The Importance of Mass Flow Measurement and the Relevance of Coriolis Technology

Why is Mass Flow Measurement important within process industries and what are the strengths of Coriolis Flow Meters and Controllers?

Measurement of the flow of a fluid, either liquid or gas, is commonly a critical parameter in many processes. In most operations this can be linked to the basic “recipe” of the process—knowing that the right fluid is at the right place and the right time. Equally, it can be linked to asset management, keeping the fluid in motion or even simple tank balancing. Some applications, however, require the ability to conduct accurate flow measurements to such an extent that they influence product quality, Health & Safety, and ultimately can make the difference between making a profit or running at a loss.

In other cases, the inaccurate measurement of flow, or even the failure to take such measurements, can cause serious or even disastrous results. With most liquid and gas flow measurement instruments, the flow rate is determined indirectly by measuring the fluids velocity or the change in kinetic energy. Velocity depends on the pressure differential that is forcing the fluid through a pipe or conduit. Because the pipe’s cross-sectional area is known and remains constant, the average velocity is an indication of the flow rate. The basic relationship for determining the liquid’s flow rate in such cases is:

\[ Q = V \times A \]

where

\[ Q = \text{fluid flow through the pipe} \]
\[ V = \text{average velocity of the flow} \]
\[ A = \text{cross-sectional area of the pipe} \]

Other factors that affect liquid flow rate include the liquid’s viscosity and density, and the friction of the liquid in contact with the pipe.

With the many variations of flowmeter technology available it can be very hard for an operator to make a decision on which technology is right for the application. Industry experts claim that a majority of flowmeters in the field are selected incorrectly. An important and perhaps overlooked question, is what the instrument is supposed to do versus what is it able to do? When selecting a flowmeter technological improvements can sometimes get overlooked through historical knowledge of what has been possible in the past—in a way, experience working against you.

Direct mass flow measurement is an important development across industry as it eliminates inaccuracies caused by the physical properties of the fluid, not least being the difference between mass and volumetric flow. Mass is not affected by changing temperature and pressure. This alone makes it important method of fluid flow measurement. Volumetric flow remains valid, in terms of accuracy, provided that the process conditions and calibration reference conditions are adhered to. Volumetric measuring devices, such as variable area meters and turbine flow meters, are unable to distinguish temperature or pressure changes.

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Figure 1: Difference of mass of gas by volume with changing conditions

One method of Mass Flow measurement employs the phenomenon of Coriolis force. This force is a deflection of moving objects when they are viewed in a rotating reference frame. Coriolis force is proportional to the rotation rate and the centrifugal force is proportional to its square. Coriolis force is a deflection of moving objects when they are viewed in a rotating reference frame.

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Figure 2: How Coriolis technology can help with process improvement

Another example of process improvement has been seen within the field of specialist chemicals. The customer was unaware that low to ultra-low flow control was possible with a Coriolis instrument resulting in the raw ingredient being mixed with water to create a carrier volume. This higher volume was then metered and dosed into the main product flow. The process added cost to the production method and, as the dilution step added variability to the concentration of the additive, product quality was often compromised with a resulting additional cost of re-work. Furthermore, the final process step saw the bulk material being heated and stirred to evaporate the added water to reduce volume and increase concentration. The energy requirement to do so was significant and the operational stock-holding was high. Further complications were added by the need for the “dosing system” to handle multiple additive doses with stringent cleaning needed between batches resulting in yet more wastage and high additional cost.

By understanding the extended capabilities of Coriolis instruments it was possible to establish that the concentrated raw ingredient could be added via a highly accurate low flow Coriolis Flow Meter...
directly coupled and controlled a precision pump. This solution ensured that the costly addition and removal of the water could be eliminated and that very close tolerances on the dosage rate, and hence final product quality, could be maintained. The inclusion of multiple synchronous injection points eliminated the costly clean-down process and the reduction of working process volume also reduced the stock holding inventory further reducing operational costs. Re-producible product quality has been increased, productivity has been increased, wastage has been reduced, energy consumption has been reduced and operational costs have also been dramatically reduced.

Figure 3 : Flow Rate profile of the meter for the example application

Although currently configured for control via the client DCS the Coriolis flow meter can, if needed, be “paired” with the main process line flow meter to act in master/slave mode. Standard on-board firmware can be utilised to immediately match the required dosage rate to any variability within the main flow line. This facility eliminates any idle time in process response and further enhances the very tight tolerances on product quality. A host of secondary benefits have also been utilised within the solution. The density of the concentrated natural raw ingredient is measured, recorded and trended thereby allowing tracking of the natural innate variability and further fine-tuning of the control process. The pump steering signal is utilised for condition monitoring and as a preventative and trended thereby allowing tracking of the natural innate variability and further fine-tuning of the control process. The pump steering signal is utilised for condition monitoring and as a preventative maintenance tool. This, together with dry-running protection, will ensure less emergency break-down and catastrophic down-time.

