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Model-Based Fault Diagnosis in Carbon Fiber Reinforced Composites Using Particle Filtering

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Abstract : Carbon fiber reinforced composites (CFRP) used as aircraft structure are subject to lightning strike, putting structural integrity under risk. Indirect damage may occur after a lightning strike where the internal structure can be damaged due to excessive heat induced by lightning current, while the surface of the structures remains intact. Three damage modes may be observed after a lightning strike: fiber breakage, inter-ply delamination and intra-ply cracks. The assessment of internal damage states in composite is challenging due to complicated microstructure, inherent uncertainties, and existence of multiple damage modes. In this work, a model based approach is adopted to diagnose faults in carbon composites after lighting strikes. A resistor network model is implemented to relate the overall electrical and thermal conduction behavior under simulated lightning current waveform to the intrinsic temperature dependent material properties, microstructure and degradation of materials. A fault detection and identification (FDI) module utilizes the physics based model and a particle filtering algorithm to identify damage mode as well as calculate the probability of structural failure. Extensive simulation results are provided to substantiate the proposed fault diagnosis methodology with both single fault and multiple faults cases. The approach is also demonstrated on transient resistance data collected from a IM7/Epoxy laminate under simulated lightning strike.

Keywords : carbon composite, fault detection, fault identification, particle filter
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