The Displacer Replacer: Guided Wave Radar in the Oil & Gas Industry

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John Hulme, Level Product Manager at Endress+Hauser Ltd (UK) examines how the increasing sophistication of level instrumentation has resulted in a viable alternative to traditional displacer systems in the petrochemical and oil & gas industries.

Reliable level measurement within the oil & gas industry is essential to ensure safe, accurate and efficient production. Consequently, there are a number of considerations that must be taken into account with regard to specific and often difficult application conditions. The correct selection of instruments according to the required specifications places much responsibility on both instrumentation engineers and suppliers to provide the ideal solution. One which will satisfy a wide range of application conditions, such as corrosion, sour gas and explosive atmospheres, and also meet the regulatory requirements of NACE and SIL, etc.

Whilst displacer devices have been the 'traditional' method of choice in the oil & gas industry, in the quest for increased efficiency, many companies are now looking for a more accurate, reliable and repeatable level measurement. With displacer systems, not only is the initial purchase cost high - that's just the start of it - over a 10-year period the costs associated with these mechanical devices are often grossly underestimated. Displacers are susceptible to build-up, changes in process conditions and mechanical failure. To remove, repair or re-fit displacers is costly and labour-intensive, significantly increasing plant downtime. This often results in overdue replacement, which in turn produces inaccurate level measurement. A reliable alternative to significantly reduce maintenance costs, downtime and long-term cost of ownership has been sought for many years.

In providing this much sought-after alternative, suppliers must not only possess an expansive product basket that covers the various application requirements, but also superior in-house knowledge, experience and proven expertise in the oil & gas industry in order to suggest the best and most appropriate replacement. Measurement techniques such as capacitance, ultrasonic, radar, hydrostatic and gamma are all equipped to measure level, however, the extent to which each method is appropriate for the individual application is dependent on advanced knowledge and consideration of the plant process conditions.

With recent advances in technology, Time of Flight (ToF) brings a viable alternative to troublesome displacer systems. The Time of Flight principle operates by radar pulses or ultrasonic waves being emitted from a transmitter, reflected by the product surface and again detected by a receiver. From the Time of Flight of the pulse, the distance between the transmitter and the surface is determined and the level is calculated taking the tank dimensions into consideration.

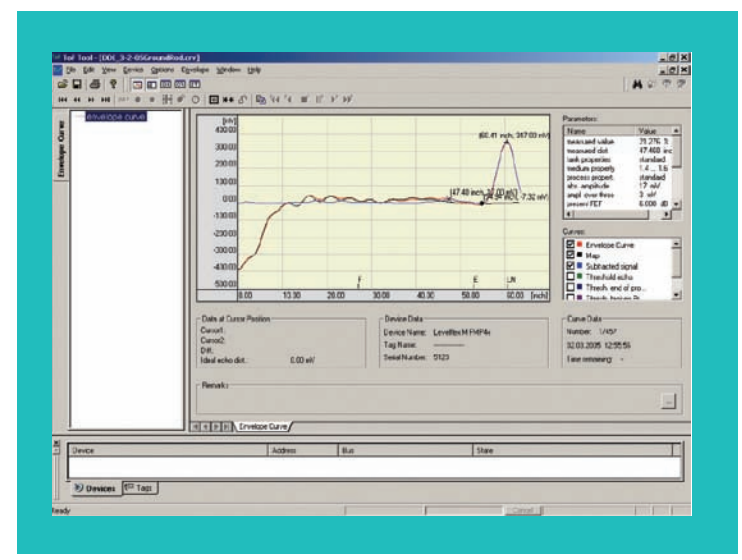
A solution to the replacement of displacers has been to use Time Domain Reflectometry (TDR) – otherwise known as guided wave radar (GWR), from the Time of Flight range. These instruments operate independent of changes in product density, are unaffected by the upper gas phase and the two side process connections on the vessel. This measurement principle has been used for many years in the telecommunications industry to detect cable faults and, over the last decade, advances in GWR technology have meant that it has been adopted for process level measurement applications.

The principle of operation of GWR is that a pulse of microwave energy (approximately 1GHz) is emitted from a high frequency generator and guided along the outside of the probe. This probe may be a rod, wire or coaxial antenna depending on the application. When this microwave pulse meets a change in dielectric constant (the product surface), an energy reflection is seen - this energy reflection is proportional to the change in the product's dielectric constant. Air has a dielectric constant of 1 and water has a dielectric constant of 80, therefore the reflected energy from water is greater than air; hydrocarbons (oil) generally have a dielectric constant of 2 or 3. The reflected pulses are transmitted along the probe to the electronics where a microprocessor analyses and identifies the reflection from the product level. The distance 'D' to the product surface is proportional to the Time of Flight 't' of the impulse:

$$D = c \cdot t/2 \text{ where } c = \text{speed of light}$$

Major instrumentation manufacturers have recently added to the features of the GWR product range to better suit the extreme process conditions of the oil & gas industry. Designed for high precision and reliable operation in high temperatures and pressures, these GWR devices are ideal for the rigours of the petrochemical and oil & gas industries, such as in separators and corrosive applications.

Software developed during years of experience of Time of Flight techniques has been adapted to the guided wave radar principle to offer simple menu-driven configuration of the working parameters of the device. This, along with the ability to view the quality of the waveform or envelope curve either at the device or via a software package, means that the performance can be viewed and monitored on or offline and this information can be used as a diagnostics tool locally or directly by the manufacturer. The graphic representation of the envelope curve and the various analysis functions are an integral part of this software and facilitate easy diagnosis of all aspects of the measuring point. They permit, for example, an assessment of the signal quality and thus the reliability of measurements, the analysis of process influences or the storage (also time and event controlled) and retrieval of envelope curves. The envelope curve can also indicate signs of build-up in the chamber, thus preventing the need to carry out costly radiographic or physical inspections.



The most important parameters are displayed by the envelope curve.

Flow Level Pressure

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The devices themselves should directly replace the displacer using the existing process connection and, of course, have the required certification for hazardous areas and sour gas. With this in mind, guided radar devices are available with standardised process flanges as well as manufacturer-specific flanges to offer a 'drop in' replacement for displacer systems, eliminating the requirement for costly modifications. In addition, where required, bridles can also be purchased from a single sourced supplier. Along with mechanical installation considerations, the connection and use with existing loop-powered systems, is a big cost factor. The flexibility of connection should include both 4 wire and 2 wire options, as well as the required hazardous area certification e.g. EEx d, EEx ia.

Pressures of up to 400 bar and temperature ranges up to 400°C are available with many guided radar systems, as is the option of NACE MR0175 conformity for applications where sour gas must be considered – these are standards demanded by the oil & gas industry. In addition, SIL2 (safety integrity level) conformity is also becoming a standard requirement for applications on high demand safety loops, as is the availability of related safety documentation.

Increasingly, the protocol of the signal transmission from the device must also be considered. 4...20mA/HART are considered as standard options on most guided radar systems, however greater focus is now being placed on fieldbus compatibility e.g. PROFIBUS PA and FOUNDATION Fieldbus.

As with all process industries, the future of the oil & gas industry lies in safe, efficient production based on reliable process data. Measurement technology designed specifically to meet the needs of the industry in terms of process, application environment, compatibility and conformity to industry legislation is essential in achieving this aim.

Endress+Hauser's Levelflex M FMP45, specially designed for the rigours of the oil & gas industry.