Advanced radar technology optimises separation process performance

Emerson's Varshneya Sridharan explains how the latest guided wave radar transmitters can minimise product cross-contamination and increase throughput by accurately measuring a thinner top liquid layer to the top of a tank, improve measurement reliability by overcoming the challenge of double bounces, and increase safety through remote proof-testing capability.

The ability of manufacturers and processing companies to produce final products that meet stringent quality standards can often be influenced by how efficiently a liquid separation process is performed. To help make the process of separating two immiscible liquids in a tank or vessel as efficient as possible, it is crucial to install instrumentation that can perform accurate and reliable interface level measurements.

In most interface applications, the liquids will separate and settle naturally because of their different densities, with the lower density liquid on top of the higher density liquid. In the example of oil and water occupying the same vessel, the oil floats on top of the water, and the interface would be the lower level of the oil and the upper level of the water.

Some applications require the thickness of the upper liquid layer to be measured – for example, where only the upper liquid needs to be poured off and an accurate indication of when to stop pouring is required. This measurement is also vital when controlling the flow of both liquids out of the vessel and into independent channels, to minimise product cross-contamination. In oil production, for instance, it can prove extremely costly if oil is channelled to the water tank, or if water is sent further along the process.

MEASUREMENT TECHNOLOGIES

Various technologies can be employed to measure an interface level. These include the most basic method – a sight glass on the side of a vessel – through to floats and displacers, capacitance transmitters, differential pressure transmitters and magnetostrictive sensors. However, these technologies can all have limited accuracy and reliability under certain process conditions, while their maintenance and calibration requirements can be complex and time-consuming.

