The increasing value of modern 2-wire loop power technology

Advances in two-wire instrumentation make it possible to use flowmeters in hazardous areas, replace old, obsolete instrumentation with more accurate devices, and reduce maintenance and operating costs

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Some chemical manufacturing plants are competing for survival, not only externally against other global companies, but even internally among the global facilities of their own company. Other industry sectors face similar challenges.

Process improvements to increase yield or cut manufacturing cost, typically require enhanced process control, but the installed base of measurement instrumentation on a process plant may simply be unable to facilitate it, because of age, inadequate performance or unreliability. Maintenance cost and unscheduled process down time for an ageing process plant can be very damaging to the balance sheet. Upgrading to new, more accurate and more reliable instrumentation can be prohibitively expensive. New plant construction must also maintain a focus on optimizing costs for the process control infrastructure. The budget approval decision for new plant construction must weigh such costs against projected market conditions for the products that the plant is intended to manufacture. In today's volatile global marketplace, return on investment calculations for plant upgrade or new plant construction projects may go through several iterations before the trigger is finally pulled, or indeed not pulled.

This paper describes advances in two-wire instrumentation, specifically in relation to flowmeters, that have taken place in the past few years, and the significant cost benefits that this new technology can realize for plant builders and operators in terms of capital investment and cost of ownership.

The significance of 2-wire loop power

A survey involving 204 participants in the chemical industry across Germany, Switzerland, the UK, Canada and the USA (source: Dr. Manfred Koenig of K.I.M. Ludwigshafen, Germany 2006) revealed an 87% preference for 2-wire instrumentation versus 4-wire in process applications, and 89% to utilities. This overwhelming preference may stem from the fact that older process plants were built with 2-wire twisted-pair cable networks, connecting all the process units and measuring instruments together in an overall plant control scheme.

However, these existing cables are relatively unsophisticated and incapable of supporting anything but low energy instrumentation that is insensitive to interference from other electrical sources which might be sharing the same cable conduit. Furthermore, the low energy levels supported by these 2-wire "loops" are more easily rendered safe, in terms of explosive risk in "hazardous areas" containing flammable materials. Many older process plants are also likely to have a significant installed base of flowmeters employing pre-war (pre-1945) technology, such as positive displacement (PD), turbine, variable area (VA or Rotameter) and differential pressure (dP).

One reputable source for market data (Flow Research Inc: World Market for Flowmeters 2010) indicates collectively a future compound negative annual growth rate approaching minus 3% to 5% for PD, turbine and VA meter types, while dP is expected to keep pace with market growth.

The need to replace older technologies

Until the 21st century, 2-wire loops were only able to support these relatively unsophisticated instruments which convert their measurement by various means into a 4-20 mA output or pulse signal to the control system. The cost of ownership of dP, PD, turbine and VA meters can in many applications be significant, while maintenance budgets are under increasing pressure.

High cost of ownership will often translate into low process reliability, and that is also of major concern. Beyond that, these devices are fluid property dependent, not able to withstand fluid contaminants and frankly, their overall performance is too often inadequate for a process plant in this century.

The more advanced post-war technologies, such as Coriolis, ultrasonic or electromagnetic flowmeters have until just eight years ago, required a dedicated power supply for their function, in addition to the output loop, and thus a 4-wire infrastructure was required as a minimum. Therefore, upgrading older 2-wire meter devices to more modern 4-wire technology could demand significant expenditure in terms of the installation of separate power cables and supply modules.

There was a major breakthrough in 2006 when the world's first true 2-wire, loop powered inline liquid ultrasonic flowmeter was introduced (Figure 1). The nature of this breakthrough was innovation in device power management. That was the missing piece up to that point, because to be a true loop powered device, it had to directly provide a full 16 mA span using less than 3.6 mA of remaining loop current and less than 1 Watt of electrical energy. The flowmeter operated on a single, 4-20 mA HART® 2-wire loop, was remotely powered by a DC supply, was certified Class 1 Division 1 and could be deployed as Intrinsically Safe through the use of an approved safety barrier.

Figure 1: The world's first two-wire ultrasonic flowmeter in 2006 operated on a single, 4-20 mA 2-wire loop.

