By John Hemphill

Microwave Propagation

Helps Measure Sludge Density

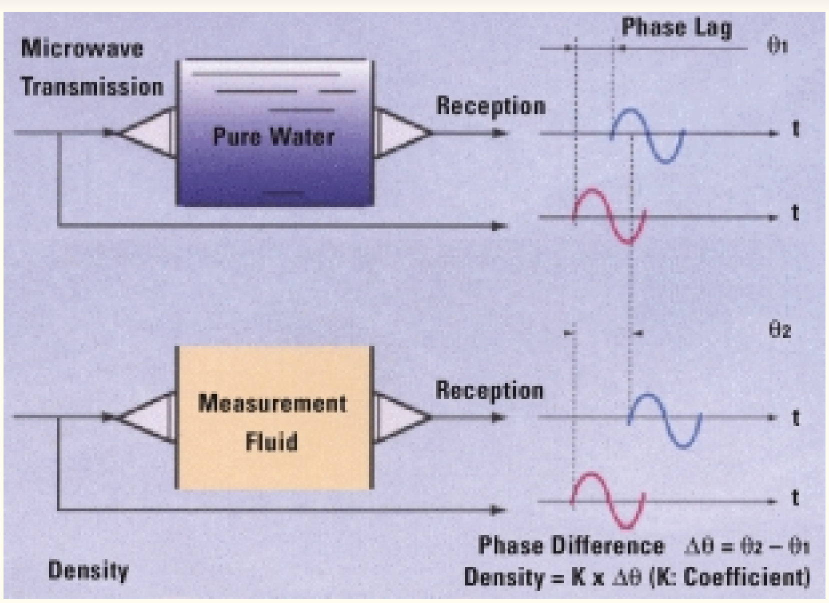
In the late 1980s, Toshiba began experimental research with the City of Tokyo to find answers for solving sludge density measurement problems. The City of Tokyo was looking for a replacement solution for ultrasonic density meters. What the City wanted was a density measuring device that could be used to accurately determine precise polymer injection, control the density of a thickener, measure return activated sludge, measure digested or "black" sludge and improve overall plant efficiency all with low maintenance. After numerous years of trying to make conventional density measuring devices work plus trying many brands of density devices, they came to the conclusion that a product that met their needs did not exist.

Research Begins

In 1989, Toshiba engineers along with engineers from the City of Tokyo began experiments using a completely new approach to measuring sludge density: microwave propagation. The engineers found that it was possible to determine the density of a fluid by measuring the microwave propagation speed change through that medium. As the microwave traveled through the sludge, the phase of the microwave signal was shifted based on the density of the material. They also experimented with different microwave propagation techniques to see which technique would offer the highest accuracy under the worst process conditions.

This joint research continued for more than two years, at which time Toshiba engineers solicited the help of engineers from a major university in Tokyo for additional research. With the university's scientific results in hand, they headed for Toshiba's Fuchu Lab to begin designing a workable microwave density meter. In March 1993 a prototype microwave sludge density meter had been developed. The prototype microwave density units were installed into various wastewater plants throughout Japan to refine the technology. The results from the trial units were excellent and thus in 1994 Toshiba introduced the world's first phase shift microwave sludge density meter (the LQ165 Microwave Density Meter).

Figure 1: How Phase Shift Works



Propagation Technologies

Propagation technologies include

- Amplitude Reduction
- Time of Flight
- Single Phase Difference
- Dual Phase Shift

During the research stage, Toshiba engineers experimented with each of these propagation technologies. They found that each had its own peculiarities. However, phase shift offered higher accuracy and less susceptibility to noise and entrained air. Dual phase shift is an enhanced version of the single-phase shift technology.

