DEVELOPMENT OF MICROWAVE MOISTURE SENSORS AND LOW INTENSITY ULTRASONIC SENSORS FOR AGRICULTURE, INDUSTRIAL AND SCIENTIFIC APPLICATIONS

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Introduction

Low intensity microwave has been extensively used for biological sensing, in particular, monitoring of moisture content (MC) which is an important parameter in determining quality of agriculture product, degree of ripeness and completeness of industrial processes. In the Sixth Malaysian Plan we have successfully developed a Microwave Reflection Type Latexometer and Moisture meter for hevea latex and various lossy liquids and microstrip sensor for oil palm fruits (Khalid and Abbas, 1992; 1996). Further studies on the development of microwave sensors for oil palm fruit, application of latexometer for industrial application and development of ultrasonic sensor for characterisation food emulsion were studied.

Materials and Methods

New design, analysis and performance of a conductor-backed coplanar waveguide (CBCPW) moisture sensor (Khalid and Hua (1998) and other microwave sensors (Khalid and The, 1998) were conducted in this project. The CBCPW sensor consists of three components the coupling system representing the transition between the coaxial line and the CBCPW, the two-layer structures of the CBCPW and the sensing area with its semi-infinite three-layer CPCPW structure. A relationship between the scattering parameter S_{21} and the moisture content of the oil palm fruit has been. The reflection and transmission phenomena in the sensor structure can be represented by a signal flow graph and can be simplified developed by using non-touching loop rules. The calculation of S_{21} was based on the quasi-transverse electromagnetic mode approximation. Oil palm fruits in various stages of maturity were selected from the Tenera variety. The fresh mesocarp was pressed firmly into the sensing area to ensure a good contact. The magnitude of attenuation was measured using automatic network analyzer at 2.2 GHz and temperature at 26°C. The second part of the project dealt with the development of MRT-latexometer for latex-based industries Basically the sensor consists of microwave transmitter, non-lossy protective cover, receiver, detector, signal conditioning and display unit. The sensor is dipped in the latex and the reflected wave detected by the meter can be calibrated with the total solid content (TSC) of the latex. This sensor covers a wide range of TSC, ranging from 0% to 60%. For a trial run, this sensor was installed at the Rubber Glove Factory RRIM Sg. Buloh, Kuala Lumpur.

Results and Discussion

The performance of the small-gap and large gap CBCPW sensors on oil palm mesocarp is presented. Reasonably, close agreement of about 0.5 dB is found between the experimental and theoretical data. Both attenuation and sensitivity of the sensors were affected significantly by the thickness of the protective layer. With a sensing area length of about 1.6cm (i.e. small gap sensor) the sensitivity for s/h =0.13 (ratio of protective cover with respect to the thickness of substrate) was about 0.14 dB/MC while for s/h=0.22 the sensitivity drop to 0.11 dB/MC. This phenomenon is due to the decreasing interaction between the e.m field and the sample as the thickness of the protective layer increases. It was also found that the large-gap sensor has a better sensitivity than the small-gap sensor. For example at s/h=0.18, the sensitivity of the large-gap sensor is about 0.17dB/MC while the small - gap sensor is 0.11 dB/MC. This effect was possibly due to higher field density in the large-gap sensor. MRT-Latexometer is found suitable for the process control in the rubber glove factory especially to prepare the latex with correct TSC for dipping process.

Conclusions

Close agreement has been found between theoretical analysis and experimental results of attenuation and sensitivity of CBCPW sensor with respect to the thickness of the protective layer and the size of the gap between the conducting strip and the upper ground plane. Based on this analysis, optimum geometrical sensor parameters can be obtained in order to give highest sensitivity at a particular dynamic range. Furthermore, the strong relationship between attenuation and moisture content for this kind of sensor offers the possibility of the development of a compact microwave instrument for assessing the quality of oil palm fruits that could reach the factory.

MRT-Latexometer developed for latex-based factory is a future instrument for a rapid, accurate and non-destructive method for determining the TSC or moisture content of latex.

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