A further example illustrating where Coriolis flow technology can benefit the customer has been seen with the dosing of performance chemicals within the Oil & Gas industry. The traditional method of chemical injection, a piston pump with check valves on the inlet and outlet, is tried and tested and works well for quite long periods of time. However, on occasion the check valves can foul and begin to “pass”. Also, out-gassing or entrained air can cause an air-lock within the piston chamber that is simply compressive/decompressed in situ rather than pumped. In each of these cases the pump appears to be still working but there is no actual transfer of chemical into the pipeline. The only way to verify actual flow has been via a graduated gauge and a stop-watch; an empirical measurement but time consuming.

Another issue with the traditional method of injection is actually changing the flow rate. This can only be done manually by changing the stroke length of the piston – a process that is “trial and error” and only verifiable using the graduated gauge as above. Fine tuning of injection rates, for example to compensate for daynight changes in temperature across a field, is virtually impossible as the labour required to do so is prohibitive. This results in the injection rate being set for worst case thereby resulting in overdosing during normal conditions – a very expensive waste.

Modern communications networks now allow for technology to arrive at diffused production fields. The Coriolis flow system can be installed at each injection point and real-time monitoring, control and logging of injection rates can be achieved. This allows for remote checking of flow rates, remote instantaneous re-setting of those flow rates, on-board auto-alarm for status checking (for example, empty tank alarm and pump protection shut down), density change alarm, single point totalisation, multi-point (total field) totalisation for cost per barrel calculations and pump steering signal monitoring as a guide to preventative maintenance. In short, a very powerful tool within field management.

With these applications it can be seen that Coriolis Flow Technology can be a benefit to the user especially when the extended product capabilities are employed. Process improvement, cost reduction, real-time measurement and greater accuracy can all be achieved.

About the Author
Ashley Buck has been working for Bronkhorst for just over 4 years. He started as internal sales engineer, then moved to product management in 2013. Ashley has been in the process industry for 18 years, and has experience of working with all types of instrumentation.

New Multi-Function, Hand-Held Pressure Calibrator

GE Measurement & Control (USA) announced The new DPI 611 hand-held pressure calibrator from the GE Druck family of products. The DPI 611 business builds on the legacy of the DPI 610, which has long been acknowledged as the industrial workhorse of pressure test and calibration. A robust and easy-to-use device, it is twice as efficient at generating pressure, half the size of its predecessor, and has twice the pressure accuracy and three times better electrical accuracy. The DPI 611 is the latest addition to GE’s integrated calibration and communication solutions platform and are designed for use throughout the process, oil and gas, power generation and engineering sectors.

The new instrument is the first dedicated pressure calibrator to feature swipe screen touch technology. Its intuitive screen interface displays a comprehensive application dashboard, and a task menu allows simple, three-touch set-up for any pressure test or calibration. A ‘Favourites’ facility also enables quick access to frequently used tasks and custom configurations, which are easily stored. Results are displayed on the large screen and can be documented in 8GB of user memory. The instrument can automate processes to significantly reduce calibration times by running pre-defined procedures, calculating errors and reporting PASS/FAIL errors. The DPI 611 integrates seamlessly with leading calibration and maintenance software, including 4Sight from GE, to help maintain compliance with industry standards and regulations and improve process and operational efficiency.

The DPI 611 retains the comprehensive electrical measurement and sourcing capabilities of the DPI 610 and includes a 10VDC regulated supply and 24V loop power but is three times more accurate. However, it is in pressure generation where it demonstrates truly significant improvements. Its mechanical pressure-generating system eliminates the pitfalls of electro-mechanical devices and has been totally redesigned to create 95 percent vacuum or generate maximum pressure of 20bar/300psi in just 30 seconds, while holding the instrument in one hand or on a table top.

"The DPI 611 will be the new workhorse of instrument calibration, a workhorse with thrushipped features," said Mike Shelton, product manager at GE. "It is rugged and waterproof, light and compact and easy to use, offering reliable, fast and powerful performance in the most arduous of working conditions."

New Pressure Transmitter is UL Listed

After being tested by an independent certification company, Underveters Laboratories Inc. (UL), the new S-20 pressure transmitter from WIKA (Germany), which is available in numerous variants, is listed to applicable UL standards and requirements by UL. The globally accepted UL listing facilitates the use of the S-20 in all major markets. WIKA has developed the new measuring instrument for general industrial applications. It is available with all the connections and output signals expected in the market and in different accuracy classes. Customer-specific solutions are also possible. The S-20 has been designed for demanding applications and measures precisely, even under extreme conditions. It features international approvals and is available with short lead times in all variants.

Figure 1 : Flow Rate profile of the meter for the example application

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