

Time for Calibration?

Is it really time for your Coriolis flowmeter to be calibrated? *Jonas Berge* explains how advanced diagnostics technology can help determine if the instrument needs to be removed from the process or if it can wait.

A Coriolis flowmeter sensor consists of one or two tubes through which the fluid flows. A control circuit drives electric coils applying an oscillating force to the tubes moving them from side to side maintaining amplitude at its resonant frequency. As fluid passes through the tubes, they twist slightly due to the Coriolis effect. The amount of tube deflection is directly proportional to the mass flow and is registered as a phase shift from which the mass flow is calculated.

Coriolis devices can also measure density, because the period of oscillation of the flow tubes, at its resonant frequency, is related to the density of the fluid in the flow tubes. This frequency is measured and the density calculated.

Coriolis flowmeters are suitable for liquids and gases, and they have an advantage in that their direct mass flow measurements are largely unaffected by changes in temperature, pressure, density, viscosity, and flow profile. They also have high accuracy and repeatability.

However, one problem is that corrosion and erosion cause thinning of the tube walls inside the

Coriolis flowmeter sensor. These and deformation due to harsh process conditions may cause changes in the stiffness of the tubes, which in turn changes the sensor's response to mass and density causing the sensor to drift out of calibration. Calibrating too frequently is costly, is time consuming, and disrupts the production process. But if calibrating is not done often enough, product quality can be negatively impacted.

Calibration options

Traditional methods for checking flowmeter calibration require expensive equipment including master meters, calibration carts, provers, or weigh scales. These in turn require a skilled technician, who must go to the field and pull the Coriolis flowmeter from the process line, breaking process seals and shutting down the process. The procedure is both time consuming and disruptive.

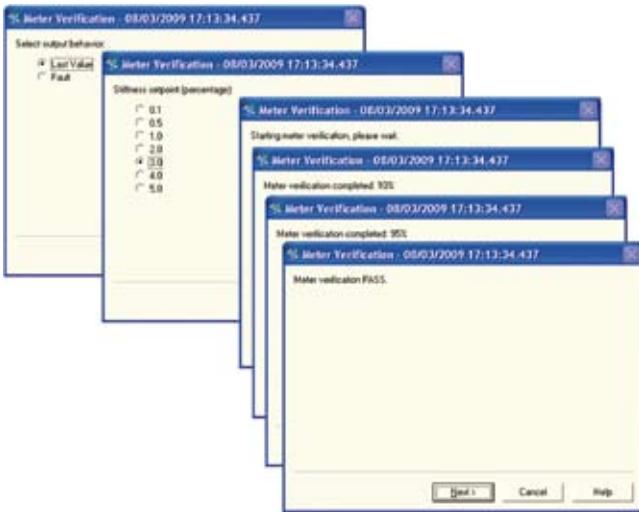
A better solution is in-situ meter verification, a form of diagnostics by which the complete performance of a Coriolis flowmeter is verified. Electronics determine whether a Coriolis flowmeter has experienced a change in stiffness due to corrosion, erosion, or deformation.

The structural stiffness of the Coriolis flowmeter element is measured from a unique signature that is created in response to a set of very carefully selected test tones. The measured stiffness is compared to the original stiffness when the Coriolis flowmeter left the factory to determine if the structure of the sensor tubes has changed or been damaged in any way. Multiple test frequencies are used to keep the diagnostics independent of density and flow and thus can be performed on any process fluid; it need not be the same fluid as in the factory benchmarking.

If the stiffness of the flow tubes has not changed from the original baseline captured in the factory, there cannot have been any erosion, corrosion, or plastic deformation of the flow tubes. A positive result allows operations and maintenance personnel to focus on troubleshooting the process and other instrumentation instead of spending time only to find out that the meter is, in fact, healthy.

Only if the stiffness has changed significantly is further meter troubleshooting required. A change





EDDL wizards guides the user step-by-step through flowmeter verification

can point to issues with the meter itself and more importantly with the process. After these issues are resolved, the meter can be recalibrated and put back into service with a new baseline for detecting changes in stiffness.

Getting smart

This so-called “Smart Meter Verification” can be embedded in Coriolis flowmeters; no external equipment is required, and technicians need not take the meter out of line or inject sample fluid, so the process keeps running. The Smart Meter Verification test procedure takes only 90 seconds and can be run at any time – started remotely at the click of a button. No long-term trending is required.

Thanks to digital communication protocols such as HART, Foundation fieldbus, or WirelessHART, the Smart Meter Verification can be triggered remotely from the maintenance station in the control room (see *Control Engineering Asia*, August 2009). The technician need not go to the field to connect equipment or press buttons on the local operator interface.

Instead, electronic device description language (EDDL) makes it possible to initiate the Smart Meter Verification from any control system supporting EDDL (www.eddl.org), and today all leading systems do. EDDL wizards created by the flowmeter manufacturer guide the technician step-by-step; no specialized training is required to perform meter verification. Percent completion is displayed throughout the process so technicians know how much longer they need to wait.

