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Monitoring Technology in Composites Using Carbon Nanotube Yarns Based on Piezoresistivity

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Abstract:
The paper puts forward a new kind of method by using carbon nanotube yarns with piezoresistive effect for monitoring composites damage online. In this method, a well-designed carbon nanotube yarns grid is built on a composite surface; the strains and stresses on the composite can be real time detected by the grid. In this paper, the experimental analysis of the resistance characteristics of carbon nanotube yarns is carried out. Finally, the feasibility of the scheme is concluded. Compared with other structural health monitoring methods, the grid sensing technology with carbon nanotube yarns is more suitable for composites kept un-destructed, and it does not affect the composite mechanical characteristics. One of the advantages is that it is easy to deploy and implement this method.

Keywords:
Carbon nanotubes; Composite materials; Electrical properties; Piezoelectric materials; Sensors

1. Introduction

In the light of carbon nanotube yarns sensor theories, a new kind of carbon nanotube yarns sensing method is well designed in this paper for surface damage detection of composites. It can realize health monitoring online of composites stress and damage.

Carbon nanotube (CNT) has special micro-structure and can be regarded as one-dimensional quantum wire. In 1991 when Iijima [1-2] discovered carbon nanotube, it stirred up researchers' great interest due to its excellent electrical, thermal and mechanical performances [3]. Carbon nanotubes would not be damaged [4] in conditions within strain lower than 15%-20%, and its cross section can be restored to original state after unloading, which is different from graphite fiber that is prone to be damaged in compression. Carbon nanotubes yarn, applied as a sensor, can make real-time monitoring on structure health of composites. Advantages of the carbon nanotubes yarn are mainly attributed to its excellent conductivity, customizable piezoresistivity and multiple-layered micro structure [5], which determines carbon nanotube's electrochemical impedance characteristic. In case one position on the yarn deforms due to stress, the yarn's resistance value will be changed, and the original resistance value would be restored after stress unloaded. By taking advantage of its piezoresistive effect, which changes resistance due to stress, a well-designed carbon nanotubes yarns grid is built on the composite surface to achieve health monitoring online [6-7].

2. Experimental Section

2.1 Composites health monitoring system

To build composites health monitoring system, technologies are needed such as signal acquisition, signal processing, data storage and analysis, system functions including problem identification, model updating, composite state evaluation and service life prediction, etc. Health monitoring system based on the carbon nanotube piezoresistivity can solve the problems about damage existence, damage position, composite state evaluation [8] in real time. In this system, Wheatstone bridge is used to recognize the electrical current value any subtle change from carbon nanotube yarns array; it is convenient to use the current value change to work out resistance change accurately.

2.2 Monitoring method

Carbon nanotubes yarns are built on the composite surface on a network pattern, making online monitoring on stress and strain. The yarns can be fixed through the bonding method. Figure1(a) shows the deployment of carbon nanotubes sensing wires on the composite surface.

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