Temperature Measurement of Various Permittivity Medium by AC ECT

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Abstract

The measurement of temperature is important in various sectors. In this proposed method, AC Electrical Capacitance Tomography (ECT) is used to detect the temperature of the container with contact less of the medium. In our system, depends on permittivity distribution of a dielectric medium inside the tank. The ECT electrodes are mounted outside the tank and it is act as sensor. The dielectric permittivity changes, which temperature rises of the medium in the container. In according to this method the ECT sensor output varies. Ac signal is applied to the ECT. Based on the dielectric medium inside the tank, the electrodes exhibit equivalent current signal of the medium and signal conditioning circuits are used to convert electrode current in to voltage. Finally, the liquid and solid medium temperature can be measured from the AC ECT system. It is a non-contact, non-intrusive, radiation free, simple and low cost technique.

Keywords: Electrical Capacitance Tomography, temperature measurement, permittivity, dielectric medium.

1. INTRODUCTION

The Electrical Capacitance Tomography generally used for flow measurement. In this projected work temperature measures with the help of ECT principle. The medium range temperature is sensed and equivalent voltages are exhibits to each set of electrodes with necessary circuits. In process industries temperature sensor and flow sensor widely used. The proposed method tells that single sensor is sensing both parameters at a time after calibration. The experimental study analyzing the output voltages and input temperature, based on changes of

permittivity medium. ECT is a technique for measuring the permittivity distribution of a mixture of two dielectric materials inside a closed vessel, from which the concentration distribution can be found. They have application in industry, medical imaging, geophysics, biology etc. Industrial Tomography is an emerging technique used to visualize internal behavior of industrial processes such as temperature, level in tank, gas/ oil/ water flows in pipelines, pneumatic conveyors and in mixing/separation processes (1).

The temperature measurement in industry is a complex and random mechanism Modulation of light signal takes place in side fibres sensor based on change. Measurement is done through Fibres Electro Optic active sensor the biological sensor (cell) constructed around the fibres optic probe in which 3ml of water solution and saline it held the cell constant. Optical signal absorption rate is varied based on change in biological cell then Electro Optic technique is used to convert light signal to electrical is proportional to change in (2,3).The sensor is made-upon UV molding process with simple and safe procedures. The overall sensor size is around 150 μm in diameter and 343 μm in length. It is used in biomedical applications to simple and pressure. The change cavity length and diameter sensed by change in intensity of wave length of UV signal. The range signal measurement is less and very sensitive type. (7).

The Brine activity of human being is done through capacitance measurement the permittivity of capacitance is varied by varied

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change of in head. The 21 electrode is placed on head to measure the activity brine .Electrical impedance method is used earlier bio medical application in which sensitivity of measurement is respect to voltage to current ratio then the operating range is minimum because change of in brine is very less. In this method they use Electrical Capacitance Tomography to analysis the brine activity image reconstruction was done various algorithms [10]. The MEMS technology is used to analyze the in process industry in which cascade triple bend the beam structure. The sensitivity of the sensor is increased through cascade. The sensor contains LC circuit in which resonant frequency of sensor varied based on field. The thermal energy converted into mechanical energy then the mechanical energy converted to electrical energy of resonant circuit. Triple beam cascade structure contain electrode parallel plates that are embedded on substrate and movable beam whenever the change occur in the field then the plate get deformed due to the deformation the capacitor value changed. The change in capacitor value is proportional to. This method is used to measure high range in the process industry. The design of sensor is difficult [11].

The electrical property of water is analyzed based on change at different frequency range. If the excitation frequency increased the electrical constant increased. The basic electrical capacitance principle used to measure process parameter. The pressure is one of the factor to change of capacitance so they where consider the pressure range. Whose property of medium to analyze is placed in parallel plate of c If the frequency level is increased the conductance gets reduced as well permittivity gets reduced. [15].

2. PRINCIPLE OF ECT SYSTEM

The principle of the ECT system is that, when the dielectric medium between two conducting plate's changes, the capacitance between the plates also changes. The ECT sensor usually consists of conducting plates connected in parallel or series. They can be considered as electrodes. These electrodes can be placed around the vessel (external connection) or it can be placed internally. The relationship existing between the capacitance and permittivity is governed by the equation:

$$C = Q/V = \varepsilon_0 . \varepsilon_r . (A/d) \qquad (1.1)$$

Where, ε_0 is permittivity of vacuum.

ε_r is relative permittivity of medium inside the sensor.

d is distance between the plates.

A is area of the plates.