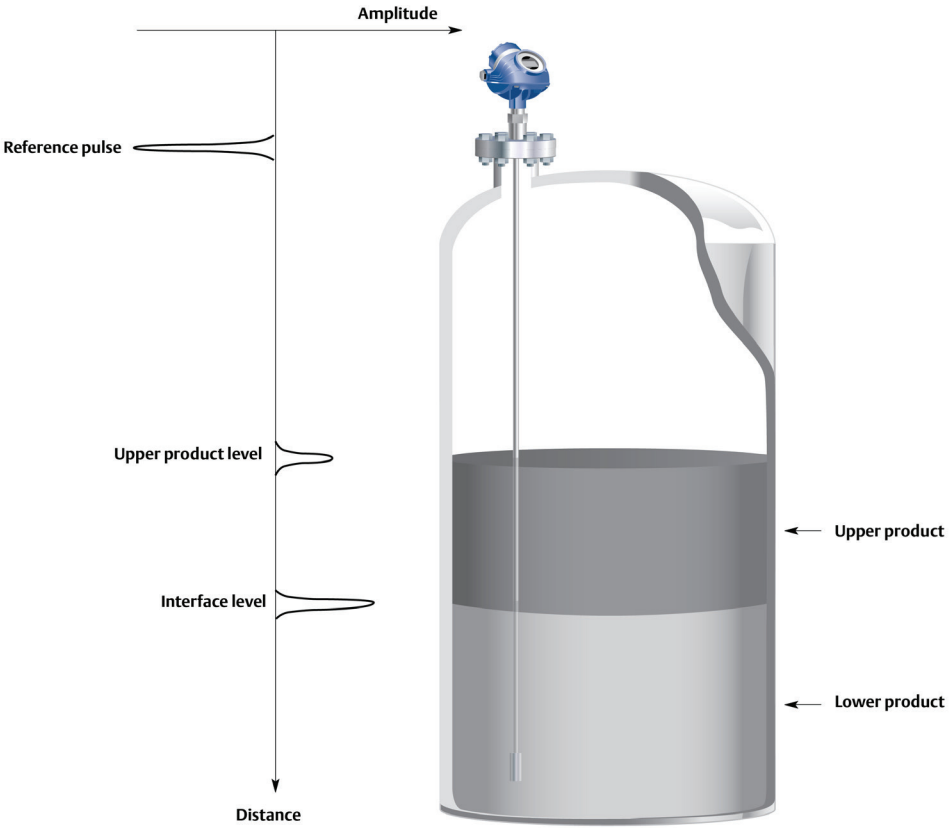
BENEFITS OF GUIDED WAVE RADAR

Guided wave radar (GWR) is a well-established technology and field-proven in a broad range of interface level measurement applications. These include oilfield production tanks; free water knock-out vessels; water and skim tanks; accumulators; desalters; scrubbers; and storage and buffer tanks containing oil, condensate, water or solvents. Transmitters based on GWR technology deliver a top-down, direct measurement of the distance to the process material surface and the interface, and provide many advantages compared to other technologies. For example, changes in pressure, temperature and most vapour space conditions have no impact on the measurement accuracy of GWR transmitters. Also, compensation is not required for changes in the dielectric constant, conductivity or density of the liquid.

GWR devices provide accurate and reliable measurements in vessels with tight geometry, in chambers and in tanks of all sizes. As GWR transmitters have no moving parts, this minimises their maintenance requirements, whilst their advanced diagnostics ensure that operators are quickly alerted to any degradation in performance.

MEASURING INTERFACE LEVEL

Transmitters based on GWR technology emit low-energy microwave pulses that travel at the speed of light and are guided along a probe submerged in the process material. When a pulse reaches the surface of the upper liquid, a significant amount of the microwave energy is reflected back to the transmitter. The time difference between the generated and reflected pulse is converted into a distance, from which the level can be calculated. As a certain proportion of the pulse continues down the probe through low dielectric fluids, a second reflection, or 'echo', then occurs at the interface between the two liquids.



A typical guided wave radar level and interface measurement application

THE EFFECT OF DIELECTRIC CONSTANT

The dielectric constant of the two liquids affects the speed at which microwave pulses travel, and therefore also impacts measurement accuracy. Consequently, top-down GWR transmitters are only suitable if the upper liquid has a lower dielectric constant than the lower one, and if there is a difference of at least six between the two dielectric constants. Where the interface being measured is between oil and water, because water has a significantly higher dielectric constant than oil, the interface can be easily detected by a top-down GWR transmitter. In applications where the upper liquid has a higher dielectric constant than the lower one, the mounting position of the transmitter can simply be inverted, with the device installed on the bottom of the vessel to provide accurate interface level measurement.

THE EFFECT OF EMULSION LAYERS

In some applications, the natural separation of two immiscible liquids can occasionally be imprecise, with an emulsion layer – i.e., a mixture of the two products – forming between them. The absence of a distinct interface between the liquids can influence measurement accuracy when using GWR devices. Typically, the thicker the emulsion layer, the more challenging it becomes to accurately measure the interface level. An emulsion layer can sometimes break down into two distinct layers if given time to settle. In these instances, installing a transmitter in a stilling well can achieve more accurate measurements.

ABILITY TO MEASURE A THINNER TOP LAYER

When using GWR transmitters in interface level measurement applications, the upper process material layer must be of a certain minimum thickness, so that the device can distinguish between the signal reflections from the two liquids. Previously this minimum thickness has been between 50 and 200 millimetres, depending on the transmitter model and probe style being used. However, advanced Rosemount™ GWR transmitters from Emerson provide functionality that enables the minimum detectable thickness to be reduced to just 25 millimetres. This significant enhancement has been enabled by Emerson's Peak in Peak interface algorithm. This enables the transmitter to detect signal peaks that are closer together without having to decrease its signal bandwidth, which would

Emerson's Rosemount™ 5300 Guided Wave Radar Level Transmitter, with a large coaxial probe, enables the minimum detectable thickness of the upper liquid layer to be reduced to 25 mm, and measurement accuracy to be maintained to the top of the tank

