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Effect of electromagnetic wave irradiation on the radar multilayer structures

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Abstract

The purpose of this study is to understand a correlation between interlaminar delamination and radar Absorbing performance of composite radar absorbing structures (RAS). In this study, a multi-layer Dallenbach radar absorber with glass/epoxy and glass/epoxy-Multiwall Carbon Nanotubes (MWCNT) was designed. Based on the design, test specimens were fabricated and the ‘split specimen’ test method was introduced.

The reflection loss of the specimen for normal incident EM waves in the X-band was measured. The measurement and analysis results verified that the changes in the thickness-wise location and thickness of the delamination altered the magnitude as well as the resonance frequency of the reflection loss.

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Keywords: multilayer structure, reflection loss, split specimen

Introduction

Composite materials are widely used in many industrial aspects as Well as in military applications due to their high specific modulus and high specific strength. Radar absorbing structures (RAS) are one of the applications that composite materials have shown their effectiveness, especially since the development of carbon nanotubes (CNTs) [1]. CNTs embedded in composite materials are associated with energy dissipation of incident electromagnetic (EM) waves due to its conductive properties. Recently, because of their good electrical properties, CNTs are also utilized in composite materials for EMI shields [2, 3]. RAS works as an electromagnetic wave absorber as well as a load bearing structure . A large number of researches have been conducted on the RAS, and many of them are on different types, shapes, and materials of the RAS. The Salisbury screen requires a thick substrate, and the Dallenbach layer contains additional lossy materials for absorbing electromagnetic (EM) waves at the resonance frequency. A sandwich structured RAS with glass/epoxy and polyurethane has been proposed to improve the mechanical stiffness of RAS , and periodic patterns of resistive materials are employed for lightweight RAS .

On the other hand, due to the low inter laminar fracture toughness, a major weak point of composite materials is the occurrence of delamination. The delamination may be induced from ‘low velocity impact’ which can cause barely visible impact damage (BVID) during operations and services. Numerous researches have been conducted on BVID and delamination since they are major failure modes in composite materials and hard to be detected with visual inspection [4].

Despite the fact that so many researches have been conducted on radar absorbing structures and composite delamination, no research preceding this study has dealt with how delamination affects the EM wave absorbing performance of RAS.

In this study, the multi-layer Dallenbach radar absorber with glass/epoxy and glass/epoxy-MWCNT was designed to measure the delamination effect in the X-band (8.2–12.4 GHz). For the measurement of the delamination effect, the ‘split specimens’ were designed and fabricated, using the optimized design parameters. The reflection loss measurement test utilizing the ‘split specimen’ method was validated by excellent agreement between the analytical results and the experimental results.