Identification of a critical time with acoustic emission monitoring during static fatigue tests on ceramic matrix composite: toward lifetime prediction

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Abstract

A main purpose of this paper is to consider the possibility of predicting rupture time of CMC from damage evolution recorded by AE technique. In this study SiC_f/[Si-B-C] composites are studied under fatigue at 450 °C under air. The objective of this approach is to propose a method based on acoustic energy in order to evaluate the remaining lifetime during long-term-mechanical tests. The approach is based on the determination of energy released and identification of a critical point in energy release during mechanical test. So beyond this characteristic point, the criticality can be modeled with a power-law in order to evaluate time to failure.

A parameter denoted R_{AE} has been defined. This coefficient is the increment of energy ΔE released during a time interval Δt, divided by the energy liberated during initial loading $E_{loading}$. In both cases, R_{AE} decreases first, down to a minimum value, and then it increases up to the failure of the composite. On average, the minimum of R_{AE} appeared at 55% of the rupture time. R_{AE} allows identifying a characteristic time and the minimum of coefficient R_{AE} indicates the beginning of the critical damage phase and provides an estimate of the remaining lifetime. Another parameter, denoted B, has also been introduced in order to evaluate energy attenuation in real-time due to damage. During the static fatigue test, attenuation coefficient B increases significantly during the first half of tests and reaches a plateau value at approximately 55% of the rupture time. The monitoring of attenuation coefficient B constitutes a new indicator for damage monitoring of ceramic matrix composites and the detection of the plateau is an indicator for lifetime prediction. Beyond, this characteristic time, the restart of activity prior to final rupture may be attributed to the avalanche fibres ruptures, controlled by the oxidation of fibres and by the recession of interfaces. The experimental results show that the Benioff's law, which was initially used to study the activation of a seism, was relevant on average after 55 % of rupture time. So the applicability of the Benioff law to model energy release associated with fibers failure offers a possible tool for lifetime prediction under static fatigue.

Keywords: Composite material, fatigue tests, Acoustic emission, lifetime prediction.