On-line measurement of material properties for composite wing structures

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Abstract

Structures will encounter degradation of material properties in changing service environments. To improve structural safety and prevent accident, it is necessary to examine material properties of structures in nondestructive ways. Although several nondestructive evaluation techniques have been developed in the literature, most of them detect local damages not global material properties. In this paper, an on-line and real-time detection system is developed through the concept of inverse analysis. In this system, the detectors are selected to be natural frequencies and static strains whose relations with material properties can be obtained from analytical solution or commercial finite element software or experimental data. Transferring their relations into training patterns of artificial neural networks, the elastic properties of composite wing structures can be determined on-line with frequency and strain sensors embedded into structures. To illustrate this on-line measurement system, an example of NACA 2412 composite wing is provided in this paper. This example shows that the material properties determined through this on-line system well agree with the values obtained from the conventional testing methods. The difference is that the present method determines the properties on-line and real-time without cutting any specimen on the structures and testing specimens in the laboratory.

Keywords: On-line measurement; Composite wings; Material properties

1. Introduction

Recently, the technologies of nondestructive evaluation have attracted more and more attention. These technologies play increasingly significant roles in maintenance of structures and in-service monitoring. However, most of them such as ultrasonics and X-ray are concerned with point-measurement using detectors to scan a specific area or a spatial region [1]. Obviously, it costs a lot of time to finish scanning procedures; besides, without any further analysis it cannot provide information about entire structures. To get global information of the structures, inverse analysis through optimization or neural network techniques is popularly used in the literature. To determine material properties, the commonly used detectors in the inverse analysis are natural frequencies, static strains and displacements, etc. Grediac and Paris [2] investigated two-dimensional anisotropic plates with all free edges and used mode shapes and natural frequencies as detectors to determine the material properties. Hwang and Chang [3] utilized natural frequencies to determine the elastic constants of orthotropic composite plates and adopted impulse testing to verify results. Shieh [4] applied the finite element software MSC NASTRAN to do forward analysis and calculated the elastic constants of orthotropic plates and shells through non-linear optimization and neural networks. Liang and Hwu [5] made use of static strains computed by boundary element methods and identified the sizes and locations of holes and cracks in a plate. Wang et al.