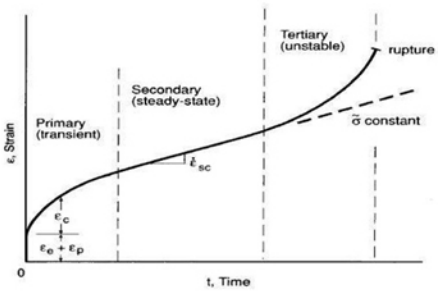
Innovation @ WSTF 2011

Use of Modal Acoustic Emission to Monitor Damage Progression in Carbon Fiber/Epoxy Tows and Implications for Composite Structures



Distinct tertiary creep phase (ductility observed before rupture) is absent in advanced fibers such as Kevlar® and carbon, so the stress rupture occurs with little or no advance warning.

Issues

- Risk of insidious burst-before-leak stress rupture failure of carbon-epoxy (C/Ep) composite overwrapped pressure vessels (COPVs) during mid to late life, causing catastrophic failure
- Risk of lower burst strength of C/Ep COPVs subjected to impact damage
- Manufacturing defects and inspectabilty of COPVs on NASA spacecraft (International Space Station (ISS), deep space)
- Lack of quantitative nondestructive evaluation, causing problems in current and future spacecraft applications
- Must increase safety factor or accept more risk
- Thinner liners are driving need for better flaw detection in liner and overwrap

Background

- Currently have 17 high-pressure COPVs on ISS (most are C/Ep)
- Seven additional COPVs are planned and under development
- Long-term reliability risk levels are 10^{-4} to 10^{-5} for nitrogen tank assembly and Space-Dynamically Responding Ultrasonic Matrix System COPVs, which have risk levels of 10^{-6}
- Reliability is much lower if C/Ep overwrap sustains impact damage

Goals

- Develop quantitative acoustic emission procedures specific to C/Ep overwraps, which also have utility for monitoring damage accumulation in composites
- Lay groundwork for establishing critical thresholds for accumulated damage in composite components, such as COPVs, so that precautionary or preemptive engineering steps can be implemented to minimize or obviate the risk of catastrophic failure

Summary

Felicity ratio (FR) and fast Fourier transform frequency analysis show promise as analytical pass/fail criteria. This would allow COPVs to be removed from service before the critical FR is reached. COPVs could also be removed from service at a known level of cumulative composite damage, for example, fiber breakage or matrix cracking.