Microwave radar technology for level measurement – what is it all about?

Process Instrumentation

When you have a difficult level measurement requirement in a challenging environment, microwave radar technology is often the best solution. The following is a look at the technology behind this popular application problem solver and what allows it to perform so well in tough conditions: heavy vapors, steam, changing physical and chemical conditions, and high temperatures and pressures.

What is Microwave radar?
Microwave radar technology can be a non-contact or a contacting method of level measurement, depending upon the technique used. The non-contacting method uses a pulsed or FMCW Frequency Modulated Continuous Wave) technique of propagating electromagnetic energy at a frequency from 6 GHz to 26 GHz from a rod or horn antenna. The contacting method is known as Guided Wave Radar (GWR) or Time Domain Reflectometry (TDR). This technique employs a rigid or flexible rod to focus the electromagnetic waves with a micro impulse signal from the launch pad. The "launch pad" is below the threaded connection or flange and sends the impulse signal down to the material level. This operating frequency band pulses from 1 to 3.5 GHz. There are a handful of probe styles for GWR and each probe is designed for a specific measurement, as well as application requirements.

Choosing the correct technology specified for the application involves considering the details associated with the application: material type, process temperature and pressure, measurement range and required mounting connection, a proper selection of either contact or non-contact radar can be made for any given application.

Microwave radar is preferred by many end users because it can handle many application conditions: vapors, changing dielectrics, high temperature and pressure, corrosive materials, as well as measurements of over 300 feet. The various microwave designs, in particular contacting microwave radar, also provide unique measurements like the interface of two immiscible liquids. In the case of oil on water, the interface, as well as the top level measurement, can be measured.

Microwave technology offers a level measurement solution for almost every application involving solids or liquids. When discussing liquid applications, the most important benefit is the ability to propagate microwave energy through varying vapor gradients. Most times, when a hydrocarbon or chemical mixture is contained within a vessel, the empty space above the liquid develops stratification layers of vapor. As microwave energy launches from a radar antenna, the energy is unaffected by these changing vapor layers; thus the accuracy is not affected.

A liquid, like gasoline, that is stored outside in varying temperatures throughout the day, will have vapor layer stratification that can cause errors in measurement with some other technologies. In addition, microwave energy changes only slightly with travel time, so changes with the liquid properties such as specific gravity, dielectric, and chemical makeup are irrelevant. With most transmitters, microwave technology can deal with process temperatures beyond 1000°F as long as the temperature at the flange connection is below 400°F. Also, a mixture in a vessel can have varying solvents or chemicals with a host of different properties. With GWR, the instrument's probe must have material compatibility verified, because the probe has to touch the liquid. Non-contacting radar is virtually unaffected under similar conditions. With solids material like grains, powders, and plastic resins, the microwave techniques like FMCW and Pulse operating in the K-band or the new approved W-band or 78 GHZ to 110 GHz models are impressive in applications involving heavy dust particulates in the airspace. The measurement ranges for some powerful radar devices can exceed more than 300 feet.

Different designs for different vessels
The microwave design has an antena with the sole purpose of directing microwave energy towards the level and then capturing it on the return flight back. Common antenna styles are either rod style, full length probe designs for guided wave radar, tube antennas (stand pipes/bypass tubes), parabolic antennas and horn types. Typically, the available vessel entry or mounting will determine the size and type antenna to use in the application. The most practical, effective and best performing antenna is the horn design. It provides a directive source for the microwave energy, withstands very high temperatures, and tolerates condensation and some build-up or coating. Although the rod style antenna is lighter, usually costs less, and is normally chemically resistant to more materials, its minimum length is about 16 inches long. This places a limitation on how close the material can get to the top of the vessel. The rod antenna must not touch the top of the liquid because there is a blanking or dead zone on a radar system. Parabolic antennas are effective and do have narrow radiation beam angle like some horn antennas. However, their massive sizes require large process connections that are often impractical or an expensive retrofit.

The standpipe type with a horn antenna mounting inside the vessel is also a good method for accurate and reliable readings. This design antenna appears to be the perfect design. However, the microwave energy propagates at a slower rate. With this slower transmission rate, there is an easily calculated correction factor that must be applied depending upon the standpipe diameter. Also, the standpipe must have a smooth inner wall with no weld seams. There are times when a vessel may have a bypass pipe mounted externally to the inside of the vessel. This is yet another common installation for microwave radar devices. It is commonplace for a guided wave radar probe and transmitters to be installed in these bypass pipes.

Contacting and non-contacting microwave technologies have made their way into the industrial instrumentation market with a strong presence in many applications such as chemical, oil and gas, coal, aggregate and the food and beverage industries. Both technologies lend themselves to overcoming the effects of changing dielectric properties and perform well in applications that, in the past, were out of the scope of microwave radar instruments due to the low dielectric properties of the material.

Even though GWR is a contact technology, the probe is offered with various chemically-resistant exotic metals and Teflon coatings. The benefits of the GWR technology is that small openings in a vessel will accommodate a GWR probe and it is a technology that can provide accurate measurements for level or interface or both level and interface with one probe.

Non-contacting microwave radar has advanced dramatically in the past few years. The signal power on these instruments has been boosted along with more advanced microprocessor capabilities and features that make them user friendly, and thus easier to configure.Microwave radar instruments operating in the 6 GHz, or 25 GHz, or the latest 78 GHz offer a variety of antenna configurations ranging from shielded and unshielded rods of various lengths, horn antennas from 1.5 inches to more than 8 inches in diameter, and parabolic antennas that help reduce the radiation angle. Some of benefits of using non-contacting radar devices are inherent in the fact that the material does not come in contact with the antennas and are less prone to material buildup. The 78 GHz design has the narrowest signal spread of just 4 degrees using the smallest and non-visible horn that is essentially protected from the process environment. The non-contact models also offer greater chemical compatibility, and there is no need to anchor a long flexible cable or be concerned with cable loading. This is a consideration that has been addressed with GWR.

Microwave technology, regardless of contacting or non-contacting, has risen to the top of the process level instrumentation chain for level measurement needs. When microwave technology was introduced to the instrumentation market in the early 1970’s, the design was a non-contact product and the technology was extremely expensive. The microwave instrument was designed to meet custody transfer accuracies of less than 1 mm and had communication protocols to transmit data to virtually any system.The technology soon became almost the standard by the 1980’s with installations on many vessels containing petroleum products like gasoline and jet fuels. These liquids are very expensive, and they are contained in forty to fifty foot diameter vessels. Each 1 mm change in level corresponds to hundreds of gallons of fuel. The fuel companies are mandated to have custody transfer measurement devices, so tank gauging radars are just the answer for desired accuracy requirements.

When do you need it?
As microprocessor-based technology advanced with software capabilities and surface mount printed circuit boards, microwave radar technology became less costly to manufacture. The price of microwave radar instruments has dramatically decreased. For instance, a level measurement device that once cost $10,000 is now in the $1,000 to $4,000 price range. With more reasonable prices and advancements in level measurement using this technology, many of the manufacturers of radar level instruments have begun applying microwave on many additional applications, not just the ‘tough’ ones.

In conclusion, the advancement of radar technology has brought valuable functionality and accuracy to rough environments and applications where there is a significant financial stake. It’s easy to see why it has gained such popularity.

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