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Strain rate effects on the intralaminar fracture toughness of composite laminates subjected to tensile load

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Abstract

This paper presents a numerical and experimental study on the intralaminar tensile fracture toughness of carbon fiber reinforced composite subjected to high strain rates. As there is no standardized testing procedures for intralaminar fracture toughness characterization of composites at high strain rates, there is a clear need to design specimen geometries, testing apparatus and data reduction schemes that allows the characterization of the fracture toughness of composites in the dynamic regime. Initially numerical studies were performed based on finite element simulations in order to investigate the viability of its construction for different testing configurations to characterize the intralaminar toughness of composite laminates. A comparative study is presented showing the advantages and disadvantages of each testing configuration. A new data reduction scheme based on modifications in the ASTM standard, accounting for material anisotropy and specimen finite geometry effects is suggested. Experimental tests were carried out, using the proposed specimen configuration at different strain rates in order to investigate the strain rate effects using a modified version of the Split Hopkinson Pressure bar. Fractography analyses using Scanning Electron Microscopy(SEM) have been also performed in order to investigate the strain rate effects on the failures mechanisms of the composite material studied herein.

Keywords: Composite materials, Fracture mechanics, Dynamic analysis, Failure analysis, Fracture toughness

1. Introduction

Nowadays, modern structures require materials with a variety of unusual combinations of properties that can not be achieved by conventional materials, therefore, carbon composite laminate materials are increasingly being used in the industries, especially in aeronautics. The use of composite materials has grown annually in the aeronautic industries, due to the clear need of reducing weight, but preserving the structural strength and stiffness of the structural parts. Many primary structures that are conventionally made of metals have been replaced by composite materials, such as, fuselage, spoilers, doors and etc [1]. However, this replacement from metals to composite materials should be done with care, mainly in critical parts of primary structures, because the mechanical behavior of composite materials is not thoroughly known like metals, particularly in the dynamic regime.

In recent years a considerable effort has been dedicated towards a better understanding on the mechanical behaviour of composites structures **when they are subjected** to extreme loading conditions such as impact

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