The world's first true 2-wire loop powered Coriolis flowmeter followed in 2011 (Figure 2), from the same manufacturer, now employing a new and more advanced common electronics platform. The world's first 2-wire loop powered inline ultrasonic flowmeter for low pressure gas was introduced in 2012. A second 2-wire loop powered Coriolis meter followed in 2013 offering improved measurement performance and an additional high-performance meter tube material.

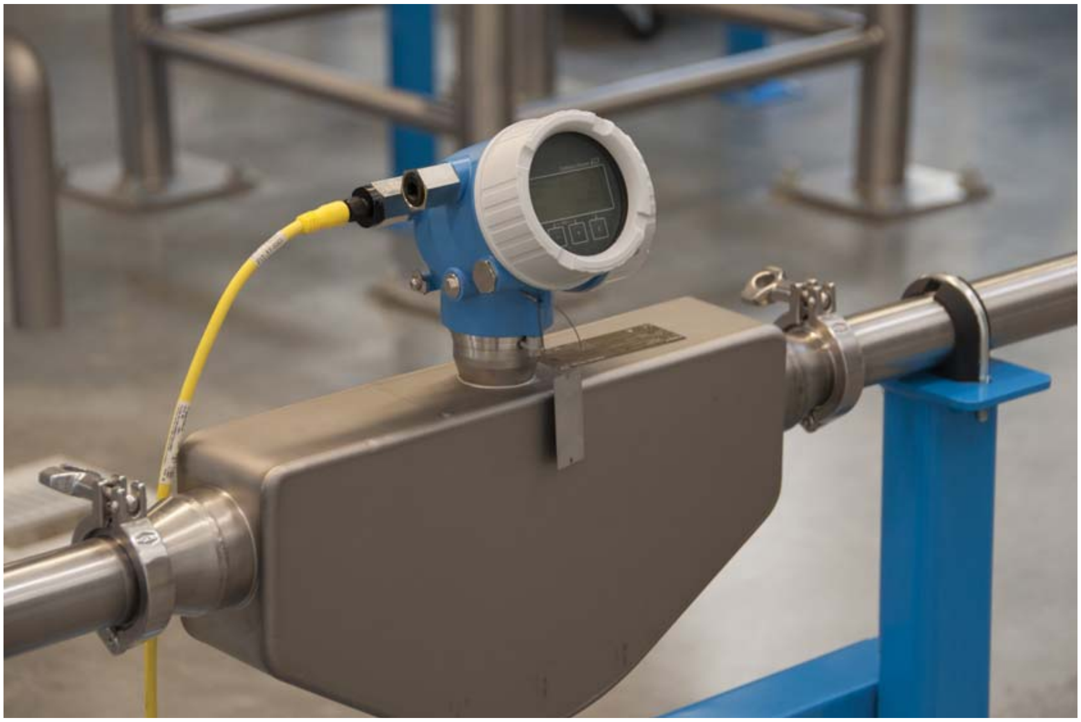

Figure 2: Two-wire Coriolis flowmeters became available in 2011.

Electromagnetic and vortex flowmeters had already been available for some years in 2-wire loop powered form, but improved performance resulted as these designs were incorporated into their new, common electronics platform in 2013. So all the "modern" flow measurement technologies, that is to say those introduced post-war, have become available as 2-wire, loop powered devices with one exception, namely Thermal Mass (a.k.a. Thermal Dispersion). Unfortunately, the power requirements for this technology exceed what is deemed possible with 2-wire loop power management.

Payback for technology upgrade

Consider a 1-inch process line containing a liquid process ingredient costing $1.00/lb at a mass flow rate of 150 lb/minute. We have $150/minute flowing in the line, translating to $9,000/hour, and $72,000 per eight-hour shift. That calculates further to $360,000 per five-day working week, and for a working year of say 40 weeks, that is $14,400,000. Assume the current flowmeter is a turbine.

