Determination of the Electromagnetic Characteristics of Pultruded Composites Incorporating Various Constituent Materials

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The objective of this research is to determine the electromagnetic (EM) properties of pultruded composite materials. There are many constituent materials that can be utilized for the manufacture of polymeric composites; with such a large variety, these constituent materials can be incorporated and the composite can be "engineered" to possess certain EM characteristics while also maintaining other desired properties such as high strength-to-weight ratio, excellent environmental durability, and good fatigue lifetimes. Pultruded composites that incorporate EM signature materials were manufactured using commercial pultrusion equipment at the University of Mississippi (UM); the presentation will primarily focus on the electromagnetic characteristics that were measured at UM using an HP8510C Vector Network Analyzer (VNA) in conjunction with both a waveguide setup and the HP 85070 Dielectric Probe Kit. In addition to the electrical properties, some of the mechanical properties will also be discussed.

For this research, several different composites were manufactured using different constituent materials. These materials included a commercially available "super conductive" grade of carbon black, a commercially available proprietary carbon black/intrinsically conducting polymer (ICP) additive, two carbon veils (30 g/m^2 and 17g/m^2) and one nickel coated carbon veil (11 g/m^2). These materials were selected for examination due to their EM characteristics and suitability for use in the pultrusion process. For comparison, standard flatbond polyester veils were also examined.

Transmission and reflection measurements were made using an X-band waveguide setup. A waveguide test kit was manufactured and tested, and this setup was used for the determination of the absorption through the different composite materials. For the measurement of permittivity of the composites, the dielectric probe was used. Another proposed approach for determining the permittivity of the pultruded composite that will be presented is the use of computer simulation/optimization. Using Agilent's ADS software, an RF circuit simulation of the waveguide measurement setup will be designed within the software. The simulation package can be utilized to compare a simulated dielectrically filled waveguide circuit with the obtained measurements. By setting up an optimization process with ADS, the software is setup to run numerous simulations while changing the different characteristics of the simulated dielectric waveguide circuit. Once the differences between the simulated results and the measured results approach zero, the properties of the simulated dielectric will correspond to the characteristics of the measured composite. In addition to permittivity, this should also allow magnetic properties of the pultruded composites to be determined. It is expected, then, that this approach should allow more complete, if not more accurate, characterization of the composite materials. With measurement and characterization of the pultruded composites accomplished, it is expected that results of this research will be used to fabricate pultruded composites with desired EM signatures.