TILO MERLIN, ANDREAS DECKER, JÖRG GEBHARDT, CHRISTIAN JOHANSSON – The majority of measurements made in the process industry are of temperature and pressure. Around half of the temperature measurements are used for monitoring purposes to secure product quality, increase process efficiency and ensure plant safety. There are virtually no chemical processes in which temperature measurement is not required. Suitable conventional temperature measurement instruments are widely available and the cost of these has decreased over time due to high volumes, technological progress and competition. However, these devices are mostly intrusive in nature. ABB’s noninvasive, wireless and energy-autonomous temperature sensor is now changing the face of industrial temperature sensing, as has been illustrated in a recent pilot installation in The Absolut Company’s vodka distillery in Sweden.
Thermowells
The thermowell protects the sensitive measuring inset from the hot, chemically aggressive, abrasive or pressurized flow inside pipes, boilers and vessels. However, the thermowell obstructs flow, leading to a pressure drop. This phenomenon creates low-pressure vortices downstream of the thermowell. Vortex shedding causes the thermowell to vibrate and if the vortex shedding rate matches the eigenfrequency of the assembly, resonance occurs and dynamic bending stress increases substantially.

In terms of plant safety, thermowells are the most critical part of a temperature instrument: At high flow speeds and pressures, thermowells can easily burst if they are not designed properly. Accordingly, standards have been developed by organizations such as ASME (American Society for Mechanical Engineers) to assist engineers in selecting suitable designs. For applications where the standard is not applicable, the engineer is fully responsible for the proper design of shape, length, diameter, coating and interface type. Altogether, this leads to a greatly enlarged number of variants – resulting in higher cost, stock levels and logistic effort.

ABB has now transformed the temperature sensor once more, making it autonomous by introducing wireless communication as well as an energy-harvesting power supply that feeds the instrument from the temperature gradient between the process and its surroundings. This ABB innovation was a major milestone in temperature sensing and an enabler for wireless communication in process automation.

One remaining shortcoming of industrial temperature measurement devices, however, was the thermowell.
Noninvasive methods

Thermowells can be eliminated by using a noninvasive temperature measurement. Noninvasive instruments leave pipes and vessels unaffected, with many advantages:

- The shells of pipes and vessels are not penetrated.
- There is no need to empty the pipe for installation.
- No welding is required on site and no special permission for hazardous areas is needed.
- The possibility of contamination is eliminated.

These advantages have considerable implications: Measurement points are now easy to install and can thus be used on a temporary basis – eg, during setup and test of a new process or, if there are issues in production, for root-cause analysis. As soon as a satisfactory situation has been arrived at, the number of measurement locations can be reduced to an economically and technically appropriate long-term value.
Why have noninvasive methods not been used before?
There are good reasons why noninvasive technology has not been used in the majority of temperature measurement installations so far.

The easiest way to obtain a noninvasive temperature measurement would be to attach an existing instrument to the surface of a pipe or vessel instead of introducing it into a thermowell. However, the temperature sensor is then further away from the process medium so that the response time would be impaired, and ambient conditions would have a bigger influence on the measurement.

A good noninvasive temperature instrument, therefore, has to have an appropriate design of the thermal pathway from the process to the sensor, which includes all materials and all interfaces through which the heat has to be transferred. It would also be beneficial if the existing (thermowell design) instrument could be adapted to fit as this would reduce the development effort significantly, keep the number of variants and additional parts low, and make it easy for the customer in terms of familiarity and certification retention.

A challenging case
Two autonomous [3], noninvasive temperature instruments were given to The Absolut Company in Nööbelöv, Sweden so they could explore the device’s capabilities without having to interrupt the processes in their vodka distillery ➔ 5. To keep the effort on ABB’s side low, adapters were manufactured to mount existing (thermowell design) instruments with adjusted inset length to the pipes.

The sensors were easy to integrate into the existing ABB Extended Automation System 800xA. The System 800xA automation platform has a built-in field device management system. This allows users to have one single system that covers operations, engineering and field device management – including functions such as device configuration and condition monitoring. Such an approach has significant advantages – reduced engineer-
The sensors were easy to integrate into the existing ABB Extended Automation System 800xA, which has a built-in field device management system.
Easy installation
The newly designed adapter can be mounted onto a wide variety of pipe diameters; only the length of the clamps (simple steel bands) has to be adjusted, thus greatly reducing the number of variants and increasing flexibility. The design’s lower complexity requires less machining and allows simpler installation, which is especially beneficial in hard-to-reach locations. The installation does not require calibration or extensive parameterization.

Following this optimization, The Absolut Company installed four TSP341-W units and the predicted improvements in measurement accuracy and response time were confirmed.

A new flexibility
Noninvasive, wireless and energy-autonomous temperature measurement ushers in a new era of flexibility. With temperature measurement and the job of engineering it into a System 800xA DCS now made so easy, applications that add a high value – but traditionally have been difficult to justify from a cost perspective – are now well within reach. One good example of such an application is short-term instrumentation of processes during optimization and continuous improvement exercises or energy efficiency initiatives. Another example is to supply ABB’s System 800xA heat exchanger asset monitor (HXAM) – a condition monitoring tool that identifies heat exchanger performance changes and operational degradation – with the temperature inputs it requires to guarantee more energy-efficient operation and reduced maintenance costs. In large facilities, improved heat exchanger performance delivers substantial energy savings.

Only applications with extreme spatial or temporal gradients pose a challenge to the complete closure of the gap between the performances of the noninvasive sensor and its invasive counterpart – both in terms of measurement accuracy as well as response time. A next logical step, once the thermomechanical options are exhausted, is to use advanced model-based algorithms that can correct the measurement.

Tilo Merlin
ABB Process Automation, Measurement and Analytics
Frankfurt, Germany
tilo.merlin@de.abb.com

Andreas Decker
Jörg Gebhardt
ABB Corporate Research
Ladenburg, Germany
andreas.decker@de.abb.com
joerg.gebhardt@de.abb.com

Christian Johansson
ABB Process Automation, Control Technologies
Malmö, Sweden
christian.johansson@se.abb.com

References

Absolut zero invasion