The meter verification wizard makes this a simple pass or fail test, it does not present incomprehensible numerical values or charts that need interpretation, but rather offers actionable information. If the result is “fail”, the technician must check the process, possibly schedule calibration, or if damaged, replace the flow sensor. If the result is “pass”, calibration can wait.

In-line meter verification is faster than calibration and non-disruptive to the production process. Unnecessary calibrations are eliminated, saving the plant thousands in operating costs each year by fully calibrating only those Coriolis flowmeters that really need it. Verification helps ensure regulatory compliance required for some industries with fewer calibrations at lower cost.

By knowing the Coriolis flowmeter is structurally unchanged, maintenance personnel may be able to extend the time between calibrations. Plant availability is increased as process downtime for calibration is reduced. And verification enables Coriolis flowmeter structural integrity problems to be identified before they adversely affect the process.

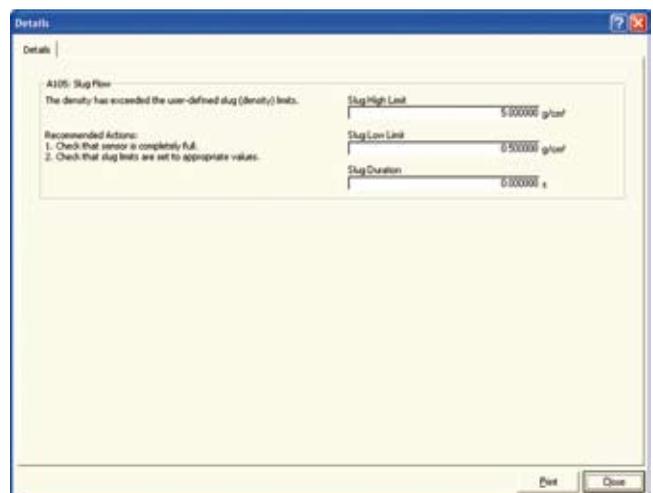
Calibration at the right time improves quality, avoiding costly rework or ruined batches if product is not within specification because ingredient quantity was not right. Even plant throughput can be improved, since setpoints of properly calibrated flowmeters can be pushed to run the process closer to peak efficiency, particularly for processes relying on precise mass balance.

Detecting slug flow

Bubbles in the liquid as a result of leaks in pump suction or due to tank agitation allowing air to be pulled into a line are known as entrained gas, transient, two-phase, or slug flow. This changes fluid dynamics, disturbing the drive circuit in the Coriolis flowmeter sensor.

Some Coriolis flowmeters have sophisticated mechanical design and fast drive control processing that can handle disturbances from both small bubbles and slug flow and are able to continue operating with an error as small as one percent. However, the root cause of the bubbles may be an abnormal situation that could escalate to a serious problem if not recognized and corrected. Therefore, the maintenance group should be alerted.

Moreover, the density reading for two-phase flow is the combined fluid density of the liquid and gas, not the liquid-only density. Since both low flow reading and density is affected, it is important for operators also to know when slug flow is occurring.



Advanced Coriolis flowmeters have diagnostics that can detect slug flow and guide operators and maintenance technicians towards corrective action.

First generation Coriolis flowmeters are unable to diagnose bubble flow or slug flow, so the underlying problems go undetected, and operators are unaware the measurement is misleading. But some advanced Coriolis flowmeters now have diagnostics that can detect and report bubble or slug flow to both operators and maintenance technicians directly at their workstations. The operator can take alternate steps to look after the process, while the technician can take steps to fix the root cause.

By using standard EDDL (IEC 61804-3) to structure the content in a hierarchical menu system, adding graphics, wizards, and conditionals to automatically handle data dependencies, the flowmeter becomes intuitive to use while providing full support for all its functionality. Since diagnostics detect these problems early, quality and yield is improved while waste and rework is reduced.

Online diagnostics

Most process plants have hundreds or thousands of field devices, many of which are not easily accessible, or located in hazardous areas. Most device failures will, if they go unnoticed, have a negative impact on the process in terms of inferior product quality, reduced process efficiency, or even a complete process shut down. Although operators walk around the plant on a regular basis, they cannot check on all of these devices.

In the past, Coriolis flowmeters and other devices were not inspected unless the operators suspected some type of problem. While they had self-diagnostics, a technician still had to be sent to the field to check the indicator or hook up a handheld field communicator to know if the sensor or transmitter had a problem.

This maintenance approach was reactive rather than predictive and therefore not very effective. By relying on the local display, plant personnel were not utilizing the full power of the intelligence built into Coriolis flowmeters.

Today, digital plant architecture with a network infrastructure such as HART, Foundation fieldbus, or WirelessHART establishes a permanent digital connection with Coriolis flowmeters and other instrumentation. Intelligent device management software that is part of asset management solutions uses this infrastructure to continuously monitor every networked device in the plant. Unnecessary trips to the field can be reduced by checking flowmeter health remotely. As a result, technicians can focus on the devices that really need their attention, thus reducing failures and process downtime.

