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Level Measurement of ASH Handling System Using AC ECT

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Abstract: The measurement of level in a container is significant in process industries. In this proposed method, AC Electrical Capacitance Tomography (ECT) is used to detect level of the Ash storage tank with help of necessary tool. In current scenario, nuclear level sensors are used to measure the ash handling section for thermal plant but other sensors are not used for this measurement. It recognizes the level with variation in intensity. These are non-contact type with high installation cost and radiation source holders may be heavy. In projected method, AC ECT system is employed the level measurements instead of nuclear level sensors. The ECT output depends on permittivity distribution of a dielectric medium inside a tank. Each sensor consists of 8 electrode system mounted at top sensor 'A' and bottom sensor 'B' of the tank. The sensors output is compared and tank level is obtained. Ac signal is applied to both sensors at a time. Respect of the dielectric medium within the tank, the electrodes are bring current signal of the medium. The equivalent voltages of the electrode current it is obtained by using signal conditioning units. Finally, the image based on voltages is recovered through MATLAB. It is a non-contact, non-intrusive, non-invasive, radiation free and low cost system.

Key words: Electrical Capacitance Tomography · Solid Level measurement · Nuclear level sensors

INTRODUCTION

The level measurement is necessary for various applications, such as thermal power plant, fermentation industries and continuous process plants. There is a large variety of methods for measuring liquid level, ranging from those using mechanical float and capacitive and optical to ultrasonic methods [1-4]. The Existing solid level measurement using process plants are nuclear based methods. Atomic radiation based level sensing measurements are used to for tip as well as incessant measurement applications for level. Neutron radiation can also penetrate through metal incredibly efficiently, but is powerfully attenuated and scattered by any material holding hydrogen (e.g. hydrocarbons, water and a lot of other industrial fluids), it makes almost ideal for sensing the attendance of numerous procedure materials [13]. Limitations of Nuclear based level measurement are that the devices are very luxurious, changes of density can be generate measurement fault, Medium put up on container walls must affect measurement outcome, certified from pertinent authorities is required to employ them, usual leak make sure as well as elevated degree of health, security checks, source treatment and removal are serious requirements [11, 12]. The above mentioned sensors are associated with some problems. A capacitor sensor is formed by Electrical Capacitance Tomography system. The ECT systems are grooming day by day in industrial sector .The technique is for analyzing the process that takes place inside pipes (or) tank by internal distribution of the permittivity. The study of internal permittivity distribution requires a pictorial representation of the permittivity, which is possible by constructing permittivity distribution image [5-8]. The image can be constructed by acquiring inter-electrode capacitance. If the vessel is fitted with capacitive sensors, it works on the principle that the admittance of the alternating current circuit changes with the change in level. The method of

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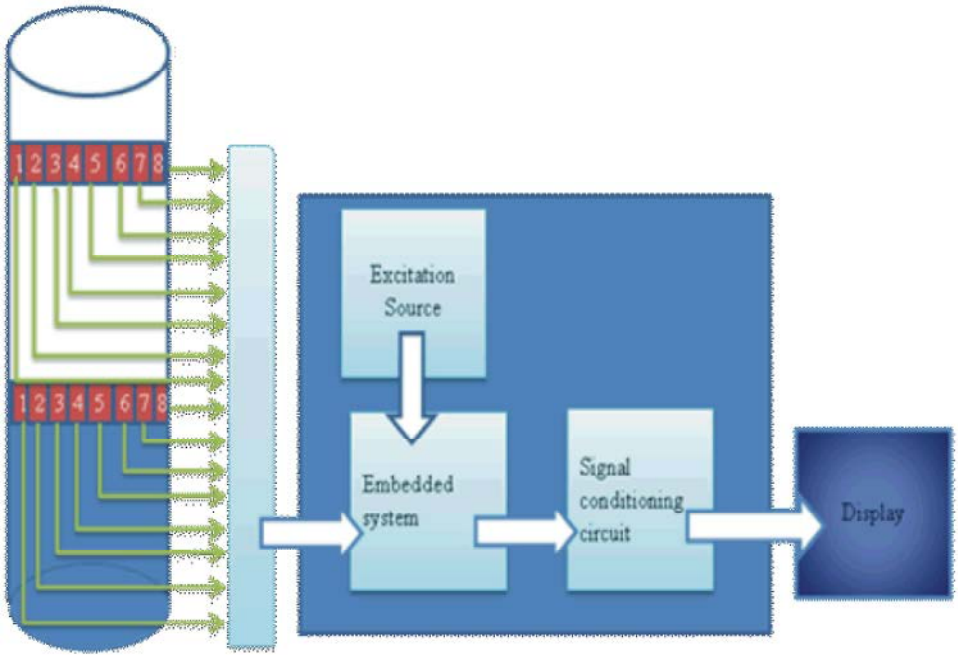