Now imagine a 2-wire loop powered Coriolis mass flowmeter is installed in place of the turbine meter. The line would need to be drained, and probably one process flange replaced allowing the Coriolis to fit mechanically in place of the turbine. However, the two-wire loop already used for carrying the turbine meter's flow signal to the control room can be used unaltered for the complete electrical installation aspects of the Coriolis meter.

The upside of the change is significant and clear cut. Generously assuming the turbine meter measurement uncertainty was 0.2% of reading, then measurement uncertainty improves through use of Coriolis to 0.1% of reading, giving a 0.1/100 x $14,400,000 improvement in control of the ingredient annually, or $14,400. A 2-wire Coriolis mass flowmeter with 0.1% mass flow accuracy would be paid for in around six to eight months. In practice, the improvement in measurement uncertainty would be greater, as the operator would gain temperature and density information from the Coriolis and the measurement would be devoid of any fluid property dependence. Viscosity change for example can have a major impact on turbine meter performance. Mechanical wear and tear as suffered eventually by turbine meters, causing them to under-register flow, is precluded by modern devices like Coriolis.

Furthermore, if the process ingredient was being blended with another, then additional process improvements could be realized through in-line blending control using Coriolis technology for final density as the control point. It is possible to have dual 4-20 mA outputs from 2-wire loop powered meters, but as the main 4-20 mA output representing the primary variable is also HART, then an external HART Loop Converter or HART I/O card in the control system, can provide secondary, tertiary and quaternary variables as 4-20 mA signals. A Coriolis meter is truly a multi-variable device. Certain two-wire devices are also available with Profibus or Foundation Fieldbus communication.

Cutting wiring costs

In 2003, WIB/EXERA (International Instrument Users' Associations) Report T 2732 X 03 was published, and it provided an average survey of prices quoted in projects at that time for the provision of power supplies for 4-wire instruments. The price ranged from $1400 to $2100 per instrument, depending upon design and plant characteristics, for an average cost of €1,500 (about $2,000). It would be reasonable to assume an inflationary factor of 2% per annum, giving an approximate current-day figure of $2,500.

From another source within the chemical industry, an estimation of $40 to $50/foot was given for installation of 4-wire cabling. For a linear 50 foot cable run, with say a 10 foot vertical at each end, this equates to $3,150. Actual costs and budget estimates have been given as high as $10,000.

The extent of the opportunity

The modern "post-war" flow measurement technologies have different power requirements, and consequently they are not all available for the same size range in 2-wire loop power form. For example, 2-wire Coriolis meters are limited to 3-inch diameter, electromagnetic and inline low pressure gas ultrasonic are limited to 8-inch, and vortex and inline liquid ultrasonic are limited to 12-inch.

Nevertheless, for the chemical industry in particular, perhaps two thirds of the process pipes on a plant will be no larger than 2-inch, and even when the host process pipe is larger, a correctly sized flowmeter can still be less than 2-inch. There is considerable scope for 2-wire loop power to deliver value for flow measurement applications with total safety.

We have discussed the virtues of Coriolis technology, but what of the other 2-wire technologies? An electromagnetic or "mag" meter in 2-wire form can be used on water, wastewater or a light water-based slurry provided the fluid has around a 20 μSeimens/centimeter (μS/cm) electrical conductivity.

A magmeter is full bore, unless flow rates dictate a reduced meter size in the interests of performance, and so there are no intrusions into the flow stream and no pressure loss. An accuracy of 0.5% of reading is normal from a 2-wire magmeter, and a modest five diameters (5D) of straight inlet run is needed to avoid error from upstream flow disturbances. When the fluid exhibits insufficient conductivity, then the same performance and installation requirements can be met by an inline ultrasonic meter provided the liquid is essentially clean and bubble-free.

For gas or steam applications, a vortex meter is the normal choice. Using a built-in temperature sensor, a 2-wire loop powered vortex meter can calculate mass flow of saturated steam using internal steam tables. An external pressure input allows mass flow of steam to be accurately calculated even when saturated steam becomes superheated, as can occur downstream of a pressure regulating valve. With mass flow known, the vortex meter can calculate energy and heat flow.

