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SAND MANAGEMENT

Explaining sand erosion in oil & gas production

Part 2: Erosion due to entrained sand is a growing problem and existing technologies have limitations, but new solutions are available to address this issue.

ANCA DIENES and **WILLIAM FAZACKERLEY,** Emerson

Part 1 of this two-article series, "Explaining sand erosion challenges in oil and gas production," ran in the May 2024 issue of *World Oil,* and it examined issues with sand erosion. This article presents solutions to address the issues raised in Part 1, and it includes two use cases demonstrating the effectiveness of the solutions.

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, gravel packs, sand cyclones or desanders, or even predictive models for sand production—are not fully effective. Part 1 of this series discussed sand erosion issues in detail, and this article—Part 2—shows how the integration of acoustic sensors and ultrasonic thickness (UT) to detect and assess sand particles in pipelines and process equipment addresses these issues.

This article presents a practical, cost-effective solution for successful sand management in the oil and gas industry by leveraging two complementary, non-intrusive technologies for sand and erosion monitoring: acoustic particle sensors and wireless UT sensors.

MEASURING ENTRAINED SAND

Non-intrusive acoustic particle sensors detect the noise generated by solid particles and derive it into an entrained sand measurement. This technology utilizes the fact that the solid particles, while transported in 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).

It is critical to get accurate, early signals that sand is present in the pipe fluid before the pipe faces potential erosion damage. The accurate detection of solids in the flow, and the quality of the output signal, depends on the correlation of these multiple factors:

- Flow velocity—Solid particles in the flow will produce a noise only when they are moving, meaning there is enough kinetic energy for the particles to hit the inner pipe wall.
- Type of flow—This is important, because various flow phases—such as liquid, gas or mixed—will each generate a different flow noise. It is also important because sand is carried differently in various phases (i.e., velocities are typically higher in gas and lower in liquid phases).
- Mounting location—The typical mounting location for an acoustic sensor is at the wellhead, downstream of a 90° bend to maximize the effect of inertia and pipe geometry, ensuring proper measurement.
- External noise—The noise from nearby pumps or valves can affect the reading if it is not eliminated because the acoustic sensor will pick it up as noise from entrained sand and generate a higher rate than actual, so a background noise calibration performed on site is necessary to eliminate the frequencies associated with external noise.
- Particle size and type—The sound signature of particles varies with their type and size. For example, sand, proppant and barite are heavy particles (2.65–4.5g/cm^3),[1] so they produce a loud noise when impacting metal, making it easier to detect their presence at lower velocities, as opposed to chalk, which is a soft particle and would, therefore, require high velocities to be detectable by an acoustic sensor. Particle size is directly correlated with particle type and velocity, **FIG. 1.**

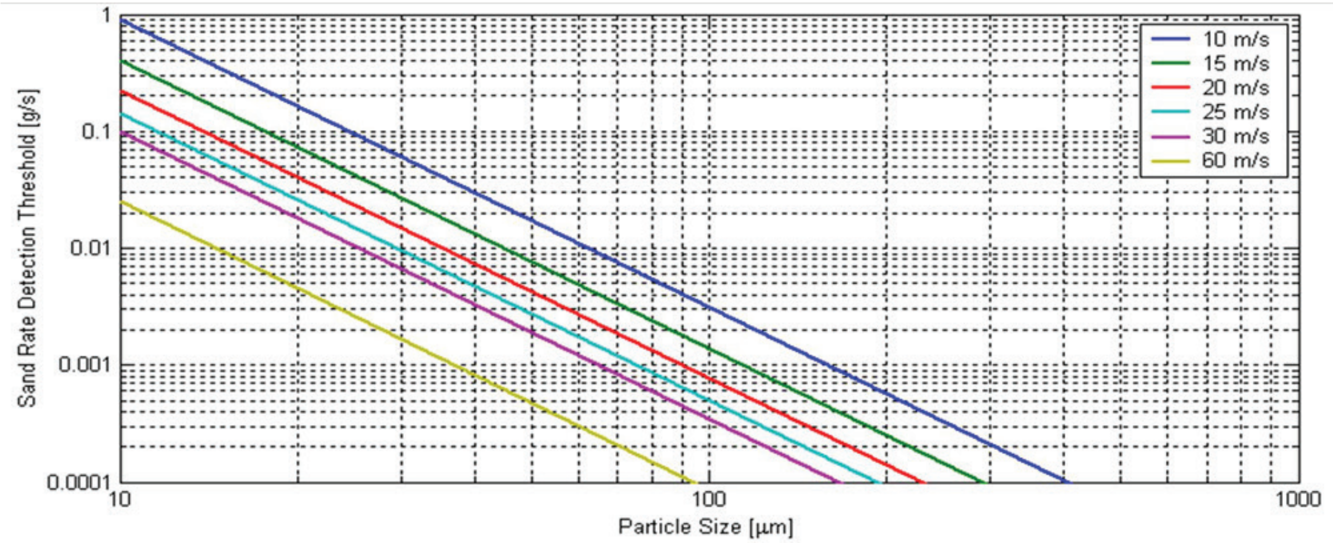

FIG. 1. This graph shows the correlation between velocity and particle size for entrained sand rate detection. Smaller particles require higher velocity to be detectable by an acoustic sensor, while larger particles may be detectable at lower velocities.

- Depending on the use case and application, operators can utilize entrained sand measurement data in various ways, including:
  - Production optimization in offshore and onshore oil and gas–Uncontrolled sand can lead to reduced production due to pipe clogging and rotating equipment damage from erosion, generating losses of hundreds of thousands of dollars per day. In this application, operators can adjust the production flowrate based on the entrained sand measurement.
  - Flowback and clean-up of a new oil and gas well–Flow velocities and erosion potential are usually lower in this application, but operators would like to end the flow-back/clean-up phase as soon as possible, while avoiding sand separator fill-up. Based on entrained sand intensity readings, operators can assess the flow-back status and separator efficiency on critical wells, and then decide if they should release the well for production.
  - