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Fatigue damage in angle-ply GFRP laminates under tension-tension fatigue

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Abstract

The fatigue behavior of $(\pm45)_{2S}$ angle-ply glass/epoxy composite laminates was investigated. Rectangular specimens were subjected to constant amplitude fatigue loading at different stress levels, with stress ratio 0.1 until failure. A video-extensometer and an infrared thermal camera were employed respectively to measure the evolution of strain and the self-generated temperature during the fatigue experiments. Using a digital camera and microscope, the progression of damage at the different locations and the fracture surfaces were also studied. At higher stress levels the damage was severe and localized and caused fiber pull-out failure at short lifetimes; however, by decreasing the fatigue stress level, a more uniform distribution of less severe damage was observed and fiber breakage prevailed, which led to a longer fatigue life. When the number of cycles was increased, the fatigue stiffness dropped at a higher rate at higher stress levels at the same age due to the localized and intense damage growth. The fatigue stiffness at failure, however, decreased more at lower stress levels than at higher ones, which was attributed to the material's greater capacity to withstand damage. The dissipated energy increased with the number of cycles and fatigue stress level due to more friction in the area of the unbounded regions; the magnitude of the total energy dissipation (TDE) however significantly decreased as the fatigue stress level increased.

Keywords;

Fatigue; Damage mechanism; Dissipated energy; Self-generated temperature; Reflectance

1. Introduction

Damage accumulates in the volume of composite materials during fatigue loading and eventually leads to failure. Several damage mechanisms, including fiber breakage and matrix cracking, debonding, transverse-ply cracking, and delamination, are activated either independently or synergistically during fatigue loading; the predominance of one or the other is strongly affected by both material variables and the sequence and duration of the damage events [1, 2]. The presence of these damage mechanisms results

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