The value of $\varepsilon_0 . \varepsilon_r$ is the global average of fluid dielectric property over the entire sensing volume of the sensor known as permittivity. If the area of the plate and the distance between them are known, then we can measure the value of dielectric constant. This equation implies that capacitance is directly proportional to permittivity of the medium. A capacitor consists basically of two conductive plates separated by an insulating layer called the dielectric. The purpose of a capacitor is to store energy in the form of an electrical charge, Q on its plates. The ac capacitor will alternately charge and discharge at a rate determined by the frequency of the supply. This instantaneous change in voltage across the capacitor is opposed by the fact that it takes a certain amount of time to deposit (or release) this charge onto the plates and is given by V = Q/C. So we now know that capacitors oppose changes in voltage with the flow of electrons onto the plates of the capacitor being directly proportional to the rate of voltage change across its plates as the capacitor charges and discharges. Unlike a resistor where the opposition to current flow is its actual resistance, the opposition to current flow in a capacitor is called Reactance. Capacitive reactance of a capacitor decreases as the frequency across its plates increases. Therefore, capacitive reactance is inversely proportional to frequency.

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Capacitive reactance opposes current flow, but the electrostatic charge on the plates (its AC capacitance value) remains constant. This means it becomes easier for the capacitor to fully absorb the change in charge on its plates during each half cycle. Also as the frequency increases, the current flowing into the capacitor increases in value because the rate of voltage change across its plates increases.

3. DESIGNING OF SENSOR

The modeling of capacitor sensor depends on the cross section of the pipe used around which the sensors are wounded. The sensor cross section can be of any shape square or circular. The sensor contains an array of electrodes external to the pipe/vessel or internal to the pipe/vessel. The following figures represent how capacitors sensor is built surrounding the pipes in circular and square model. The sensor contains eight capacitance electrodes. These electrodes are made of copper whose permittivity is 6. Due to low frictional loss, circular pipes are preferred. The pipe is made of PVC pipe (Poly Vinyl Chloride) whose permittivity is 3.4. In order to improve the accuracy of imaging there are two ways: 1. Increase the number of measurement by increasing number of electrodes.2. Improve the image reconstruction algorithm in order to obtain more information from captured data. If we increase the number of electrodes, the signal level will be low. As a result, the sensitivity in the center of imaging area will decrease.

3.1 Sensor arrangement in Tank

The number of sensor electrodes that can be used depends on the range of values of inter-electrode capacitances.

3.1.1 Sensor specifications

Total height of tank =   56cm
Diameter of the tank =   74cm
Length of the electrode =   8cm
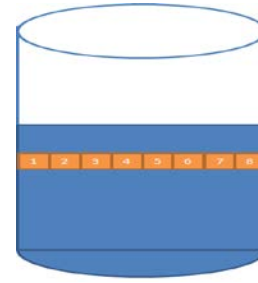Height of the electrode =   5cm

Fig.1 ECT Sensor arrangement

The ECT sensor consist of eight electrode placed on tank with insulator. The insulator protects damage and irresponsive of electrode from high temperature.

4. PROPOSED METHOD

The proposed system consist of tank with insulating layer and electrodes ,heater, AC execution source, embedded system, signal conditioning circuit ,DC voltmeter. Initially maintain the reference temperature to be measured at which the AC signal applied to the electrodes. If the electrode output is get based on permittivity of medium. They were used ECT system to measure the temperature at various range. Permittivity of medium is increase proportional to temperature and conductance decreases. Embedded system is switched electrode logic to measure various combinations then the signal conditioning circuit is used to convert current to voltage finally displayed in dc voltmeter. Here we measured temperature range is (25-70) Degree Celsius the equivalent voltage is varied (3-5) µv based on permittivity of medium. Temperature measurement is most important in parameter in thermal power plant to produce quality output and most of the temperature measurements are contact type in which measurement is difficult to measure at high temperature range. Thermocouple is very important role in temperature measurement and the one time used thermocouple to measure the high temperature measurement for accuracy then pyrometer is used high temperature with non-contact type. Low temperature measurement

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thermostat RTD and LM35 sensor used .In our project both high and low temperature measurement used ECT sensor only and analysis the medium through image re construction. it is simple measurement and control technique used to remote control process.
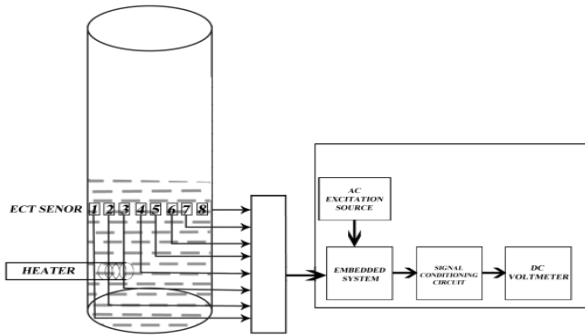

