Pervasive metering of minewater flows and process water using distributed acoustic sensor technology

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INTRODUCTION

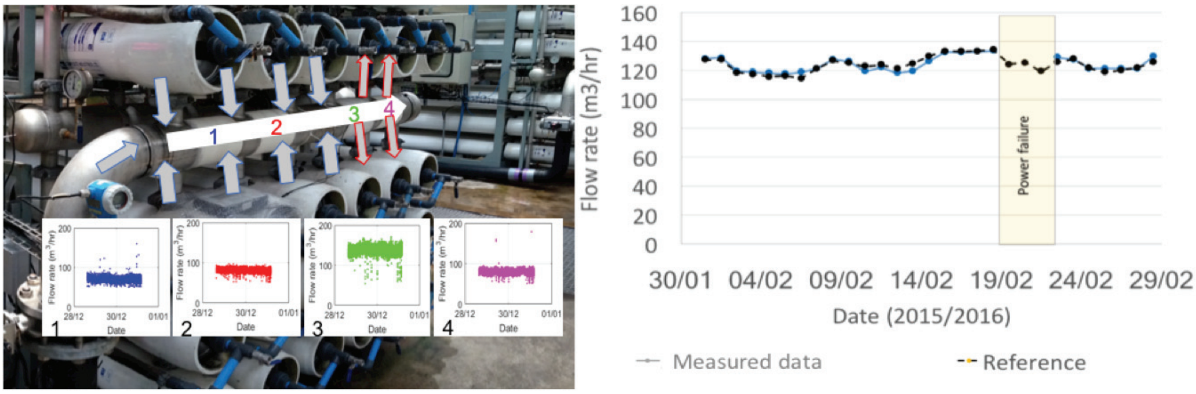
Silixa was commissioned by Anglo American to execute the world's first pilot installation for a non-intrusive, multi-zone, multi-fluid flow metering system based on distributed acoustic sensing (DAS) technology. The pilot was executed at eMalahleni Water Reclamation Plant (EWRP), where 30 ML per day of acid mine drainage (AMD) is reclaimed from local coal mines for use as both drinking water and mining process water. This metering network installation featured liquid- and slurry-handling lines (made from both steel and HDPE) ranging from 165 mm to 400 mm in diameter. As is the case for many plants of this scale, flow systems control is challenged by the need for large numbers of low-capex, reliable flow meters that can be retrofitted unobtrusively on pipes of varying materials with a range of sizes. Furthermore, in this case the flow sensing network was required to be robust against flows featuring high solid fractions (>30%). It was demonstrated that distributed fibre optic sensing can be used to enable pervasive flow sensing at several locations within the plant, simply by instrumenting all of the pipes of interest with a single continuous length of optical fibre. The sensing layout was straightforward to install, and the flow rate output was in good agreement with reference measurements made using conventional sensors. The successful sensing of these flows indicates good potential for this technology to be used for pervasive metering in a broad range of plant types.

METHODOLOGY

For the purpose of this technology demonstration, six separate liquid flow zones in three different sections of the water treatment plant were instrumented using a single continuous length of optical fibre. The non-intrusive installation was executed during two working weeks, and resulted in no unplanned downtime for the plant. Zone 1 of the installation featured a 400 mm HDPE water supply line feeding minewater from the surrounding mines into the plant. This pipe is metered continuously using a conventional magnetic flow meter, making it straightforward to obtain reference flow rates. Zone 2 featured a 200 mm HDPE flow line handling clarifier underflow water slurry with a variable solids volume fraction of approximately 10–35%. Zones 3–6 featured a 165 mm multi-branch stainless steel manifold handling reverse osmosis process flows. The reverse osmosis manifold features inflows from stubs spaced at intervals of only 200 cm, dictating a free pipe length of less than 1.5 diameters per measurement zone in this application. During the course of the 6-week pilot, flow rates were monitored continuously at one-minute intervals using the distributed optical system in combination with a processing server. Data was automatically uploaded every 24 hours from the plant in rural South Africa to the Silixa office in London.

RESULTS AND DISCUSSION

The flow measurement network successfully measured flows on the instrumented zones. The flexible sensing architecture made it possible obtain quantitative, multi-zone water flow rate data between the tightly spaced inflow stubs along the reverse osmosis (RO) stainless steel manifold (Figure 1a). Flow rate output obtained on this application compared well with reference measurements made using a clamp-on ultrasonic meter. Furthermore, good correlation was seen between Silixa's data and reference data on the clarifier slurry and minewater flows, as shown below respectively in Figure 1b and Figure 2. Over the one-month period, for days when both the reference sensors and the DAS system were available, it is seen that the accumulated slurry flow data is accurate to less than 0.5% (Figure 1b). The accumulated minewater data over a two-month period is accurate to within 1.5% (Figure 2).



(a) (b)

*Figure 1. **(a)** Multi-zone instrumentation of an RO manifold enabled flow measurement on a complex process. Colour-coded results are shown for the four zones over a two-day period. **(b)** Clarifier slurry data for EWRP over a one-month period.*

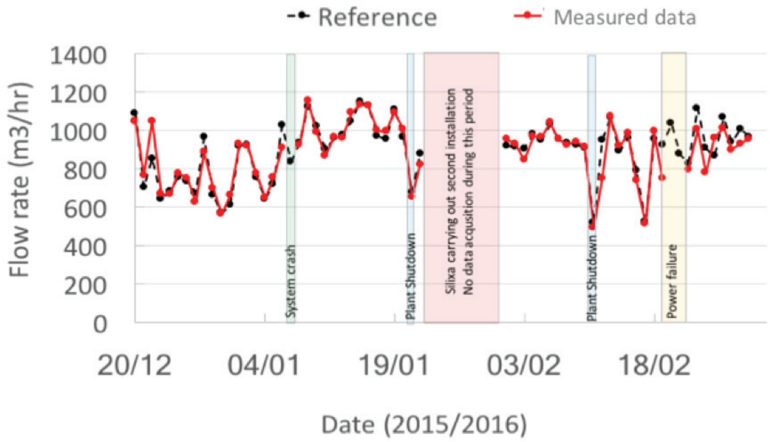


Figure 2. Minewater data for EWRP over a two month period.

CONCLUSIONS

A pervasive flow metering technology demonstration using distributed fibre optic sensing was successfully executed at a water reclamation plant. Sensing fibre was installed non-intrusively on several pipes at various locations across a 6 ha site. All of the zones were monitored using a single optical flow sensing instrument located in a control room. Precision flow measurements could be made for both water and slurry flows on pipes of various materials and dimensions. The successful application of this technology to the RO manifold is indicative of the breakthrough potential for this sensing architecture within process monitoring, as the results demonstrate that this technology can be applied on industrial processes where conventional flow measurement would be too cumbersome or expensive to pursue. Hence, these results suggest that distributed fibre optic sensing can provide a cost-effective alternative to soft sensors and virtual metering for complex industrial processes featuring high numbers of flow lines.