Supplementing Lab Analysis with Inline Measurements

Reduce production down time, off-spec product and time-consuming manual grab sampling in food plants with inline instrumentation

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Food plant managers are faced with many challenges today, not the least of which is ensuring product quality. Depending on the product being made, they may have to meet the requirements of the Food & Drug Administration (FDA), European Union (EU), and an alphabet soup of other agencies and regulations, including cGMP, GFSI, ISO, HACCP, SQF, SID, etc. These regulations specify proper ingredients, chemical and biological hazards, procedures and sanitary conditions.

Food plant managers also have to meet the expectations of consumers for proper taste and texture. For example, the pH of certain products is critical, because it can affect taste as well as food safety. When adding citric acid to jams, beverages and other products for acidification, pH must be carefully controlled.

On top of the obvious food safety and product quality challenges, a plant manager also needs to address operational issues and goals such as:

- Product loss reductions
- Variable in raw materials
- Resource conservation such as energy and water reductions
- Loss of qualified operators and maintenance people
- Need to reduce operating and maintenance budgets
- Prepare and manage documentation for internal and external audits

Currently, food plants rely on laboratory analysis (Figure 1) of samples collected manually to ensure product quality at various points in a process. Lab technicians periodically take a grab sample, hurry back to the lab for a quick analysis, and communicate the result to plant personnel. Operators and maintenance personnel then make adjustments and corrections to improve control of the process, or to make repairs when required.

The challenge with relying on lab analyses is that it's not done in real time, it's time-consuming, it's labor intensive and it has possibility for manual errors. If it takes 30 minutes to grab a sample and analyze it, then the result represents where the process was 30 minutes ago — not now. The result could be a spoiled batch. If the measurement had been done inline, a sudden deviation would be detected, allowing for instant corrective action that could save the batch.

Figure 1: Taking samples from the process for analysis in the plant's lab is the tried-and-true method for ensuring quality control. It's also expensive and not a real-time measurement.

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In this article, we'll show examples how readily available instrumentation can be used for online quality control to supplement or replace laboratory testing, speed up measurements, enable immediate corrective actions, and automate the parts of the quality control system.

Inline Analyzers

Inline analyzers are not available for every type of measurement in the food industry, but are available for many of the common measurements now being performed in labs. Table 1 is a list of typical measurements available with inline instruments.

Table 1: Inline Analytical Measurements

- Mass flow for accurate recipe management
- Density, Brix, Plato, Baumé, ˚SAL, rate of fermentation
- % concentration (solids, alcohol, etc.)
- pH (using non glass pH sensors)
- Viscosity
- Conductivity
- Dissolved oxygen
- Chlorine
- Turbidity
- Color
- Specific gravity

Using inline analyzers helps management deal with many issues. For example, the amount of disinfectant used on a hydro cooker for canned food needs to be closely controlled to ensure food safety, as overdosing can cause corrosion and waste of chemicals, while too little can compromise food safety. One plant previously monitored disinfectant by taking grab samples to a lab for analysis twice an hour.

Inline analyzers were installed to measure free chlorine, pH, and conductivity of the disinfectant. Real-time measurement saved $13,000 annually in disinfectant costs by eliminating overdosing. These measurements also allowed the automation system to add makeup water based on measured values, saving on heat energy and water usage, and producing less wastewater. The inline analyzers also eliminated the need to send a lab worker to the hydro cooker two times an hour to take grab samples. The bottom line was a payback period of just seven months.

In a similar example of how inline analyzers can cut expenses, a cheese plant performed five clean-in-place (CIP) operations per day. The chemicals cost $1,771 for a 30-gallon drum, and the plant used three to four drums per month.

The plant installed an Endress+Hauser OUSAF11 optical phase separation sensor. Using visible and near-infrared wavelengths of light, the OUSAF11 can be used for product loss detection, interface detection, and suspended solids and turbidity measurements.

By measuring phase separation between whey, water and CIP detergent in the line, operators were able to determine when the pre-rinse and CIP was complete, instead of relying on lab measurements and timing. Each CIP cycle was reduced by 15 minutes and the plant used 32% less CIP chemicals. The cost savings were $5,300 in the first three months on chemicals alone, plus savings from reduced energy and water use. The plant also increased equipment availability for processing by more than one hour per day.

Inline analyzers are nothing new, of course. Many of these measurements have been available for several years and used for traditional process control. What's new today is increased reliability, along with new features and capabilities:

Improved Reliability:

Experiences in the industry with analyzers have been mixed. Trying to apply equipment designed for use in the lab directly in a process usually led to disappointments. Washdown, high temperatures, aggressive cleaning chemicals and other environmental factors often resulted in equipment failures and maintenance nightmares. These problems have been rectified by designing analyzers and other inline instrumentation from the ground up for use on the plant floor and in the field.

Seamless Integration:

Traditionally, instruments were analog devices with a single 4-20mA output. Today, the availability of digital outputs such as EtherNet/IP™, PROFIBUS®, FOUNDATION™ Fieldbus and HART® is making integration of information into automation and information systems very easy, and also allowing multiple parameters to be obtained from a single device. For example, a Coriolis flowmeter can provide mass flow, volume flow, multiple totalizer values, density, viscosity and temperature measurements along with diagnostic information over one set of wires (or wireless). These digital protocols also help improve accuracy by eliminating A/D conversions and loss in resolution of signal transmission in an analog 4-20mA signal.