Fig.2 Block Diagram of temperature measurement

5. EXPERIMENTAL WORK

The 8 sensor electrodes are wound around the tank. The electrodes are rectangular in shape, equally spaced and have same area of cross section. Sensors used in ECT system are designed according to the cross section of the vessel and positioning of electrode. The tank of the proposed system was non- conducting or conducting material and the sensors wound around the tank which is conducting plates. Thus the sensors are non- intrusive and easy to design. The functional base of an ECT system lies in the fact that the changes of measured capacitance values will depend on the material distribution inside the tank. Thus the system is not subjected to extreme and high pressure inside the tube. Also, the number of electrodes in a system is inversely proportional to image acquisition rate and overall resolution. However change in capacitance is directly proportional to change in permittivity inside the tank. The permittivity of medium is varied based on of medium. The proposed system is shown in figure shown below.
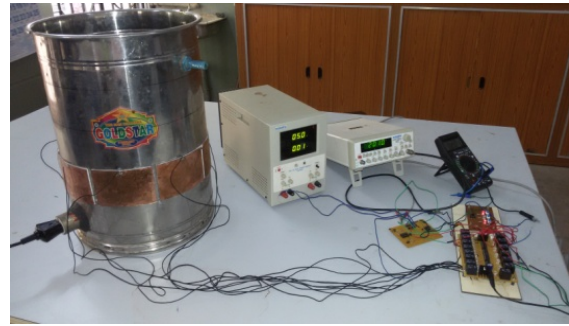

Fig.3 Hardware implementation

5.1 Result and Discussion

AC ECT system output is clearly shown in the tables. The permittivity of the air medium is low compared with water (liquid) and soil (solid) medium. Based on permittivity, medium yields the system output voltages. This assessment is used to measure the level of the medium inside the vessel. For an 8-electrode system, there are 28 unique voltage values obtained from different combination of electrode pair which acts as source and detector. The voltage values have a linear relation with capacitance in the presented system. Thus the correspondingly there will be 28 unique capacitance values, that are mapped onto a square grid containing 1024 pixels (32 pixel x32pixel) to graphically display the permittivity distribution inside the tank. The result shows water and soil permittivity inversely proportional to the temperature. The output voltages give equivalent temperature after calibration of ECT system.

Table 1: voltage values at 20 degree (c)

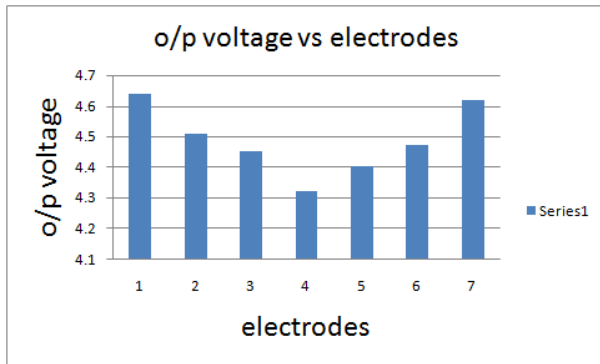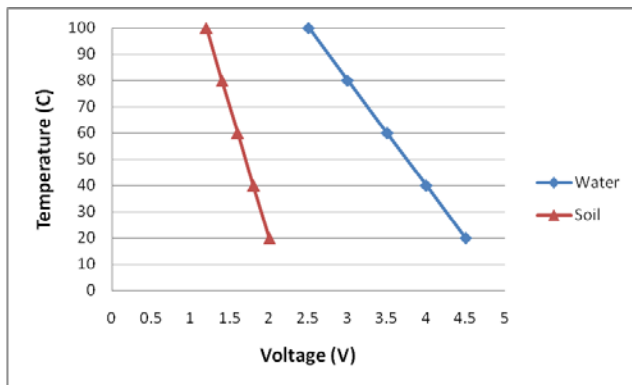| 4.64	4.51	4.45	4.32	4.4	4.47	4.62
0	4.52	4.47	4.36	4.31	4.35	4.44
0	0	4.58	4.51	4.36	4.29	4.41
0	0	0	4.33	4.3	4.22	4.18
0	0	0	0	4.43	4.36	4.32
0	0	0	0	0	4	4.28
0	0	0	0	0	0	4.46

Fig.4 voltage values at 20 degree (c)

Fig.5 Voltages vs Temperature in Water and soil medium

6. CONCLUTION

This paper has presented the AC ECT system using analyzing and measurement. In the proposed method, senses dielectric medium soil and water based on permittivity distribution. Every medium has own permittivity, which measures of the medium. The AC method helps to increase system gain and system speed; it limits effect of stray capacitance. The experimental results show that this system detected the solid and liquid of the temperature inversely to the permittivity of the medium. This set of output value could be used to reconstruct the original image of the medium inside the tank. This system provides radiation-free, less expensive, non-intrusive and non-contact temperature measurement. We can look forward

high accuracy measurement investigate for various medium.

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