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SAND MANAGEMENT

Explaining sand erosion in oil & gas production

Part 1: Erosion due to entrained sand is a growing problem, and existing technologies have limitations, but new solutions are available to address this issue.

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Sand erosion poses significant challenges in the oil and gas industry, because it can lead to equipment damage, production loss and costly repairs. Existing sand control techniques—such as well completion, sand screens, sand separation or predictive models for sand production—are not fully effective. This article discusses sand erosion issues in detail, and a follow-up article in next month's issue will show how the integration of acoustic sensors and ultrasonic thickness sensors to detect and assess sand particles in pipelines and process equipment addresses these issues.

SAND EROSION ISSUES

Sand produced as a byproduct of oil and gas production is a worldwide problem. It occurs when the stress on the formation exceeds the formation strengths and results in rock failure. Rock failure can happen, due to tectonic activities, overburden pressure, pore pressure, stress induced during drilling and produced fluid drag force. The solid sand particles will cause rapid erosion in the piping infrastructure, forcing operators to produce below the well's potential, and to increase spending on maintenance and repair activities.[1]

Additionally, as oil and gas reservoirs across the world are maturing, they start to produce more sand, thus increasing erosion risk. Sand erosion challenges span across different areas, such as reservoir management; health, safety & environment; integrity management; and production management. Operators in the oil and gas industry are seeking to prevent sand from coming out of the reservoir and flowing through the topside piping infrastructure, because uncontrolled entrained sand poses a serious risk of erosion damage to their topside assets—including choke valves and expensive rotating equipment.

This type of equipment failure can lead to unplanned shutdowns and increased operational costs for repairs. During shutdowns, the well is not producing, which means that revenues and profits are lost.

SAND CONTROL TECHNIQUES AND LIMITATIONS

In the attempt to keep sand under control, several techniques are currently utilized, including sand screens and gravel packs, temporary and permanently installed sand separators, and calculation models, to predict the amount of sand that a reservoir will produce.

Gravel packs and sand screens installed downhole directly before wellheads can capture a high percentage of the sand coming out of the reservoir,[2, 3] but there is still some sand escaping into topside piping infrastructure. Left uncontrolled, this entrained sand can damage the choke valve, pumps and other equipment, and it can even erode the pipes, causing a loss of containment, followed by imminent shutdowns. The result of this, in economic terms, can be substantial, running into millions of dollars in lost revenue. In the event of a loss of containment, well operators would also face serious environmental and safety challenges, with a high-cost impact. Gravel packs and sand screens also limit production rates, causing revenue loss.

FIGURE 1 displays a series of erosion damage examples produced by sand flowing through topside infrastructure, collected from onshore production sites in the Middle East region. To reduce the uncertainty with regard to the amount of entrained sand, even after deploying sand control techniques, operators often use sand monitoring as a complementary method to validate the

