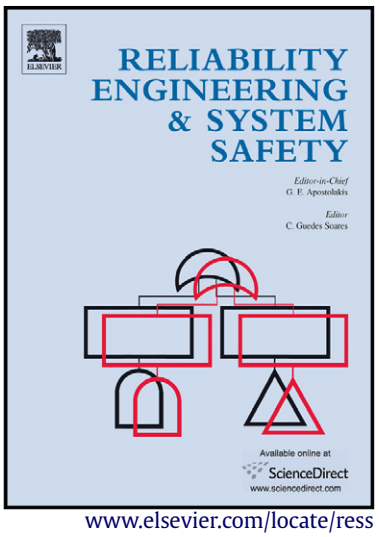

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Condition-based prediction of time-dependent reliability in composites

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Abstract

This paper presents a reliability-based prediction methodology to obtain the remaining useful life of composite materials subjected to fatigue degradation. Degradation phenomena such as stiffness reduction and increase in matrix micro-cracks density are sequentially estimated through a Bayesian filtering framework that incorporates information from both, multi-scale damage models and damage measurements, that are sequentially collected along the process. A set of damage states are further propagated forward in time by simulating the damage progression using the models in absence of new damage measurements to estimate the time-dependent reliability of the composite material. As a key contribution, the estimation of the remaining useful life is obtained as a probability from the prediction of the time-dependent reliability, whose validity is formally proven using the axioms of Probability Logic. A case study is presented using multi-scale fatigue damage data from a cross-ply carbon-epoxy laminate.

Keywords: Model-based prognostics, Time-dependent reliability, Fatigue, Composites.

1. Introduction

In general, the problem of damage prognosis is challenging [1–3] not only due to its complexity and multidisciplinary nature, but also for its direct impact on safety and cost. While structural health monitoring (SHM) technology has experienced a considerable development over the past two decades, little effort has gone into integrating SHM with prognostics science for lifecycle reassessment and condition-based maintenance [4]. The latter is especially significant for composite materials due to their increasing use in high-performance applications such as aeronautics or space. Composites are well-known for their high strength-to-weight ratios, but also for being susceptible to damage from the beginning of lifespan [5, 6]. This damage can be hard to detect [7] and usually becomes a critical issue for reliability and competitiveness

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