Chapter 8
Detection of Damage in Composite Materials Using Hybrid Fuzzy Logic Technique in Aerospace

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ABSTRACT

In the past two decades, the use of various materials for various structural and mechanical aspects has become increasingly important. Scientists in today's high-tech world have a vested interest in exotic materials with novel features. Composite material utilisation has increased dramatically during the past two decades to satisfy the needs of the aerospace, nuclear, and aeronautics industries. Fibre reinforced polymer matrix composites are increasingly being used in place of traditional metallic materials due to their superior performance in a number of areas, including fatigue, damage tolerance, and greater resistance to oxidation. In this investigation, the authors set out to develop and characterise a polymer-based composite packed with nano-micro particles for use in aerospace. In this chapter, the authors employ a hybrid of the FAHP and FTOPSIS to assign an overall rating to various dental composites. The research results presented here enhance the development of effective and precise damage detection techniques for composite materials.

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INTRODUCTION

Aluminum, titanium, and nickel alloys and other time-honored construction materials have made significant contributions to the aviation sector. Different innovative engineered materials continually produced to meet the demands of the aerospace industry for materials that are lower in weight and higher in strength (Hörrmann et al., 2016). Many industries, including aviation, agriculture, textiles, automobiles, military, electronics and electricity, sports, civic infrastructures, and the maritime industry, are switching to composites from more traditional materials. The aerospace and space sectors place the highest demands on composite materials due to their need for highly developed high-performance components (Bard et al., 2018). The aerospace industry's primary goal is to reduce bulk while simultaneously increasing damage tolerance. Lighter composites can be used in place of heavier metal alloys, cutting costs in the aircraft industry by decreasing fuel consumption and, in turn, reducing operating expenses (Bakis et al., 2021). Composites' superior metals, is another important benefit of their use in aerospace, as it reduces the number of inspections needed and the overall cost of maintaining an aircraft (Jolly et al., 2015).

Polymer matrix composites (PMC) have seen rapid growth in popularity within the aerospace industry in recent years due to its ability to significantly cut down on weight while increasing reliability and security (Kempf et al., 2014). PMCs were employed in several parts of commercial, military, and even civilian aircraft. Due to their low density, good strength, and stiffness, PMCs, particularly fibre reinforced polymer or plastic (FRP) amalgams, are being used to replace aircraft metallic components, resulting in a weight reduction (Kiyoshi et al., 2013). Lighter aircraft use less fuel, produce fewer emissions, and can manoeuvre more quickly and precisely (Bang et al., 2020). The aerospace industry's insistence on PMCs as a high-performance material has not changed over time. Their use in planes of all stripes, both civilian and military, is on the rise (Chulkov et al., 2021).

For key aerospace structures including fuselages, vertical tails, rudders, empennage boxes, and wings, FRPs, especially CFRP composites, are able to relocate the traditional materials Al-, Ni-, and Tialloys, due to their better performance characteristics (Marani et al., 2021). Since FRPs are lighter than traditional metallic materials, using them has helped cut aircraft weight by half, which has resulted in reduced fuel consumption and a 20% decrease in cost overall (Eder et al., 2021). Since then, other new composite materials composites, have emerged as viable alternatives to aluminium and steel structural aerospace parts. Low-strength, low-load aircraft components are ideal candidates for GFRPs and AFRPs (Gornet et al., 2013).

Fragile, weak, and easily broken, FRP composites are often damaged. Damages like as delamination and impact cracking are common in FRP complex aircraft constructions and can lead to a catastrophic collapse at any time. Invisible or hardly visible structures can sometimes acquire damage over time. Crack existence, size, position, and growth rate must be determined at an early stage to ensure public safety. In order to quickly and affordably estimate invisible damage in machine parts and aircraft structures, several currently available non-destructive procedures employ artificial intelligence approaches (Peyrac et al., 2015). In this study, we look at the benefits of using composite materials for aeroplane components rather than traditional metals and alloys. By using hybrid fuzzy logic concept for damage detection, this research work focused on composite materials of aerospace. The remaining paper is designed as: Section 2 presents the importance of composite materials; the study of related work is given in Section 3 and the description of proposed work is presented in Section 4. Finally, the experimental analysis with conclusion are depicted in Section 5 and 6.