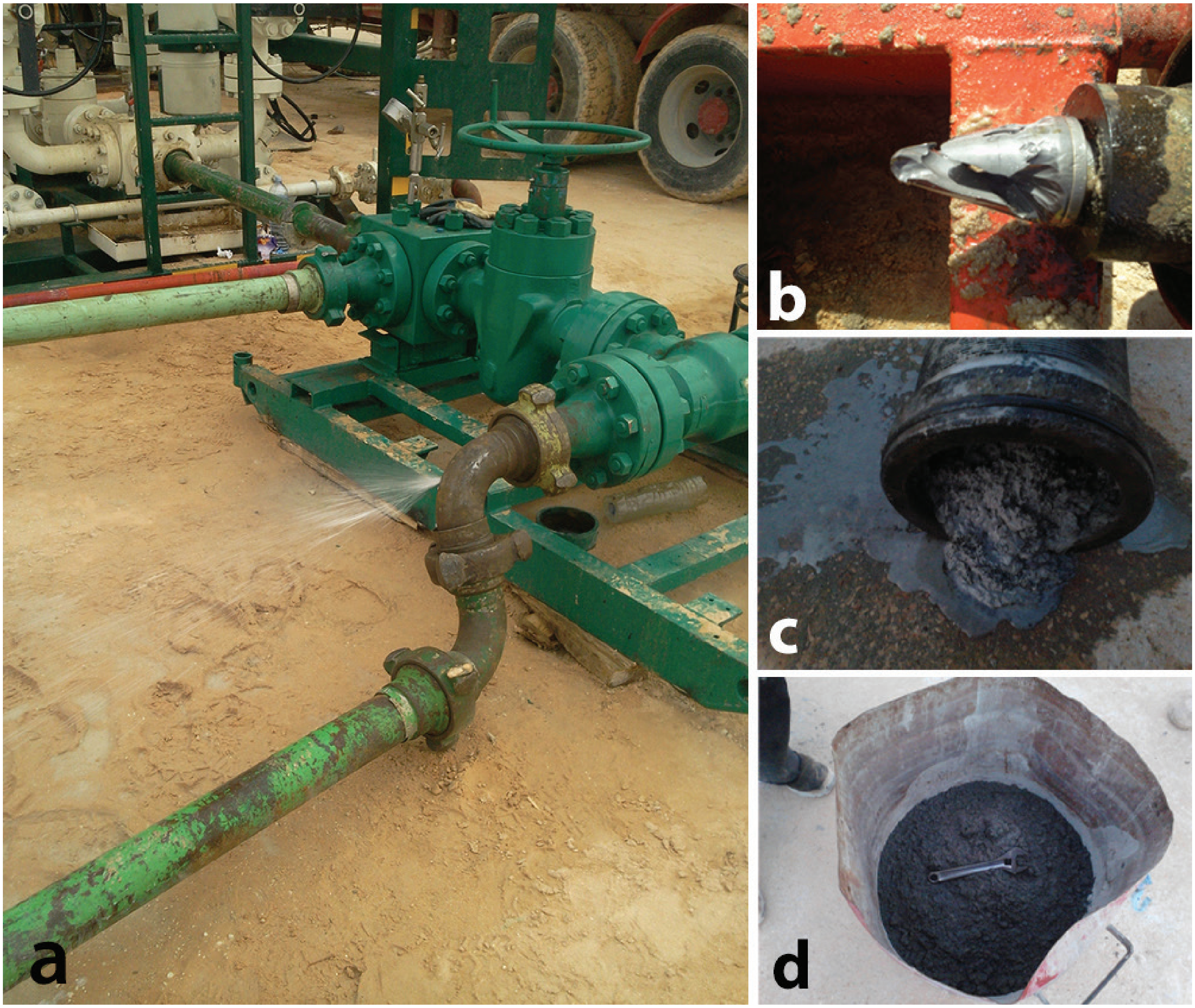

FIG. 1. Examples of erosion damage caused by sand production in upstream sites. a. Eroded pipe elbow, causing loss of containment; b. Eroded choke valve; c. Pipe clogged by sand; and d. Sand disposal challenge.

effectiveness of sand control operations. Most importantly, sand monitoring becomes a method that provides operators with the full picture of sand production risk, empowering them to take the right mitigation approach.

SAND SAMPLING AND WEIGHING

In the past, oil and gas operators assessed solids production through offline and unreliable methods, such as solids sampling and weighing downstream of the sand separator. These methods provide infrequent and unrepeatable data sets that generate blind spots, leading production managers to increase or decrease flowrates within the wrong operating windows. Such methods require manual work, and a tedious procedure must be followed.[4] And above all, these manual inspections may expose personnel to hazardous areas, introducing a high safety risk.

