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Utilizing AE data and stochastic modeling towards fatigue damage diagnostics and prognostics of composites.

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The procedure of damage accumulation in composite materials, especially during fatigue loading, is a complex phenomenon which depends on a number of parameters such as ply orientation, material properties, geometrical non-linearities etc. Towards condition based health monitoring and decision making, the need not only for diagnostic but also for prognostic tools rises and draws increasing attention the last few years. The damage process is in general hidden and manifests itself through in-situ structural health monitoring (SHM) data. Due to the hidden nature of the damage accumulation, non-homogenous hidden Semi Markov process (NHHSMP) seems to be a suitable candidate for describing adequately the aforementioned system's degradation in time. Its non-homogeneous aspect takes into account the system's ageing. Moreover, the sojourn times in each state are assumed to be generally distributed, not necessarily exponentially distributed, which is a more realistic assumption for real world engineering systems. The SHM observations are coming from acoustic emission (AE) data recorded throughout constant amplitude fatigue testing of open-hole carbon/epoxy coupons. The scatter of the cycles to failure reported is quite large, an expected result of the stochasticity in the material properties and material inhomogeneities. A maximum likelihood approach for the estimation of the model parameters is followed and useful diagnostic and prognostic measures such as the coupon's current degradation level as well as measures the coupon's remaining useful life (RUL) are proposed for the monitoring of structural integrity of composite materials.

Keywords: composite materials, structural health monitoring, stochastic modeling, fatigue, acoustic emission