Fig. 1: AC ECT level measuring system

acquiring the data is non-intrusive. The level inside the tank is not disturbed because the electrodes are placed outside the tank. The measurement can be organized into three basic categories: the measurement of non-conductive materials, conductive materials and non-contacting measurement.

Proposed Method Using AC ECT: AC ECT level sensing systems are suitable where nuclear level sensor is employed in power plants. In non-contact capacitive method, dielectric acts as medium and electrodes help to measure the medium level. Capacitance level sensing is useful to sense a wide variety of materials such as solids, organic and aqueous solution and slurries. For instance, materials with dielectric constants as low and as high can be detected with capacitance level sensing [10]. The ECT system is used to measure the similar material level without having a contact with the medium. The sensor is comprised of an array of electrodes wound around the periphery of the tank to be measured. The measuring technique is permittivity distribution of the medium [15]. The proposed system is shown in Figure 1. An ECT system consists of five basic parts: (1) sensor system, (2) Excitation source generation, (3) Embedded system, (4) signal processing parts, (5) Interface and monitoring. The sensor consists of a set of electrodes symmetrically mounted outside, on the insulation tank. The sensing electrodes measure the capacitance for all possible electrode combinations. The embedded system is used to interface the excitation source with the combination electrodes. In a static model like the level of water or any type of medium...etc, while entering in to the system, one among the eight electrodes is used as the source which is going to sense the level of medium and the remaining electrodes act as the detector. The detected signal is in the form of current. The output obtained from the sensor can be converted into a voltage with the help of a current to signal conditioning circuit. The output signal is measured by the voltmeter. An AC stable model is a method of square wave excitation. The source signal enters the electrodes with the help of embedded system. The embedded system is used for high speed automatic switching of combinational electrodes.

MATERIALS AND METHODS

Working Principle of AC Capacitance: Capacitors consist always of two conducting plates and divided by an insulating medium namely the dielectric. The reason of a capacitor is to energy accumulate in the form of an electrical charge, Q placed on its plates. The ac type of capacitor will be alternately charge and discharge at a rate resolute by the frequency of the signal. The alternate voltage is passes to the plates of and to capacitor, the AC

capacitor is charged originally in one direction and then in the contradictory direction, the polarity is changing at the same rate as the AC supplies voltage. This direct change in voltage crosswise the capacitor is conflicting by the reality that it takes a some amount of time to set down (or release) that charge onto the plates and is given by V = Q/C [9]. So the capacitors resist the modifying in voltage with the flood of electrons onto the capacitor in the plates being straight proportional to the rate of change in voltage transversely its plates as the capacitor charges and discharges automatically. Capacitive reactance of a capacitor reduces as the frequency across its increases. Capacitive reactance in between the plates (inversely proportional to frequency) resists current flow and the electrostatic charge (AC capacitance value) on the plates leftovers constant. This income it becomes trouble-free for the capacitor to fully soak up the transform in charge on its plates throughout each half cycle. As well as the current flowing into the capacitor rising value as increases the frequency, because the voltage rate will be change across this plates increases.