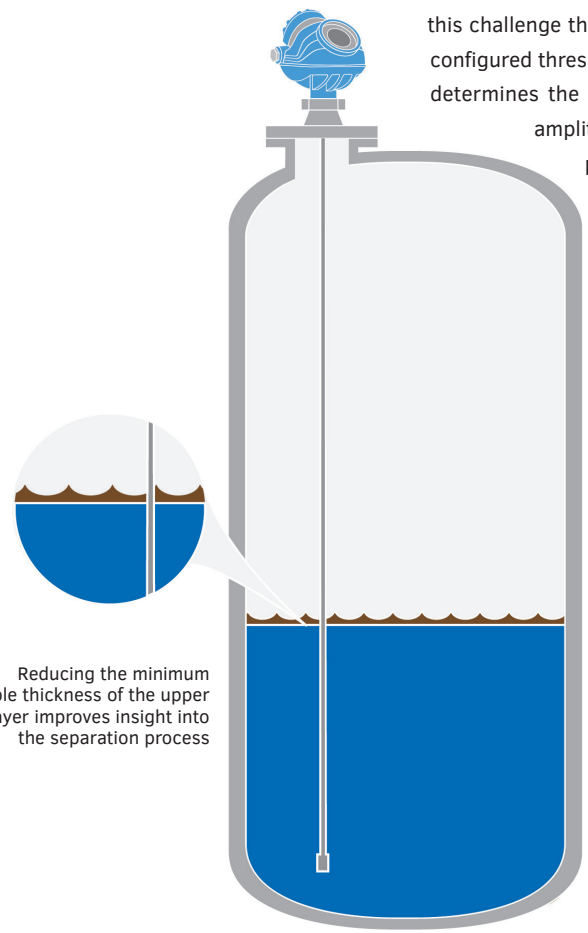
reduce its high sensitivity and its ability to overcome liquid disturbances. The ability to detect a thinner upper liquid layer helps to optimise separation process performance and minimise product cross-contamination, thereby helping end users maximise operational efficiency and profitability.

MEASURING TO THE TOP OF THE TANK

It is challenging for GWR transmitters to accurately measure interface level right to the top of a tank, even when using a large diameter coaxial probe. These probes provide the strongest return signal, have no upper dead band, and their accuracy is unaffected by obstacles on the tank wall. However, measurement accuracy to the top of the tank has traditionally been impacted by high amplitude noise created as microwaves pass through the process seal between the transmitter and the probe. Now though, Emerson has improved the design of its process seal, thereby eliminating this noise and enabling accurate and repeatable measurement to the top of the vessel. This is beneficial because it allows users to optimise their tank capacity, thus increasing throughput and profitability.

OVERCOMING THE CHALLENGE OF DOUBLE BOUNCES

A further challenge when using GWR technology in interface level measurement applications is the so-called double bounce. This is when a radar signal bounces back and forth between the liquid surface and the tank roof or another object in the tank before the transmitter detects it. These signals often have a low amplitude and are ignored by the transmitter, but the amplitude may sometimes be strong enough for the transmitter to interpret them as a reflection from the liquid surface. The latest GWR transmitters overcome this challenge through a factory-configured threshold setting that determines the minimum signal amplitude limits of key parameters such as surface echo, interface echo, reference peak and end-of-probe peak. In upstream oil and gas applications, an echo below the threshold is considered as oil, and an echo above the threshold is considered as water. This increases measurement reliability by preventing double bounces from being mistaken as an interface level measurement.



Reducing the minimum detectable thickness of the upper liquid layer improves insight into the separation process

PROOF-TESTING IN SAFETY-CRITICAL APPLICATIONS

Safety instrumented systems in separator tanks must be regularly proof-tested, to ensure the integrity of devices in safety-critical applications such as overfill prevention and dry pump protection. Proof-testing has traditionally been performed with multiple technicians in the field and one in the control room, verifying the safety system reaction. This requires much time and effort, can pose safety risks to workers, can result in the process being taken offline, and can be prone to errors. However, the latest GWR devices can be remotely proof-tested with 94 per cent test coverage using verification reflector functionality, thereby making the process quicker, safer and more efficient.

The verification reflector function uses an adjustable reference reflector fitted to a flexible single lead probe at a desired height to generate a unique echo signature. The device constantly tracks the reflector echo to determine if the level is above or below the alarm limit. A test function built into the device software verifies that the transmitter is correctly tracking the reflector echo. It also confirms that the alarm loop is working, with a high-level alarm being displayed in the control room. Testing can be performed in minutes from the control room during operation, thereby reducing downtime, minimising risk and maximising safety. **WWA**

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