A new and exciting development is the ability of the vortex meter to indicate wet steam, and calculate dryness fraction or steam quality. For safety and efficiency, saturated steam should be dry and free from condensate; that is to say, it should possess a high steam quality factor. However, the dry or wet state of saturated steam can sit on a knife-edge and shift to the opposing state due to the slightest change in process conditions. Rapid and reliable indication of this change of state is now available.

Perhaps the most astonishing achievement in the power management of 2-wire loop power flowmeters is that of the ultrasonic biogas meter. It is now possible not only to measure the flow of wet, dirty, variable composition and low pressure anaerobic digester gas, landfill gas and coal bed methane gas with a 2-wire loop powered ultrasonic meter, but the same device uses an inbuilt temperature sensor in combination with measured sound velocity to calculate methane content, calorific value and energy flow.

Technology to take us forward

Modern flow technologies provide instrument engineers with vital self-monitoring information. The format of such information is easier to understand and act upon when presented in accordance with harmonised international guidelines for online plant asset management; i.e. NAMUR Standard 107.

Continuous "plain text" self-diagnostic and process related information, with suggested remedies (Figure 3) make it possible for instrument engineers and operators to take action at the appropriate time; immediately or during the next scheduled shut-down, saving time and money by knowing the exact health of their measuring point and the probable actions required to rectify any abnormal conditions. Device verification, offering third party validated traceability, can be performed on demand either locally or remotely from the control room without the expense of a man in the field. Calibration thus be avoided or deferred without process interruption.

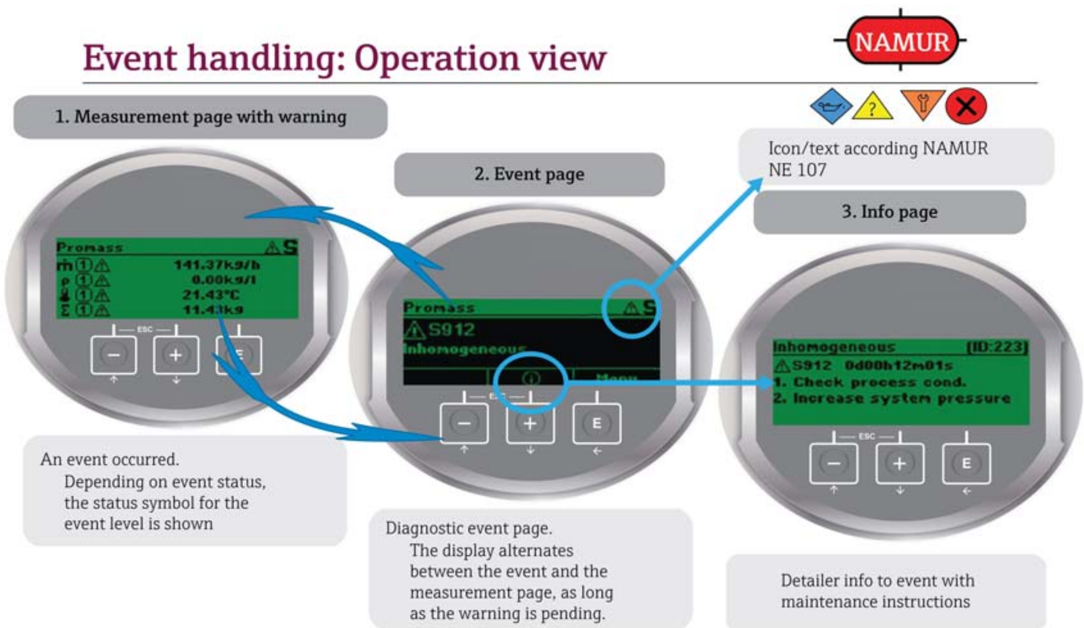

Figure 3: A modern instrument's display module can provide continuous "plain text" self-diagnostic and process related information.

Summary

Where a process plant has a large installed base of older mechanical technologies, the decision to embark upon a program of replacement for plant modernization cannot, of course, be taken easily. There are the stocks of spare parts to consider along with the plant instrument technicians who are trained on, and at ease with, the old devices.

However, a process plant which retains the older technology going forward will be at risk and may find it increasingly difficult or even impossible to maintain a cost position that competes effectively in the global market.

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