DIELECTRIC-BASED MULTIPARAMETER MICROWAVE SENSOR

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In the last few decades, microwave dielectric-based sensors were mainly developed for sensing moisture in different materials (Nyfors E. and Vainikainen P., Industrial Microwave Sensors, 1989). The fact that these sensors rely on measurement of dielectric properties, which are also dependent on other physical properties of the material, make them potentially multiparameter sensors, provided that appropriate correlations are established between measured dielectric properties and physical properties of interest. At microwave frequencies, dielelectric properties of moist granular materials depend on frequency, moisture content, bulk density and temperature (Nelson S. O, Trans. ASAE, 16, 384-400, 1973). In fact, at these frequencies, water is the dominant factor because of its polar nature, and hence effects of both bulk density and temperature are water-related effects. Decoupling these effects for purpose of determining one parameter at a time is not obvious. This explains the difficulty encountered in the early use of microwave moisture sensors. For moisture to be determined accurately, effects of bulk density and temperature have to be accounted for by means of additional measurement and compensation, or eliminated by identifying density-independent and temperature-insensitive permittivity functions. In the last three decades, efforts have been dedicated mainly to density-independent measurements of moisture content.

In this paper, different approaches are examined for determining bulk density, moisture content and temperature of cereal grain and oilseed. In the first approach, and the most straightforward, direct relationships are established between the dielectric constant, ε', and dielectric loss factor, ε'', and bulk density, moisture content, and temperature. In the second approach, bulk density and moisture content are determined simultaneously from new correlations between the dielectric properties, ε' and ε'', and the water partial density (m_w/v) and dry matter partial density (m_d/v). Effectivenes of each approach is compared to previously used methods (Meyer W. and Schilz W. M., IEEE Trans. Microwave Theory Techn., 29, 732-739, 1981; S. Trabelsi et al., IEEE Trans. Instrum. Meas, 47, 1, 127-132, 1998). Since both approaches are based on measurement of ε' and ε'', combined together, they constitute the basis for the development of a multiparameter microwave sensor. The principles and feasibility of such a sensor are demonstrated through measurement of the dielectric properties of three major commodities, wheat, corn and soybeans at microwave frequencies. The methods presented in this paper, along with the availability of microwave components at affordable prices, constitute incentives for the development of a new generation of versatile microwave sensors that can be used for real-time determination of physical properties of granular materials.