While these methods provide good insight on the characterization of the solid particles that are produced (i.e., particle type and particle size), the quantification input (i.e., the amount of sand produced in a certain period of time) will always be information from the past. Sand production is not uniform and may happen in bursts, in a short period of time, followed by low sand production in a certain time window. Because of the unpredictable behavior of the sand produced, sand sampling and sand weighing will only provide an outdated and approximate picture of the amount of entrained sand. Therefore, further manual calculations are required to calculate the amount of entrained sand over time, and the consequent erosion rate, in the attempt to estimate the asset damage and remaining life.

By the time sand is manually quantified, some level of erosion damage has already occurred, without giving operators the chance to react in due time to mitigate the erosion risk. This lagging indicator of sand bursts results in decision-making delays and the potential for serious damage to assets.

MANUAL ULTRASONIC THICKNESS MEASUREMENTS

Ultrasound thickness measurements have been used in the oil and gas industry for over 50 years and are a well-established technique for measuring metal wall thickness. The technique involves the generation of ultrasound from a transducer that is placed directly onto the metal surface. The ultrasound is transmitted through the metal until it is reflected off the inside metal surface (back wall). The reflected ultrasound signal (or A-scan) is recorded, and the time difference—or time-of-flight—between the sending and reflected signals provides the measurement of the wall thickness.

While the technique can be reliable, the completion of a full set of measurements for a facility with thousands of erosion measurement points is very time-consuming and labor-intensive, such that the wall thickness at an individual location may only be measured every three to five years. This is not an adequate frequency to measure erosion rates with any confidence or to link periods of high wall thickness loss to specific process operations, which requires measurements on the time scale of days to be useful, **FIG. 2.**

In addition, while being relatively simple to perform, manual ultrasound methods have the following disadvantages:

- Poor repeatability and reproducibility, because it is highly unlikely that consecutive measurements will be taken in precisely the same location by the same non-destructive evaluation (NDE) technician. In addition, the equipment used and the skill level of the NDE technician can vary between measurements, introducing high variability to the measurements, as shown in **FIG. 2.**
- The infrequency of measurement, coupled with the variation in data, shows that accuracy and repeatability are poor with manual ultrasound thickness measurement. The practical outcome of this is that it's not possible to correlate this data to specific process events, such as sand burst, to perform root cause analyses of the erosion events.
- Specialist technicians are required to travel to perform the inspection. Especially in offshore and other remote oil and gas well locations, the cost of travel and lodging can run into tens of thousands of dollars for a single round of inspection. In addition, many well operators want new assets to be entirely unmanned during normal operations, so there are no staff onsite to observe and report on visible damage.

CONCLUSION

In the June 2024 issue, the second and final article in this series will present a practical and cost-effective solution for effective sand management in the oil and gas industry by leveraging two complementary, non-intrusive technologies for sand and

