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

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JULAI 2002

ACKNOWLEDGEMENT

I would like to acknowledge the help and support given by following persons for successful completion of this research project. Habibah binti Hussain, Nazirah binti Kassim and Noorazida bte Jenal.

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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;

1) Materials such as ceramics, composites, etc., are homogeneous due to variations in manufacturing processes. The unwanted higher order modes can be excited at an air dielectric interface in cavities and waveguides.
2) In cavity and waveguide methods, it is necessary to machine the sample so as to fit the waveguide cross-section with negligible air gaps. This will limit the accuracy of measurements for materials, which cannot be machined precisely.

Composites have been proven as weight saving materials. Today, they have also gained some commercial application markets such as high performance cars, boats and sporting goods. Composites are however very expensive and destructive test methods are normally applied to determine their physical properties. Some of the properties that can be measured are moisture contents, fiber characterization, fiber orientations, weave architecture, voids, defects and fiber volume fraction. Hence, there is a need for a nondestructive evaluation of composites so that it could save time and cost .In this research, MNDT techniques such as reflection, transmission and dielectric measurements will be applied to characterize some of the properties of textile composites.

The free-space microwave measurement system consists of a pair of spot-focusing horn lens antennas, a vector analyzer, mode transitions and a computer. Diffraction effects at the edges of the samples are minimized by using spot-focusing horn lens antennas. Errors due to multiple reflections between antennas via the surface of the sample are corrected by using free-space LRL (Line, Reflect, Line) calibration technique. MNDT techniques used in this research is the metal-backed method. The complex reflection coefficients are measured for a sample of textile composite terminated by a metal plate. We have measured textiles composites made from different types of fibers and different types of resins namely Kevlar 129 style 101, Kevlar 129 style 258, spectra style 903, S-galss 6781 and fiberglass. These composites have different weave patterns such as plain, satin, 2x2 basket and non-woven stitch. Experimental results will be reported for dielectric constants and loss tangents of these materials