Simplified Calibration:

With the expansion of digital sensor technology, the lab can now take responsibility for calibration of quality-related measurements. For example, to calibrate a pH sensor in the past, calibration equipment had to be brought into the plant. Today, this calibration can be done in the lab in a controlled environment, and the pre-calibrated sensors can be easily placed in operation. Endress+Hauser Memosens® and other similar technologies make this possible for pH, DO, conductivity, turbidity, chlorine and many other parameters.

Hygienic design:

One of the limiting factors for inline quality monitoring has been the lack of instruments meeting hygienic design requirements and resistant to thermal processing and CIP chemicals. Today, most instruments meet with EHEDG or 3-A sanitary standards and are designed for use in the food industry. An example is pH measurement, which most people associate with glass sensors—a big problem in food processing as glass sensors can break and end up as foreign objects in the final product. Now there are reliable non-glass pH sensors that meet food processing requirements.

Coriolis Flowmeter Provide Multiple Measurements

A single Coriolis flowmeter can measure a number of parameters simultaneously, often eliminating the need for multiple instruments, and their highly accurate measurement of mass flow and density (up to 0.05% on mass flow and 0.0005g/cm^3 for density) makes Coriolis ideal for many process control applications.

Often overlooked by many instrument and process engineers is the ability of Coriolis flowmeters to be used for quality control. For example, the flowmeter's density function can be used to measure Brix and Plato values to ensure quality of ingredients being used. The viscosity option provides continuous measurement to minimize off-spec product between lab measurements.

One food plant installed a Coriolis flowmeter (Figure 2) in a continuous bypass line of a batter mixing tank. The batter, consisting of flour, water and additives, is mixed until the correct viscosity is reached, and then pumped to the production tank for processing. The resulting savings in ingredients and the improvement in product quality paid for the installation in less than six months.

Figure 2: A Coriolis flowmeter installed in a bypass line, such as Endress+Hauser's Promass 83I, measures viscosity of the batter as it's being mixed.

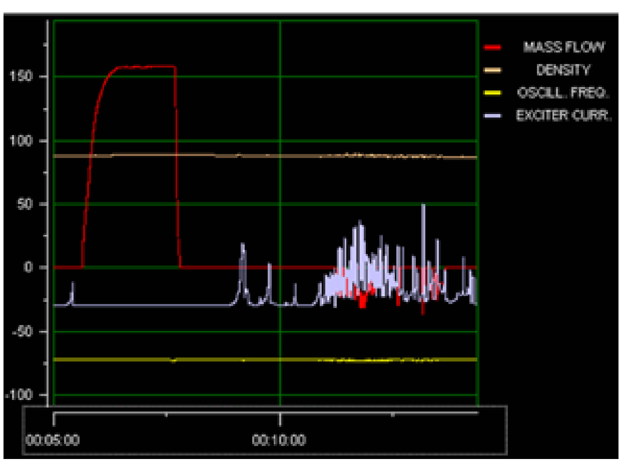

Figure 3: Diagnostics in a Coriolis flowmeter can determine if entrained air is present (purple trace in the figure). This data can be used as an operator alarm and to help during setup.

Instrument Diagnostics Detect Problems

Diagnostics enhance measurements by alerting operators to abnormal process conditions or upsets. For example, entrained air in the line can cause process problems. An operator needs to know if external air is being drawn in through a leaking seal, a cavitating pump or an empty balance tank, because air in the process can affect product quality.

A Coriolis flowmeter does not operate properly with large amounts of entrained air, so it has diagnostics to detect this condition. In an Endress+Hauser Coriolis meter, a diagnostic value shows that tube oscillation is in a good range, indicating no entrained air. If air appears in the line, the diagnostic value will change (Figure 3), setting off an alarm to the operator.

The same function can be used to improve accuracy when starting from an empty line. The automation system can use the diagnostic information in combination with a downstream control valve to automatically increase back pressure during start up, and then gradually decrease back pressure once the air is gone from the system.

Getting Started

The first step is to evaluate all the lab measurements and determine what can be replaced or supplemented with inline instrumentation. The goal is to help the lab focus on the final and critical food safety and quality measurements, while the instrumentation is used for real-time operations. Considerations here include:

- How much time is being spent taking manual grab samples?
- How much time is being spent running lab analyses?
- How many workers are needed for these tasks?
- How quickly does manual sampling detect process changes?
- How much does the delay in obtaining manual results affect product costs?

The hydro cooker application discussed above is a good example of a plant that saved worker's time by eliminating two grab samples per hour, and then saved on disinfectant chemical costs with timelier inline analysis.

The next step is asking: Which of the inline measurements would benefit a particular process?

For example, dissolved oxygen measurements in brewing, wine and juice production minimize oxidation of the product. Measuring the Brix of tomato paste can help control the amount of paste to be added during cutting. Viscosity measurements can improve the product consistency of batter coating for beans, onions, meat, poultry and other products.

Inline process analyzers cannot replace all the functions of a modern lab in a food plant, as certain measurements can't yet be reliably made by inline analyzers and instruments. However, modern inline process analyzers and instruments can reliably replace or supplement many of the measurements traditionally made in a lab.

Moving from offline to inline measurements cuts labor costs by eliminating manual sampling and analysis, and it adds consistency by automating the measurement process. Inline measurement delivers results in real-time, allowing automation systems to continually adjust process parameters to optimize quality and increase throughput.

Ola Wesstrom began his career with Endress+Hauser in 1992 at the Singapore facility, serving as the Product Manager for Level and Pressure. Since 2000, Ola has served as the Senior Industry Manager for the Food and Beverage Industry. With a degree in Process Measurement and Automation from Sweden's National Pulp and Paper Institute, Ola started his professional career with a process signal conditioning manufacturer in Sweden.

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