Chapter 8
Health Monitoring of Polymer Matrix Composites Using Vibration Technique

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ABSTRACT

Glass and carbon fiber-reinforced plastics have become increasingly popular in engineering applications as relatively new materials, and it is expected that this trend will continue. E-glass laminates have become more common in aviation components such as wings, fuselages, and stabilizers as stronger, more durable, and tougher resins such as epoxies have evolved. A sudden breakdown of an engineering component like aircraft usually results in a significant financial loss, as well as posing a risk to human life. Vibration-based detection is one type of global damage identification method. Changes in physical qualities like damping, mass, and stiffness bring noticeable changes in the modal parameters in vibration-based damage detection approaches. This chapter demonstrates how vibration-based analysis can be used to forecast the severity and position of delamination in composites. The position and area of delamination in composite beams are determined using a supervised feed-forward multilayer back-propagation artificial neural network (ANN) in the MATLAB neural network toolbox.

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INTRODUCTION

Even though carbon and glass fibre reinforced composites were primarily made for the aerospace industry, their lightness, high damping factor, and environmental resistance make them appealing in other technical fields like as transportation, automotive, marine, and wind power. Glass fibre polymer is frequently employed in traditional engineering composite structures like automotive body panels, whereas carbon fibre polymer is widely used in the aerospace applications like manufacturing of wings and fuselages. E-glass laminates have become more common in aviation components such as wings, fuselages, and stabilisers as stronger, more durable, and tougher resins like epoxies have evolved (Mangalgiri, 1999). The invention of S-glass in the 1960s, which has better strength and rigidity than E-glass, led to the creation of a large variety of aircraft components and systems. Glass/epoxy panels are also employed in various current fighter aircraft elements, such as the B2 bomber's trailing edge.

The key issues concerning composites in aircraft applications is that damage to the composite cannot be identified by visual inspection prior to flight. However, composites may have internal damage because of a low-velocity impact that left no visible alterations on the surface. Another important source of concern is the composite's polymeric matrix component. Moisture collects in polymeric matrix ingredients, which slowly but steadily alters composite characteristics. It can also build up in matrix micro-cracks and delamination's between layers of composite laminates. This trapped moisture/water would expand and encourage subsequent micro-cracking or delamination's as the aeroplane flies at top altitudes where the heat may dip below freezing point. As time goes on, aircraft may experience more flight cycles, and this process of freezing and defrosting will cause micro-cracks to grow larger, eventually leading to delamination's (Irving & Soutis, 2019).

Metals used in aerospace, such as aluminium, are well-known for their fatigue properties. Composite fatigue behaviour is extremely complex and underappreciated. The fatigue behaviour of aircraft metals has been well understood now because of recent research in this area. The fatigue data for composites is not commonly recognised. In addition, the fatigue behaviour of a composite is affected by constituent fibres, matrix, and layup sequence; hence fatigue behaviour might differ from part to part. This statement illustrates why fatigue behaviour in aerospace composites is still a high-yielding research topic. To this point, the designers have relied on extensive certification exams and tasks to ensure that the composites they utilise have sufficient fatigue behaviour. These safety precautions were time-consuming and costly. As a result, the development of new dependable solutions is undoubtedly a significant research focus.