There is no need to send a technician into the field to look at the local display to determine if there is a slug flow or other problem; the diagnostics are available on operator or maintenance console in only two clicks. In addition, problems are reported immediately when detected by the device's self-diagnostics, enabling corrective action to be taken sooner. EDDL (see *Control Engineering Asia*, September 2007) is used by the Coriolis flowmeter manufacturer's expert to share know-how in the form of text and illustrations guiding the technician toward a fast resolution of the problem.

While modern control systems using Foundation fieldbus or



By delivering accurate, actionable information, avoid unnecessary calibration and associated operation and maintenance costs.

HART can easily provide access to advanced flowmeter functionality, even if the plant's existing system does not support open bus protocols, it is still possible to benefit from Smart Meter Verification and slug flow diagnostics.

This is achieved by fitting a WirelessHART adapter on the Coriolis flowmeter. A wireless gateway and intelligent device management software enable meter verification to be run and diagnostics to be monitored from a dedicated computer. The wireless gateway optionally connects to the plant's DCS using Modbus, enabling auxiliary variables in the Coriolis flowmeter such as density, volumetric flow, and temperature to be accessed without running additional wires.

Once this simple wireless infrastructure is in place, it can be used for many other functions. It is now possible to deploy wireless transmitters for pressure, temperature, level, pH, conductivity, etc, in various applications for process improvement in "mini projects" impractical in the past. Wireless adapters can also be used on other devices such as control valve positioners to access valuable diagnostics.

Standardizing software

Instrument technicians often face the challenging task of managing a mix of device types including many kinds of flow measurement technologies, using different protocols, from different manufacturers, with different types used for custody transfer and control.

EDDL has made it possible to configure, calibrate, and diagnose Coriolis flowmeters from the same universal device management software used for the other devices in the plant. That is, Coriolis flowmeters are displayed consistently with other types of flowmeters as well as pressure and temperature transmitters, etc. Technicians apply what they have already learned from working with the other types of devices to the Coriolis flowmeter.

For instance, they are already familiar with the buttons to apply an edited value, to print, to get help, and to pan/zoom on the graphs and charts, etc. The technicians already have the clicks and key strokes at their finger tips and are less likely to make errors, as usage is second nature. It is possible to use the Coriolis flowmeter without having to stop and think and pay attention to peculiarities of stand-alone software. Even multiple versions of devices are easy to handle.

The same degree of consistency and ease of use cannot be achieved with other device integration technologies because the user interfaces are invariably programmed differently.



Through a digital network connection, overall flowmeter status can be monitored without going to the field.

Information chain

Because calibration should be checked at regular intervals, Smart Meter Verification is a sensible investment, reducing operations and maintenance costs by making calibration necessary only when really needed. Slug flow diagnostics uncover problems previously undetected, without sending a technician to the field.

These advanced new functions are user-friendly because EDDL hides any underlying complexity embedded deep inside the device, and guidance is provided by the flowmeter manufacturer. It is not necessary to switch device management technology to benefit from new innovative devices. All that's required is an upgrade from traditional DD to enhanced EDDL.

A digital plant architecture that uses the power of field intelligence to improve plant performance utilizes an unbroken chain of intelligent flowmeters and other devices, digital networking, and universal device management software to deliver accurate, actionable information to the right person in time to make a difference.

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Driving Coriolis Growth

An expanding range of applications and versatility are behind the recent growth of the Coriolis flowmeter market, according to ARC Advisory Group.

Coriolis flowmeters have continued to gain greater acceptance in the process industries. The market for these meters has enjoyed strong growth in recent years and technological improvements continue to expand their application range.

Revenue growth has been strong in all vertical industries, driven by greater user acceptance of the technology, increased sales of larger sized meters, advances in measuring two-phase flow and start empty/finish empty batch applications, the emergence of two-wire designs, and increasing popularity in custody transfer applications, particularly in the oil & gas industry.

Extensive capabilities

The versatility of Coriolis flowmeters is the most significant factor contributing to the growth of the technology. Direct mass flow measurement eliminates the need to compensate for other process variables, and Coriolis flowmeters can provide simultaneous outputs corresponding to volumetric flow rate, total flow, density, and temperature. No other flow device has such extensive capabilities.

Traditional mass flow measurement requires a primary flow element, numerous sensors, and related transmitters connected to a computational device in order to compensate for associated process variables. These additional devices add significant costs, are potential sources of error, and increase the maintenance profile of a company's field systems.

Action in Asia

This combination of factors has provided a big lift to the Coriolis market and is the reason Coriolis meters have been one of the fastest-growing flow technologies in recent years, although according to analyst Joe Gillespie, the principal author of ARC's *Coriolis Flowmeter Worldwide Outlook*, the global economic recession has taken its toll and negative market growth is a possibility for 2009.

Going forward, Coriolis suppliers can expect to see the largest growth in Asia, where heavy investment in new plant construction continues in core sectors, and in the Middle East, due to its high concentration of oil and gas activities and its growing focus on water desalination.

In the mature North American and Western European markets, suppliers will largely rely on replacement business, as Coriolis meters continue to gain preference over other flow technologies. Latin America will see above average growth, but remain a relatively small market for Coriolis suppliers.

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