Nonlinear Crack Growth Monitoring

Current design methods focus on crack growth curves which are material properties for given materials and environments. Structures subject to crack growth spend 90B95% of their lifetime in nucleation of very tiny flaws into measurable crack sizes. Due to the large variation in initial flaw sizes and the mathematics of flaw growth, the fatigue lifetimes, even of high-quality structures, can vary by a factor of as much as 10 to 20 even in a small fleet. This large variation in fatigue lifetimes leads to conservative statistics, which often prompts the premature retirement or overhaul of vehicles or other structures, since they focus on the weakest members of the fleet, while the remainder of the fleet is sound.

In the past two years, Oak Ridge National Laboratory (ORNL) has developed a new Griffith energy-based technique that can provide useful warning of the impending failure of a structure due to end-of-life crack propagation. This technique has been demonstrated by test and analysis in fiberglass composite, aircraft aluminum, and construction steel under pristine and corroded conditions, and for Mode I and Mode III fatigue, as well as Mode I low-temperature creep and stress corrosion.

Laboratory experiments on test coupons and actual aircraft flight hardware have demonstrated the usefulness of this technique in the following separate cases:

Material	Loading	Crack mode	Environment	Crack growth mode
Fiberglass	Tension	Mode I	Air, RT	Fatigue
2024-T3	Flexure		Artificially corroded	Low-temperature creep
ASTM A-36	Compression	Mode III	Seawater, RT	Stress corrosion