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EXPERIMENTAL AND NUMERICAL INVESTIGATION OF THE EFFECTS OF STACKING SEQUENCE AND STRESS RATIO ON FATIGUE DAMAGE OF GLASS/EPOXY COMPOSITES

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Abstract

In the present paper fatigue behavior of glass/epoxy composite materials under different stress ratios and for various plies orientation angles has been established. Experimental and numerical analysis (Finite Element Method) were performed on various specimens subjected to cyclic tensile tests in order to outline the influences of stress ratios and the stacking sequence ($[0_2/90_2]_s$; $[90_2/0_2]_s$; $[0_3/90]_s$; $[90_3/0]_s$) on glass/epoxy fatigue properties. Static analysis is done experimentally to identify the stress-strain diagrams, strain to failure, Young's modulus and tensile strength for each stacking sequence. Comparison between experimental and numerical prediction show good agreement. The Results of this investigation can lead us to choose the most optimal stacking sequence for giving boundary conditions to achieve the maximum fatigue life.

Keywords: Composite; Fatigue; Stress ratio; Stacking sequence; Finite element method.

1. Introduction

The increased demand for composites is mainly due to their variant applications in several areas in which lightness, rigidity and good resistance to damage are requested .Their use became more and more important in a wide range of structural components which must withstand various types of constant and variable amplitude fatigue loads, such on the construction of several frameworks in various areas (buildings, public works and transportations).

The glass/epoxy material is one of the most used composite, especially in aerospace and automotive applications, due to their high mechanical performances and low specific weight comparing to other materials. In that fact, engineers and research scientists are required to reconsider fatigue loading as an important factor which may lead to the fracture of this composite. Therefore, mechanical properties of glass/epoxy composite were a subject of thorough and extensive studies. However, it's more complex to characterize their fatigue behavior comparing to metal materials due to their micro-structural composition (anisotropy, heterogeneity, fiber/matrix interface properties). Many studies [1-3] shows that the fatigue behavior of composite materials is mainly due to the stiffness changes during cycles, which can be divided into three stages: the first stage is characterized by a rapid decrease in stiffness and the formation of ''damage zones'' with multiple microscopic crack. After in the second stage the stiffness degradation became lower and substantially linear in function of the number of cycles, more serious types of damage appears such emergence and growth of delamination, this stage lasts about 90% of the total life. Finally the third stage is characterized by a high level of stiffness degradation associated with a rapid development of all types of fatigue damage,