MICROWAVE NONDESTRUCTIVE TESTING OF TEXTILE AND COMPOSITE MATERIALS USING FREE-SPACE MICROWAVE MEASUREMENT SYSTEM

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ABSTRACT

Textile-reinforced composites play an important role in the advancement of the aeronautics and aerospace industries. The success results from the ability to make use of the outstanding strength, stiffness and low gravity of fibers such as glass, graphite or Kevlar.

In this research, microwave nondestructive testing techniques (MNDT) such as reflection, transmission and dielectric measurements will be applied to characterize some of the properties of textile composites in a frequency range of 8 to 12.5 GHz.. The free-space microwave measurement system (FSSM) consists of a pair of spot- focusing horn lens antennas, a vector analyzer, mode transitions and a computer. We have measured textiles composites made from different types of fibers such as Kevlar, spectra, S-glass and fiberglass with different types of resins such as vinylester, phenolic and epoxy. These composites have different weave patterns such as plain, satin, 2x2 basket and non-woven stitch. Experimental results are reported for dielectric constants and loss tangents of these materials

1.0 Introduction

Microwave Nondestructive Testing (MNDT) is a procedure for determining the quality or characteristics of material, part, or assembly, without permanently altering the material or its properties, by microwaves. It is used to find internal anomalies in the structure without degrading its properties. The advantages of MNDT are [1]

a) Microwaves can transverse empty space, therefore coupling can be easier than using the ultrasonic methods.
b) No material contamination problem occurs from the coupling material.
c) Microwaves do not penetrate to any significant depth in electrical conductors, therefore they can be used as reflectors.
d) Microwave can penetrate most commercial plastics and glass-reinforced structures.
e) Unlike ultrasonic, microwave is not totally reflected at interfaces between solids and air.
f) Information about amplitude and phase of propagating microwaves is measurable.
g) Microwave can be used in hostile environment such as blast furnaces and nuclear reactor silos or bunkers to measure depth of burden, depth of grain, or depth of cooling water.
h) Microwave components can be measured from metal stock, and the electronics power supplies and controllers can stand reasonably difficult environments of vibration, temperature and corrosion.

The applications of Microwave Nondestructive Testing include the measurement of mechanical quantities, geometrical dimensions, physical properties of materials, and diagnosis of nonmetallic media. .

Free-Space techniques are nondestructive and contactless, hence they suitable for measurements of the electrical properties of a materials such as reflection coefficients, transmission coefficients, dielectric constant and dielectric loss factors as a function of frequency and temperature. The measured parameters can be related to material parameters by suitable modeling and calibration. Among the reasons for the free-space measurements are preferred over cavity and waveguide methods are;