Cross-Sectional Imaging of Dielectric Materials using Electrical Capacitance Tomography

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Cross-sectional imaging of objects is an important area in many applications, especially in medical and engineering fields. Computed Tomography is one such technique that refers to the cross-sectional imaging of an object by using either transmission or reflection of data over the object. This can be achieved using various fields, such as x-rays, ultrasonic waves, magnetic fields, electric fields, microwaves/ RF etc. Since x-rays have properties of straight line propagation and better penetrating ability, x-rays can be considered as the best among them. However, it cannot be used for simple and low cost applications, because of its harmfulness and high cost of experimental equipment. Therefore, a requirement for finding alternative methods for x-rays emerged.

According to the analysis carried out, it was found that Electrical Capacitance Tomography (ECT) can be applied for cross-sectional imaging of dielectric materials. It was developed in the late 1980's and it is a technique that can be used to obtain the spatial distribution of a mixture of dielectric materials inside a vessel.

In ECT, the object that is needed to be imaged is placed inside the vessel and the relative capacitances between electrodes are measured. Ultimately these capacitance measurements are converted into an image showing permittivity distribution as a pixel-based plot. Since the measured capacitance values depend on the permittivity values of the dielectric material inside the vessel, substances having different dielectric properties can be identified by using this technique.

The system used in ECT may vary depending on the number of electrodes and the sizes of the vessel and the electrodes. The sensor system discussed in this paper has eight electrodes placed along the periphery of the vessel. The permittivity distribution inside the vessel is obtained using Linear Back Projection Algorithm (LBPA). Also, it was shown that iterative and non-iterative reconstruction methods can be used to improve the results further. The Least Square method is used as an iterative method and the Tikhonov Transform is used as a non-iterative method.