Conductivity measurement:

a hidden key to dairy industry success

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As the dairy industry moves to continue to grow and thrive, while remaining globally competitive, one of its biggest challenges will be how well the industry can maintain best practice processes that sustain a high quality focus, while delivering high-efficiency processes that minimise waste and downtime.

To ensure this consistent product quality, the equipment used in the manufacturing of dairy products is not only made from the highest grade of material, but also needs to be cleaned and maintained in such a way as to minimise any possible contamination when changing from one product to another or from one batch to another. This process is called CIP (clean-in-place).

To remain competitive, it is important to minimise production downtime without compromising on the safety and quality of the end product. In the CIP process, conductivity measurement is used to determine how effectively equipment has been cleaned and flushed. Conductivity in CIP picks up the change in the electric conductivity of a sample stream to indicate when a flushing process has started and ended. On a rinse cycle, for example, low conductivity indicates that all chemicals in the process stream have been flushed out and it's ready for the next batch of product.

An interesting case history

A major global dairy company with plants around the world was experiencing challenges with its liquid analytical systems, particularly as related to CIP. CIP systems thoroughly clean wetted components such as tanks, vessels, fermenters, process lines and inline sensors. The CIP process controlled the flow of pre-rinse, wash and post-rinse cycles, which include caustic rinse, acid rinse and water rinse cycles.

Conductivity sensors are a critical component in the design of CIP systems. The various cleaning solutions have more conductivity than the water used for flushing and final rinse. Since many systems are a 're-used design', the sensor can monitor the strength of cleaning solutions as chemicals get used up through successive cleaning cycles. Conductivity measurements can indicate the need for replenishment. To ensure that each piece of equipment has been thoroughly sanitised, conductivity sensors are used. Low conductivity indicates rinsing, as well as the completion of the cleaning process.

Any sensors that have to withstand CIP and sterilisation must be able to function under very harsh conditions — not a simple requirement for a sensitive analytical sensor. The dairy company was experiencing up to a 50% failure rate on sensors each year, at an approximate cost of $1200 per sensor. Much worse, however, was the cost of plant downtime — up to $100,000 per hour. The significant failure rate called the reliability of every sensor into question after a short usage period. As a preventive measure, every conductivity sensor

was replaced at the end of the season, which required another CIP cycle to be performed, adding even more costs and delay to production. It was preferable, however, to the possible dumping of milk product that would have to occur in the event of a sensor failure during processing.

The company had an equally pressing problem in that it required a supplier that could provide backup stock immediately in the vicinity. Due to the remoteness of the locations worldwide, this issue is more of a problem and requires the costly step of having additional inventory in stock. When the company set out to solve its technical issues, it also required that the new supplier provide backup stock and an agreed-upon price.

A unique solution

To solve the problem, the company settled on a unique sensor technology designed for CIP in the life sciences and food and beverage industries, using four electrodes rather than the traditional two. The wide dynamic range of the sensor, called the 410VP (1 µS/cm to 1400 mS/cm), makes it ideal for CIP monitoring.

Instead of two sensors — one to measure the high-conductivity cleaning solution and the other to measure the low-conductivity rinse water — a single 410VP was used. This is the first single four-electrode sensor that does the complete CIP conductivity measurement. The result is lower initial cost, less space taken up by sensors and analysers, and reduced maintenance and training requirements. In addition to CIP monitoring, the sensor can be used to observe the conductivity of elements and detect liquid interfaces.

