Profiling device for determining liquid properties in tanks

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Abstract

When liquids are stored in tanks, it is important to know liquid properties such as their quality, phase separation, usage properties, water content etc. Methods currently used are mostly based on taking samples, which may be difficult and time-consuming. Rocsole Ltd has developed a novel profiling device to measure liquid properties, components and interfaces directly in a tank. Utilizing measurements and mathematical models, it is possible to determine vertical admittivity profiles in a tank. This paper presents a typical tank scanning procedure followed by an example of results and conclusions.

1. Introduction

The profiling device is used to estimate vertical admittivity (i.e. both conductivity and permittivity) profile in tanks, containers and vessels. Liquids, mixtures of liquids as well as mixtures of liquids and solids can be characterized by a quantity called admittivity. In mixed conditions, material fractions determine the bulk admittivity of mixtures. The operation of the profiling device is based on impedance measurements between electrodes mounted on the surface of device. An array of electrodes is used for measuring impedances between different pairs of electrodes, and the admittivity of materials in the measurement location affect the impedances. It is notable that the electrode array is designed so that measurement data gives information also on possible contamination the sensor surface while fluid properties can still be estimated from data. This is important especially in conditions where contamination of sensors is a serious problem due to which conventional sensors give false readings.

The sensor can be moved vertically in the tank so that readings are recorded on different levels. Data processing algorithm is then used to characterize possible contamination on the probe and fluid properties which is the primary quantity of interest. Measurements on multiple vertical levels enable the reconstruction of vertical admittivity profiles that can be used for assessing e.g. phase separation, mixing conditions and material quality. The sensor can also penetrate bottom sediments if they are not very dense. Repeated measurements can give valuable information on temporal changes in the material. The system is solely based on electrical low-amplitude measurements with no radioactive sources. Therefore, it is completely safe for operators and environment. ATEX/IECEx certified sensors are available for explosive environments.

2. Equipment and methods

Figure 1 shows the measurement equipment. A tripod and winch are used to lower the device in to the tank through a hatch located on top of the tank. The device is attached to the winch by wire rope and is connected to the control unit and PC through a separate data/power cable. Only the device and part of the wire goes inside the tank. All other equipment is located on top of the tank.

Figure 1: Measurement equipment

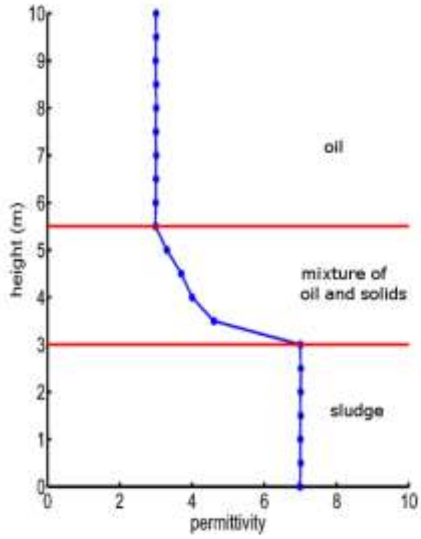

Figure 2: Permittivity as a function of height.

Measurement time is dependent on the height of the tank and desired resolution in vertical direction. For example in the case of 18 m high tank and with desired resolution of 50 cm, total of 37 measurements at different heights are needed. In this case the measurement time would be approximately 0.5 hour.

3. Results and conclusions

In this section, a typical tank scanning scenario is presented and results from a test case are given. Oil containing some unwanted solid material is stored in a tank. Over time this unwanted material separates gravitationally from oil and settles to the bottom. However, the state of separation cannot be monitored with conventional methods but it is known that the materials have different permittivities. Using the profiling tool, the permittivity profile can be determined, and Figure 2 shows the result graph. It shows material permittivity as a function of distance from the tank bottom. Three sections can clearly be detected from the graph and they are pure oil, a transition region with a varying mixture of oil and solids and sludge on the bottom. The profile reveals the levels of sludge and pure oils as well as the fact that settling can still be in progress. The development of the system has relied on computational approaches and models for compensating the effect of contamination on the sensor surface. Such methods are under constant research and development in Rocsole Ltd.

References

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