If X_c = capacitive reactance, $X_c = \frac{1}{2\pi FC}$

F = Frequency, C = AC capacitance

When dealing with AC capacitance, the capacitive reactance is also defined in terms of radians, where, ω equals $2\pi F$.

$$X_c = \frac{1}{\omega c}$$

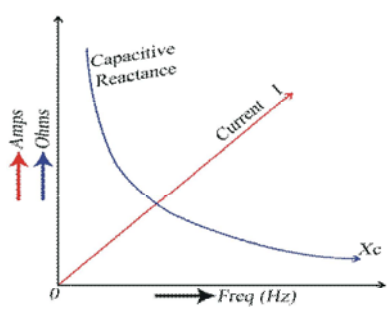

Fig. 2: Capacitance reactance against frequency

Measurement Technique: The 8 electrode method is used in the following ECT sensor section. One electrode is used as source, which is going to sense the medium. Then the remaining electrodes act as detectors. The charge accommodates between the two electrodes based on the dielectric medium, which lies inside the vessel. The charge is received in the form of current through this section. In final, section the detected current signal is converted into equivalent voltage (0-5) with the help of signal conditioning circuits. This voltage could be used to reconstruct the original image inside the tank. The electrodes are arrangement outside the tank with insulator. The 16 electrodes are mounted on bottom and top of the tank and each set have 8 electrodes. This specification is given below.

The bottom level ECT sensor "A" is placed at 2200 mm from the ground and top level ECT sensor "B" is placed at 2200mm below from the top. The space between sensors is 5200mm. The proposed method enables to measure the level of liquid and solid medium. The medium level below the sensors, above the sensors, in between the sensors, specifies the medium level of the tank. The technique uses three type of level to measure the medium in the proposed system. The output of the sensors A&B is similar, when the medium is fully occupied in the tank. When the tank is empty the sensors exhibit other similar output. The sensors A&B output is different, when the medium is half level of the tank. The ECT level measurement method is used instead of nuclear level measurement for thermal power plant in mostly ash handling section.

Experimental Work: The experimental setup is construct 8 electrodes ECT systems. The electrodes fix with equal space around the tank in top and bottom area. The electrodes are attached with insulator on the metal body. The ECT sensors are rectangular in shape, uniformly spaced and contain alike area of cross section. Sensors employ in ECT system is planned concurrence to the cross division of the tank and location of electrode. The vessel of the projected system has non- conducting medium with the sensors wound in the region of the cylinder which act as conducting plates. Therefore, the sensors are non- invasive and simple to design. The purposeful stand of an ECT system lies in the information that the change of calculated capacitance parameter will depend on the substance distribution inside the tank. Thus, the structure is not subjected to great temperature and high force inside the tank. Furthermore, the number of electrodes in a arrangement is inversely proportional to retrieval acquisition rate and on the whole resolution. Though, transform in capacitance is directly proportional to change in permittivity in the interior the tank. The proposed Experimental setup is shown in Fig. 3.

Fig. 3: Implemented AC ECT level measurement system

The embedded system plays an important role in the proposed model. It is used to interface the ac source with the combination of electrodes. It helps in automated switching instead of manual switching of ECT electrodes [14]. The signal from the sensor is fed to the embedded system. The embedded controller switches the combinational electrodes, where the switching speed can be effectively increased in terms of micro seconds.

RESULTS

The level measurement system output is clearly shown in the Tables 1-4. The permittivity of the Ash medium is low compared with urea and water medium. Depending permittivity, medium yields the system output voltages. The ECT supports the measurement of level. In the proposed model, two sensors are placed namely A&B at the top and bottom of the container. If the level crosses the bottom sensor, the corresponding output voltage is produced that depends on the permittivity of medium. The drawback in the existing system is that the image reconstruction of ash is not possible. This can be overcome through ECT system as it has a provision of image reconstruction which is made possible through the 28 voltage level calculated with the help of sensors.