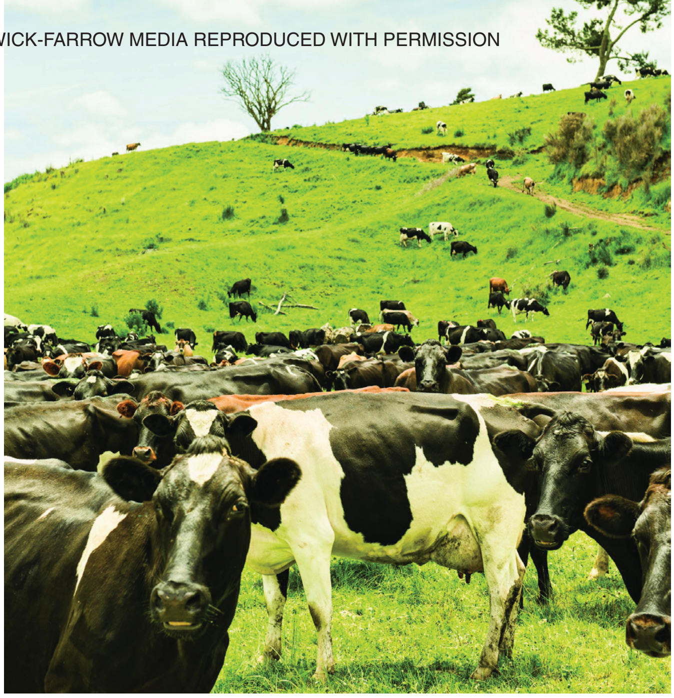
All wetted plastics and elastomers in the 410VP sensor are compliant with FDA food contact regulations, and all wetted surfaces except the electrodes have a 0.4 µm Ra finish. The sensor is designed and certified to meet 3A and EHEDG hygienic standards, and is available in 1½″ and 2″ Tri-Clamp, Varivent N and G-1¼ sanitary fittings. A quick-disconnect Variopol fitting is standard, making removing the sensor from the process piping easy. The sensor is calibrated at the factory, so startup is fast and easy. The 410VP sensor incorporates a Pt1000 RTD for temperature compensation. The RTD makes contact with the sample through a stainless steel interface, so response to temperature changes is rapid. Conductivity accuracy is reliant on temperature compensation, and more rapid temperature measurement provides more accurate conductivity measurement.

All of these features stood out for the company as compared to traditional sensors generally used for these applications. The biggest issue when looking at conductivity in the CIP system is the quick response needed to temperature changes. This is required as they want to pick up the leading edge of the flush water, since this means that less of the flush water is dumped into the chemical reclaim tanks. The traditional probe has its temperature sensor buried in the casing so it reacts more slowly to changes in temperature (up to 3–5 minutes for a 60% change). The 410VP has its temperature sensor mounted on the face of the probe, which means that it gives a far quicker response to changes in temperature (around 15–20 seconds for a 60% change). The other issue when using the traditional probe in smaller lines is that the sensor sits in the line and can create pressure drop problems, whereas the 410VP sits only marginally in the flow so it does not cause the same issues with pressure drop.

Predicting outcomes

The sensor was used in combination with a unique multiparameter, intelligent analyser (the 1056), which offered the company the flexibility to be able to add an additional measurement to the system at any time through the simple addition of an input card.

That same snap-in process enables fast, easy, inexpensive repairs should any be required. In addition, and perhaps most importantly, the analyser also offers the company a full range of predictive diagnostics. The analyser continuously monitors itself and the sensor(s) for problematic conditions. The display



flashes 'fault' and/or 'warning' when these conditions occur. Information about each condition is quickly accessible by pressing the diagnostic button on the keypad. Help screens are displayed for most fault and warning conditions to guide the user in troubleshooting. The design is very intuitive and easily guides the user through the menus.

Spectacular results

Selecting the right type of probe as well as a system designed for this kind of application has made great improvements for the user. From the up to 50% failure rate and total replacement policy, the company has literally not returned a sensor for repair, replacement or warranty claim since they were installed many months ago. The company's technicians are coming to rely on the sensor diagnostics, so if a system has a problem, the tech can walk through the diagnostics and get an immediate repair solution either directly from the system or over the phone from the supplier. The analyser's simple operation appeals to this user since they are losing much of their analysis 'brain trust' through the retiring workforce. Even the newest technicians can operate the system using the intuitive user interface and help screens. Emerson also set up backup stock for the company so that, in the event of any failure (which hasn't occurred yet), the sensor or analyser can be replaced immediately. Conductivity measurement is such a time-honoured analytical process, it's easy to believe that it is a commodity operation. As this case history shows, nothing could be further from the truth. Since production and profits can rise or fall on the success of this single measuring device, it pays to find the analyser and sensors designed for the dairy industry job at hand.

A few facts about conductivity

The dairy industry is an ideal application for conductivity measurement in that there are conductivity differences throughout each stage of processing. Conductivity is a measure of how well a solution conducts electricity and it provides important indications for the water quality throughout the process.

To carry a current, a solution must contain charged particles, or ions. Most conductivity measurements are made in aqueous solutions, and the ions responsible for the conductivity come from electrolytes dissolved in the water. Here are typical electrolytes:

Electrolyte	Description
Salts	Sodium chloride and magnesium sulfate
Bases	Sodium hydroxide and ammonia
Acids	Hydrochloric and acetic

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