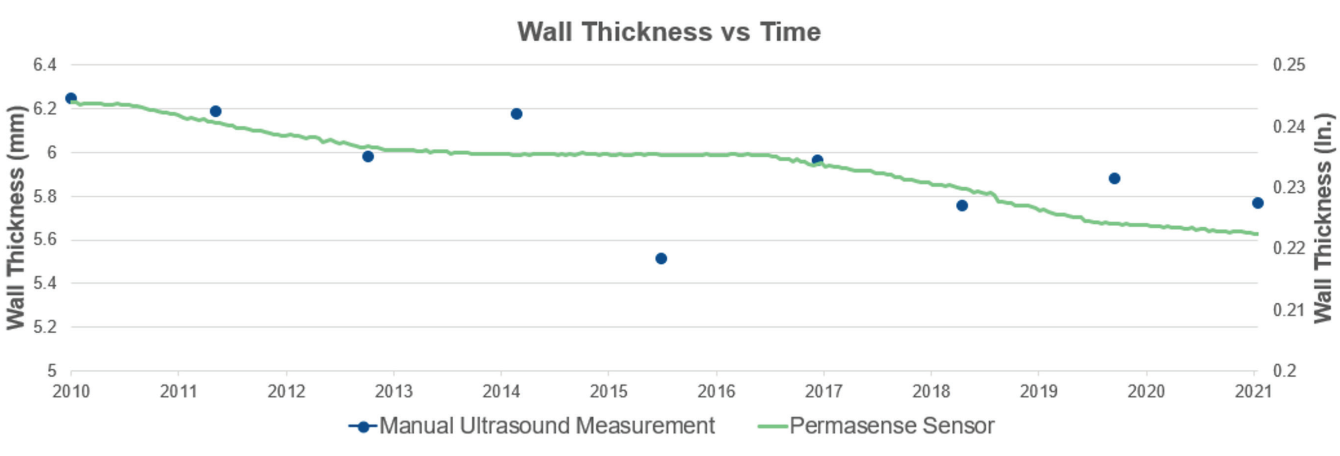

FIG. 2. Typical graph of annual thickness readings in a high-risk location, gathered using handheld ultrasonic devices, shows high variability and poor repeatability.

erosion monitoring: acoustic particle sensors and wireless ultrasonic thickness sensors, **FIG. 3.**

Non-intrusive acoustic particle sensors detect the noise generated by the solid particles and derive it into sand production measurement. This technology utilizes the fact that the solid particles, while transported with the flow, impact the pipe wall, due to inertia in pipe bends, and create noise. The sensor picks up the noise that propagates in the pipe wall and converts it to a digital signal in the form of sand rate (g/s), sand intensity (μV) or accumulated sand mass (g).

Real-time wall thickness monitoring of equipment and associated piping can provide valuable insight into the erosion status of equipment and components. The data can be trended against fluid characteristics (pH, dissolved oxygen, H_2S, and CO_2 concentrations, corrosion, scale and inhibitor residuals, etc.) and process data (pressure, temperature, flowrates, etc.) to not only highlight potential areas of corrosion and concern, but to also enable preventative measures to be undertaken in a timely manner. This monitoring technology is commonplace in oil refineries, and it is widely accepted as industry best practice in this case.

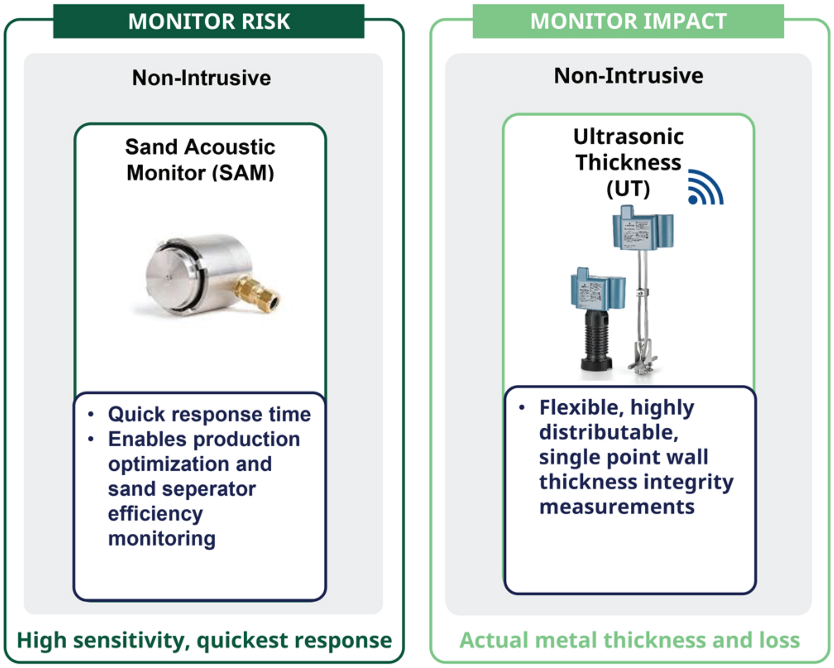

FIG. 3. Combined acoustic and ultrasonic solutions are optimal to detect the risk and determine the resulting impact on fixed equipment.

As will be discussed in the next article, these two technologies work together to help staff optimize operations. **WO**

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