Aerospace Composite Structure Inspection

Introduction

To meet the demands of high performance materials for use in aerospace composites, MISTRAS Group's Products & Systems division, Physical Acoustics Corp., has digital acoustic emission systems and specially designed sensors with the capability of detecting damage and localizing structural integrity issues. For design engineers involved in aerospace applications, this technology provides essential information that can be utilized to improve upon composite designs and construction.

Overview

Strain and deflection measurements along with visual inspection are the traditional methods used for detecting damage during the testing of airframe composite structures. A nonlinear strain-deflection measurement is expected to indicate damage in the area where the measurement was taken. Damage in areas where no measurements are taken can go undetected.

In most cases, only one ground test article is built for an entire test program while a prototype system is being developed. Unplanned damage or failure of the test article can lead to program setbacks and high recovery costs. There is a high demand to detect, locate and assess damage as it occurs during the loading process and prevent the test article from failing or subsequent damage.

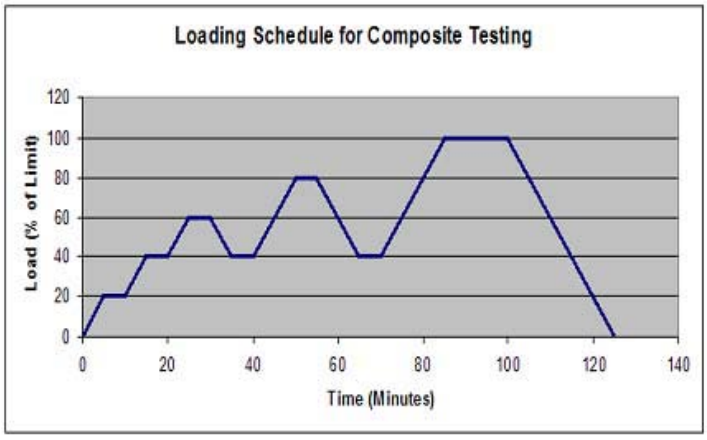

Figure2. Typical Load Schedule used when Testing Composites with AE

Figure I. Aerospace Composite Structure Instrumented with AE

Application Solution

An array of Acoustic Emission (AE) sensors (as shown in Figure 1) are used to instrument the composite structure to be tested. The AE response is monitored while a series of loads are applied as shown in Figure 2. Fatigue loading can be used as well.

A sudden increase in the AE activity rate, as illustrated in Figure 3 with comparison to the stress-strain curve (or load-displacement) for a composite material, is an indication of the onset of damage and justification to reduce or stop loading. Once the damage has been diagnosed, repairs can be made and loading continued.

In some cases, AE source location can be performed to help isolate the location of the detected damage. This requires two or more sensors. In other cases, 2-dimensional source location can be performed using three or more sensors and more precise locations defined.

For the composite structure shown in Figure 1, the material lay-up was pseudoisotropic, thus allowing conventional source location. A planar location plot is shown in Figure 4 showing the location of AE events due to damage and crack growth at the tips of a notch cut into the composite. The area is instrumented with eight transducers so as to utilize over-determined source location and produce accurate positions for the AE damage/defect events.

In the case of anisotropic material, special source location algorithms are available for materials that exhibit different wave propagation speeds in different directions.

If damage (or a defect) is present in a composite structure, it will produce AE as load is applied. Increasing load results in an increase in AE activity as well as an increase in signal Amplitude and Energy (two time-domain features that are measured whenever the AE signal crosses a preset detection threshold). When several AE events are located close together, they are called a "cluster" and are indicative of localized damage/defects. Sometimes it is necessary to perform follow up inspection in the areas of the clusters in order to estimate the size and severity of the damage/defect.

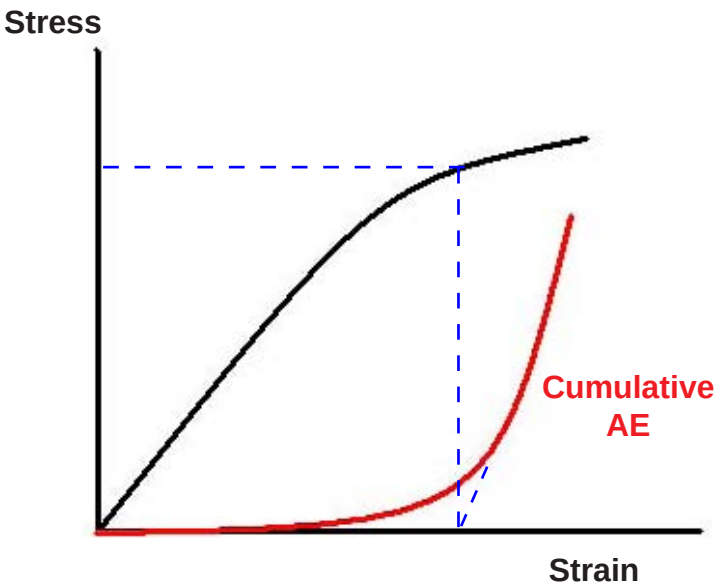

Figure 3. Stress-Strain (Black) Response of Composites Compared to Cumulative AE (Red)

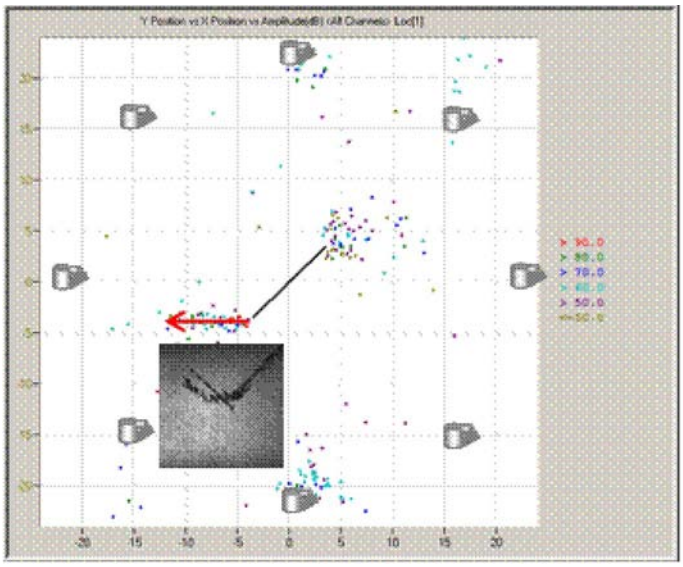

Figure 4. Planar Location of AE Events Due to the Growth of Damage at the Tips of a Notch.

The Products & Systems division of MISTRAS Group, Physical Acoustics Corp., is a team of skilled researchers, engineers, technicians and manufacturing personnel dedicated to the development of solutions to your challenging material needs.

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