Chapter 18
Design, Development and Testing of a Semi Cylindrical Capacitive Array Type Liquid Interface Level Sensor

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ABSTRACT

In this study, a semi cylindrical capacitive array type liquid interface level measuring sensor is described. The sensor consists of a continuous large semi cylindrical thin metallic plate acting as a common plate of the capacitor and an array of small semi cylindrical thin metallic plates, separated by very small gap distance. All plates are mounted along the outer wall of a cylindrical non conducting vertical storage tank. The detection of liquid interface is based on the measurement of capacitance of the array of plates which varies with the dielectric constant of the liquid within the tank. The measured capacitance has been obtained in nano farad range. Since the sensor is non contact type, it can be used for both conducting and non conducting type of liquid contained within a non conducting tank. Experimental results confirm the satisfactory performance of the sensor for liquid interface level measurement.

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1. INTRODUCTION

The interface level detection of two heterogeneous mixtures is too much necessary for an immiscible liquid extraction plant, particularly within primary separation systems. Generally, heterogeneous mixtures of multiple phases or components are a common occurrence within many industrial processes such as chemical, petrochemical, oil and gas extraction, pharmaceutical, food, drink and water treatment plants.

Capacitive type level detecting technique is very popular for its reliability, low cost, low power consumption, good linearity, robustness and easy to use. Various researchers (Brasseur, 2003; Seliskar, Waterbury, & Kearney, 2005; Reverter, Li, & Meijer, 2007) have introduced various techniques for sensing liquid level using capacitive technique. Previously, a lot of effort had been made on semi cylindrical capacitive sensing technique. Baxter (1997) designed a capacitive sensor and classified its various applications. He established that liquid level in a reservoir or container can be monitored by measuring the electrical capacitance between two electrodes immersed in a liquid. As the conventional contact type sensing techniques may suffer from the corrosion effect due to the contact with corrosive liquid, Bera, Ray, and Chattopadhyay (2003) have designed a novel non-contact capacitance type drum level measurement technique. Latter, they modified this system for conducting type of liquid (Bera, Ray, & Chattopadhyay, 2006). Pal and Barik (2010) designed a non contact type semi cylindrical capacitive sensor for liquid level measurement.

Chiang and Huang (2006b) described a Semi cylindrical capacitive sensor with interface circuit which has been used for flow rate measurement. Jaworek and Krupa (2004) implemented a ratio measurement technique for Gas/liquid using rf resonance capacitance sensor. Khalifa, Ali, Alam, Islam, Khalifa and Khan (2008), invented a non-contact capacitance type level transducer for liquid characterization, such as buoyancy, pressure at a depth, relative electrical permittivity, electrical conductivity, etc. Dyakowski, Hale, Jaworski, White, Nowakowski, Meng, and Rwifa (2005) also developed a dual-modality probe for characterization of heterogeneous mixtures.

Bukhari and Yang (2006) developed a multi-interface level sensors and a newly developed system for monitoring and control of oil separators. Jaworski, Dyakowski, and Davies (1999) designed a portable capacitance probe for detection of interface levels in multi-phase flows. But the limitations of these inventions for liquid interface detection are that the sensors are coming in contact with the measuring liquid. Lu, Hu, He, and Chen (2009) developed a sensor for monitoring oil-water interface level and oil level. This sensor can realize two sensing functions, namely, inductive and capacitive sensing. Thomsen, Hansen, and Schelde (2000) and Nemarich (2001) applied Time Domain Reflectometry (TDR) technique for water level measurement. Chiang and Huang (2006a, 2006c) utilized semi cylindrical capacitive sensor along with signal conditioning for both fluidic measuring and flow meter application.

In the present experiment, differing from the structures of all conventional capacitive sensors, a novel semi cylindrical capacitive array type sensor has been investigated for liquid interface level detection. This sensor consists of a common continuous large semi cylindrical metal plate and an array of small semi cylindrical metal plates which are separated by a gap distance. All these semi cylindrical metal plates are mounted around a polyvinyl chloride (PVC) type liquid container. Heterogeneous mixtures of two or more relatively immiscible liquids such as water, vegetable oil, crude oil, etc have been used as dielectric medium of the capacitor. The variation in capacitance due to variation of dielectric property of liquids and their interfaces within the container have been converted into voltage variation using ICL 7660.

In Time Domain Reflectometry (TDR) based level measurement device, the device generates an