materials, higher demands on material repair are observed compared to metallic materials. Due to the more difficult diagnosis of possible hidden damage to the structure of these materials, an adequate diagnostic technique designed specifically for these materials is required.