Fatigue Damage Growth Analysis of Composites under Variable Amplitude Fatigue

Waruna Seneviratne and John Tomblin
Wichita State University
Wichita, Kansas

ABSTRACT

The primary goal in a damage-tolerance certification program is to avoid catastrophic failure due to fatigue, corrosion, or accidental damage throughout the operational life of the aircraft. The damage-tolerance philosophy is well established for metallic airframes, where proven methods (structural analysis and inspection procedures) and supporting databases exist to detect damage and predict crack growth and residual strength. Damage growth mechanics and load spectra for composite and metal structures have significant differences that make the certification of composite-metal hybrid structures challenging, costly and time consuming. For metallic damage growth under spectrum loading is approximated using Minor's rule. Anisotropic heterogeneous characteristics and change in failure modes over the fatigue life as well as multiple failure mechanisms that interact with each other make it challenging to predict damage growth in composite structures. Consequently, most of the damage mechanisms and wearout approaches discussed in the literature also depend on empirical data for refinement or calibration. Some approaches only discuss failure progression under certain loading configurations and often specific to a material system. A semi-empirical fatigue analysis technique is developed using the residual strength degradation or wearout. A model is developed for using Sendeckyj analyses conducted for fatigue SN curves with various stress ratios (expected in load spectrum) so that the residual strength degradation during spectrum loading can be tracked. Unlike Minor's rule, this approach is sensitive to load sequencing. This approach also account for data scatter observed in composite fatigue data.