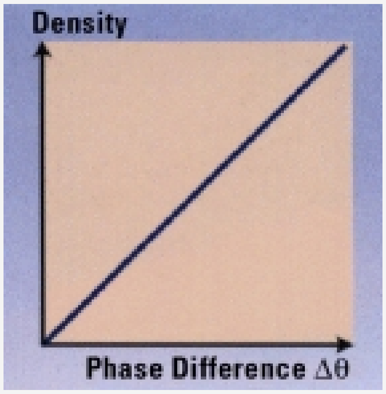
How It Works

Figure 1 shows that the blue signal (after propagating through the water) has shifted in phase compared to the red signal (the signal before it propagates through the water). Since the unit detects the amount of phase shift that occurs when traveling through water, the unit has the capability to accurately measure down to zero density. An even greater amount of phase shift occurs when sludge (measured fluid) is added in the pipe. The result is the higher the density (total solids) of the sludge, the more phase shift.

A Linear Technology

Figure 2 illustrates that the phase shift through sludge or any material is proportional to the density of the process and therefore is a linear phenomenon. Linear density measuring technology translates into simple

Figure 2: Phase Shift Through Sludge



calibration and setup providing users with quick, easy, single point calibration and wide rangeability (0 to 50 percent density).

Immune to Variations in Flow

Since the microwave technology requires no projections or moving parts in the flow stream, varying flow rates have no effect on accuracy. The phase shift of the microwave signal still occurs across the sludge if the sludge is standing still in the pipe or if the sludge is flowing at different flow rates.

Since the unit is impervious to flow profiles, it can be mounted virtually anywhere.

The Advantage of Measuring Total Solids

Microwave phase shift technology measures the density or the total solids in the process stream. (Density is equal to total solids divided by water plus total solids.) The density meter measures both the suspended solids and the dissolved solids and gives an output directly in percent total

solids (unlike optical devices). By simply subtracting the total solids reading from one hundred percent, a percentage of water present in the process is obtained (i.e., total solids equal dissolved solids plus suspended solids). Having a technology that also provides the percent water in the sludge as well as the total solids can help in optimizing wastewater processes.

Third Party Test

Early in 1999, Carollo Engineers, performing a study for the WERF (Water Environmental Research Foundation), inquired if Toshiba would like to provide WERF with two microwave density meters for long term testing in thickening and dewatering wastewater applications.

Two microwave density meters were shipped for the trial applications. Although the final report was not fully complete for this article, the results were impressive to Carollo Engineers who conducted the test for WERF. One microwave unit was installed in Oakland, Calif., at East Bay Municipal Utility District, and the other unit was installed at Orange County Sanitation District in California. The meters were tested in digested sludge and thickened waste activated sludge applications. The final WERF report will be available to their subscribers and the general public and is due out shortly.

Low Maintenance

The microwave density meter is a totally non-mechanical digital technology. There are no projections in the pipe to cause build up of materials that would require extraction and cleaning.

Since there are no moving parts, blades, rotors, seals, optics that require constant cleaning, nuclear swipe test to conduc or, records to maintain, there is virtually no maintenance associated with the unit. All settings are digitally stored in the meter and are not subject to drifting or frequent recalibration.

The low maintenance digital technology has translated into the unit working successfully in numerous wastewater applications. Wastewater applications are shown in Table 1. The next generation of microwave sludge density meters include many new options such as Teflon-lined models to prevent build up inside the meter, HART communications protocol and a Windows-based program for easy setup and datalogging.

Table 1: Wastewater Applications for Microwave Density Meters

Process Streams
Sludge density from primary clarifier
Sludge density from gravity thickener
Sludge density supplied to dewaterer
Thickened sludge density
Digested sludge density
Sludge density from washing tank
Sludge “in flow” density
Sludge density thickened by flotation
Dewatered sludge density
Sludge density from reservoir tank
Sludge density from coagulant chemicals mixing tank
Sludge density in water plant
Determining total mass balance for the plant

Possible Automation Functions
Controlling the output
Control process output
Efficient control of dehydrator
Control of chemicals’ dosing rate
Efficient control of digester
After digester
Monitoring load
Efficient control of flotator
Control dewatering process
Control chemical dosing rate

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