Simulation and Measurement of a Guided Microwave Spectrometry System

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Previously a novel microwave measurement device known as the Guided Microwave Spectrometry (GMS) system was developed which proved capable of non-destructively measuring the composition of various mixtures of known constituents [*Jean, IEEE Transactions on Instrumentation and Measurement, Vol. 55, No. 1, 180-186, 2006*]. It operates by measuring the cut-off and passband responses of a section of rectangular waveguide filled with a homogeneous or composite material which can be solid, liquid, or multiphase. While the system can perform multiple-component analysis and finds broad applications in food, chemical, and pharmaceutical studies, the effects of the structure parameters (e.g., waveguide dimensions, coupling loop size, etc.) on the system behavior remain to be explored. Furthermore, it is desirable to examine and understand the GMS system responses to more complex, non-homogeneous mixtures.

In this work, we present both simulation and measurement studies on the GMS system with the goal of gaining more physical insights of the system and improving its design. First the GMS system is modeled and simulated using CST microwave studio, and the simulation results are compared with composition measurements in the laboratory. Good agreements are achieved between the simulated and measured system responses for various materials such as air, oil, water, and also oil and water compositions. We also present a parametric study on the GMS to identify how various features of this system contribute to its output response. Next we present how the GMS system operates with more complex non-homogeneous materials, such as food and concrete, inside the test chamber. Finally, we explore ways of improving the GMS system design by introducing a new waveguide excitation structure which can maximize the electromagnetic wave coupling with the material under test, and by using a circular waveguide as the new energy guiding structure.