MECHANICAL BEHAVIOUR OF HYGROTHERMAL CONDITIONED FIBER METAL LAMINATES

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Keywords: Fibre Metal Laminates, environmental conditioning, mechanical properties, moisture absorption.

Abstract

Wide field of applications of composite laminates indicates the possibility of danger from environmental factors. This paper presents the effects of elevated temperature and moisture conditioning of Fiber Metal Laminates on some mechanical properties of these materials. Laminates consisting of 2024 aluminum alloy sheets reinforced with glass/epoxy and carbon/epoxy composites were taking account in the tests. The mechanical properties have been investigated by tensile, share and ILSS tests. Additionally, the moisture equilibrium for both Fiber Metal laminated and fiber reinforced composites specimens was determinated. The obtained results show the differences in moisture absorption and strength degradation of Fiber Metal Laminates and Fiber Reinforced Polymer composite specimens after conditioning. Loss of strength properties in the various tests have different values but the main trends have been identified.

1. Introduction

In recent years, composite structures have become very popular materials for different applications, predominantly in the aerospace industry [1]. Their large spectrum of properties like strength and stiffness-to-weight ratios, fatigue characteristics and corrosion resistance comprise several extremely distinctive advantages for application in lightweight primary structures. On the other hand, polymeric composites are sensitive to environmental factors such as elevated temperature and humidity [2-4]. It is well known that environmental influences may cause a decrease of mechanical properties of polymers. One of the main and significant purposes of the design process is to ensure the durability and safety of the structures. Materials that have the potential to meet these requirements are Fiber Metal Laminates.

2. Materials and methods

The subject of examination was aluminum/GFRP and aluminum/CFRP Fiber Metal Laminates (AlG, AlC respectively). The Fiber Metal Laminates were manufactured by stacking alternating sheets of 2024-T3 aluminum alloy and fiber/epoxy composite prepregs made from unidirectional prepreg tapes HexPly system (Hexcel, USA) in [0,90], configuration. The thickness of metal sheet was 0,3mm. All of the laminates were produced by autoclaving at 135°C and at a pressure of 0,45 MPa. The negative pressure in the vacuum bag was 0.1 MPa. After curing laminates were conditioned according to ASTM D5229.

Investigation of the influence of accelerated environmental conditioning was carried out by determining the changes in the interlaminar shear strength in short beam bending test (ILSS). Firstly the test samples were dried at 70° C for 10 days in order to remove moisture. The samples were then conditioned at 70°C and 99% relative humidity until the equilibrium state was reached. After the exposure, the static tensile test, and the short beam bending test were performed.

3. Results

The results of mass change of environmental conditioned samples are shown in table 1.

Material	Layups	Weight loss (desorption) [%]	Test 1 duration [days]	Weight increase (absorption) [%]	Test 2 duration [days]
GFRP1	$[0,90]_2$	0,045	10	0,825	60
GFRP2	$[0,90]_4$	0,016		0,663	
CFRP1	$[(0)_2,(90)_2]_2$	0,043		1,073	
CFRP2	$[(0)_2,(90)_2]_4$	0,077		1,148	
AlG1	0,3 2/1 [0,90]	0,0035		0,118	
AlG2	0,3 3/2 [0,90]	0,0033		0,085	
AlC1	0,3 2/1 $[(0)_2,(90)_2]$	0,0013		0,133	
AlC2	0,3 3/2 $[(0)_2,(90)_2]$	0,0016		0,201	

Table 1. The change in mass of test samples

There is a significant difference in moisture absorption between the traditional polymer composites and Fiber Metal Laminates. Traditional laminates absorb approximately 10 times more moisture as compared to Fiber Metal Laminates.
The results of ILSS test of environmental conditioned samples are shown in figure 1.

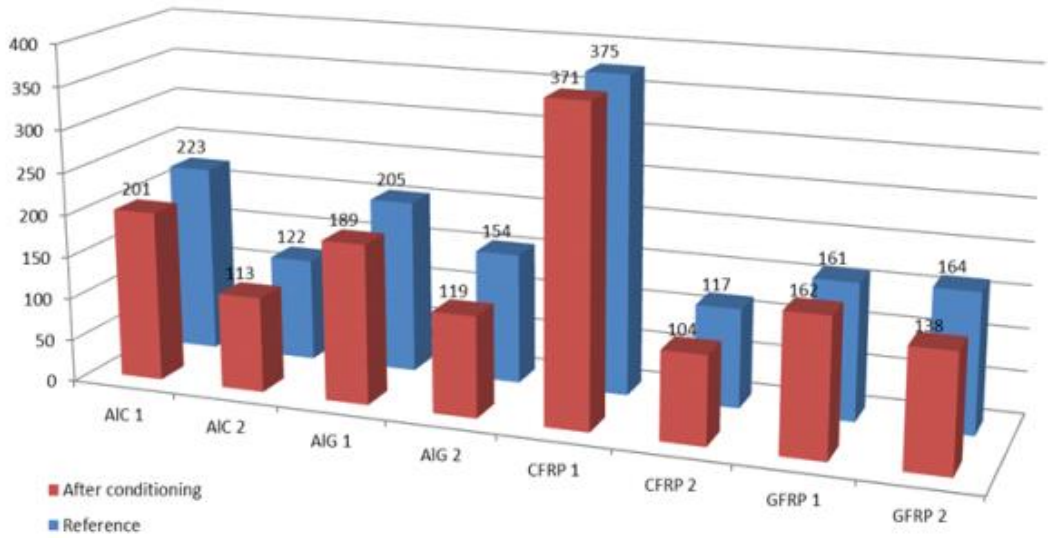

Figure 1. The results of ILSS test

Both tested fiber-metal laminates and polymer composites are characterized by a decrease in interlaminar shear strength defined in the short beam bending test after exposure to environmental conditioning. The decrease in ILSS strength is similar for both material groups.

4. Conclusion

- Experiments have shown that the fiber-metal laminates are characterized by a much smaller moisture absorption capability
- Long term environmental conditioning in elevated temperature and moisture negatively affect the interlaminar shear strength determined in the short beam bending test.
- Results of ILSS strength tests confirm the decrease in strength associated with exposure to environmental factors.

Acknowledgements

Financial support of Structural Funds in the Operational Programme - Innovative Economy (IE OP) financed from the European Regional Development Fund - Project No POIG.0101.02-00-015/08 is gratefully acknowledged.

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