ELECTRICAL CAPACITANCE TOMOGRAPHY

TECHNICAL OVERVIEW

Electrical Capacitance Tomography (ECT) is a technique for obtaining information about the distribution of the contents of closed pipes or vessels by measuring variations in the dielectric properties of the material inside the vessel. Typical information obtainable includes cross-sectional images of the vessel contents and the measurement of the volume fraction and velocities of the contents of pipes for two-phase flows. A basic ECT system will consist of a capacitance sensor, a capacitance measuring unit and a control computer as shown in figure 1.

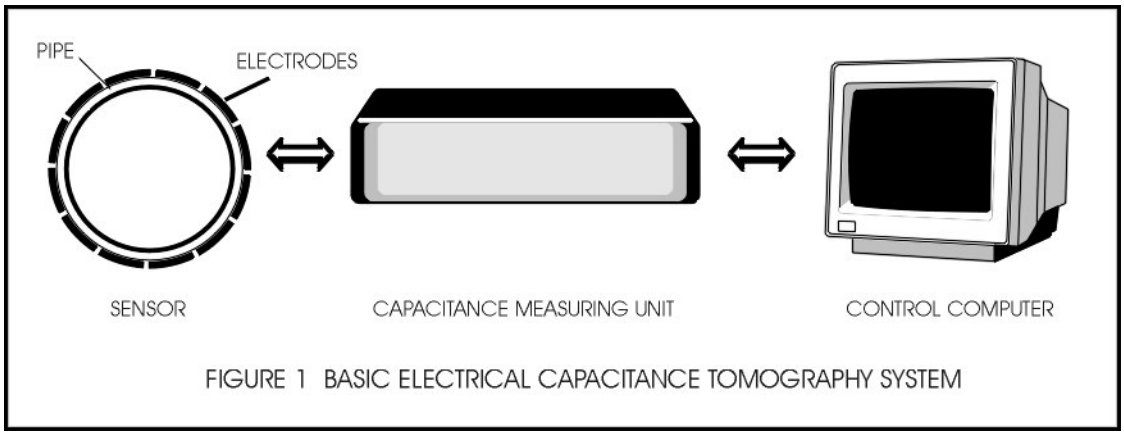
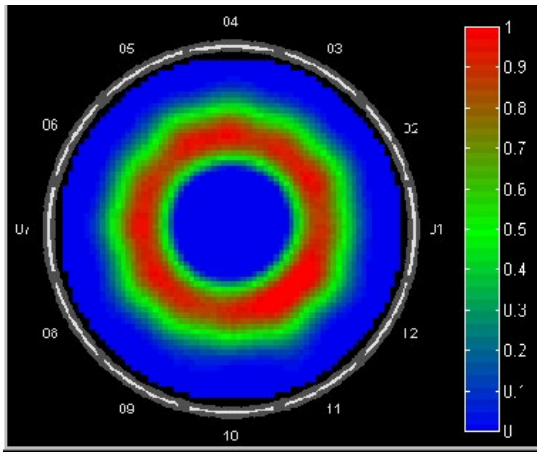


FIGURE 1 BASIC ELECTRICAL CAPACITANCE TOMOGRAPHY SYSTEM

MEASUREMENT PRINCIPLE

The cross section to be imaged is surrounded by one or more circumferential sets of capacitance electrodes and the electrical capacitances between all combinations of the electrodes within each set are measured. This information is then used to construct an image of the contents of the cross section of the vessel enclosed by the sensor, based on variations in the permittivity of the material inside the vessel. Below is a typical ECT image of a plastic tube inside a circular pipe.



ECT image of a plastic tube inside a circular sensor

ECT is most successful when applied to materials such as oils, plastics, dry powders and under favourable circumstances pure water, all of which have low electrical conductivity. It can also be used to image flames and combustion.

SENSOR DESIGN

The capacitance electrodes can be mounted either inside or outside the vessel. If the vessel wall is an electrical insulator such as plastic, then the electrodes are normally mounted on the outside surface of the pipe or vessel. In this case, the measurement is non-invasive and can be made intrinsically safe. The sensor is surrounded by an earthed shield which minimises the influence of external fields or objects. The number and size of the capacitance electrodes used depends on the application. A larger number of electrodes will give a higher resolution image but the measurement sensitivity will be low. The sensitivity can be increased by using longer electrodes but this will lower the axial resolution. If high axial resolution is required, a small number of short electrodes can be used together with separately excited axial guard electrodes, which prevent the electric field from spreading excessively at each end of the sensor electrodes.

ECT IMAGES

ECT images are normally of relatively low resolution (a 32 x 32 pixel grid is typical) but they can be captured at high speed. With existing technology, image data can be captured at 100 frames per second for a 12 electrode sensor and displayed on-line. Higher image capture rates (up to 300fps) can be achieved for 8 or 6 electrode sensors. An ECT image shows the cross-sectional distribution of the vessel contents averaged over the length of the sensor electrodes. The spatial resolution achievable depends on the size and radial position of the target object, together with its permittivity difference relative to that of the other material in the pipe. Typically, target objects (or local changes in permittivity) with a diameter 5% of that of the pipe or vessel can be detected provided there is sufficient contrast between the permittivity of the target and the surrounding media. The accuracy of the image depends on the method used to construct the image from the inter-electrode capacitance measurements. At present, the only image construction algorithm which is fast enough to be used for on-line image display is the linear back-projection method. This produces approximate images which are of acceptable quality for many applications. Other methods can be used to produce improved images off-line from captured capacitance measurements. These methods involve the use of iterative computational methods, or alternatively, the application of neural network techniques.

VELOCITY MEASUREMENT

If two or more sets of sensor electrodes are fitted to the pipe and spaced a short distance apart, it is possible to measure the axial flow velocity of the material inside the pipe by correlating information from the two sets of images or capacitance measurements.

FURTHER INFORMATION

Process Tomography Limited manufactures a range of Electrical Capacitance Tomography systems. For further information please contact us at the address below.

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