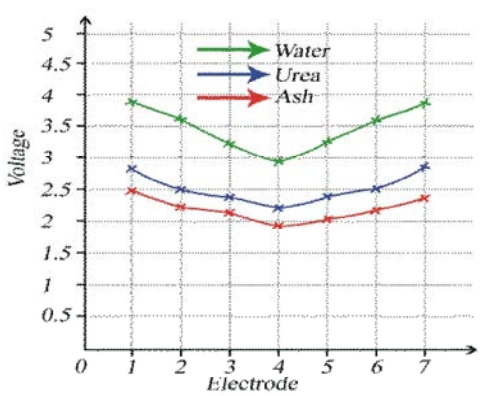

Fig. 4: Voltages versus Electrodes for various medium

Table 1: Obtained voltage from electrodes in ASH medium

D S	2	3	4	5	6	7	8
1	2.50	2.28	2.18	1.96	2.05	2.25	2.38
2	0	2.50	2.34	2.16	2.02	2.26	2.35
3	0	0	2.43	2.31	2.10	2.02	2.23
4	0	0	0	2.40	2.32	2.08	1.96
5	0	0	0	0	2.48	2.38	2.20
6	0	0	0	0	0	2.40	2.22
7	0	0	0	0	0	0	2.42

Table 2: Obtained voltage from electrodes in WATER medium

D S	2	3	4	5	6	7	8
1	3.84	3.55	3.20	2.88	3.00	3.33	3.52
2	0	3.96	3.72	3.58	3.43	3.51	3.61
3	0	0	3.73	3.59	3.50	3.48	3.56
4	0	0	0	3.82	3.76	3.58	3.46
5	0	0	0	0	3.75	3.61	3.50
6	0	0	0	0	0	3.64	3.58
7	0	0	0	0	0	0	3.62

Table 3: Obtained voltage from electrodes in UREA medium

D S	2	3	4	5	6	7	8
1	2.83	2.48	2.40	2.28	2.38	2.49	2.83
2	0	2.87	2.41	2.30	2.23	2.29	2.40
3	0	0	2.74	2.52	2.25	2.18	2.21
4	0	0	0	2.72	2.50	2.26	2.19
5	0	0	0	0	2.70	2.45	2.26
6	0	0	0	0	0	2.60	2.43
7	0	0	0	0	0	0	2.55

Table 5: Level identify WATER and UREA in the tank

Various level of Medium	Water	Urea	Ash
Below the level of sensor 'A'	1.23-1.73 both sensor output(v)	1.23-1.73 both sensor output(v)	1.23-1.73 both sensor output(v)
Above the level of sensor 'A'	3.00-3.84 sensor 'A' output(v)	2.28-2.83 sensor 'A' output(v)	1.96-2.50 sensor 'A' output(v)
Above the level of sensor 'B'	3.00-3.84 sensor 'B' output(v)	2.28-2.83 sensor 'B' output(v)	1.96-2.50 sensor 'B' output(v)

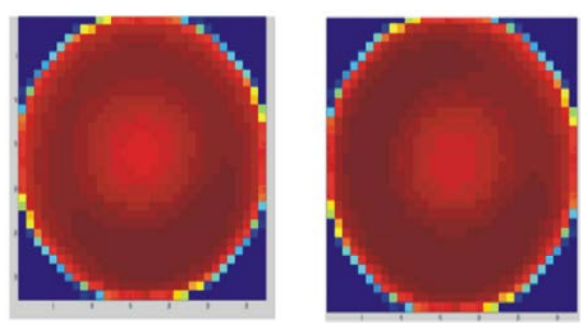

Fig. 5: Images obtained below and above in ash medium

CONCLUSION

This paper has presented the AC Electrical Capacitance Tomography system using level measurement. In this proposed method, AC ECT system senses dielectric medium level of urea, ash and water in the permittivity distribution. Each one of the medium has its own permittivity and assessment of both sensors measures the stature of the medium. The AC method helps to amplify the system gain and speed; it restrictions the effect of stray capacitance. The investigational results explain that the proposed system can sense the medium level of the tank. These outputs value could be applied to reconstruct the unique image of the medium within the tank. The systems present radiation-free, fewer expensive, non-dangerous and non-contact level measurements. Further, the process looks into measurement of the level with high temperature.

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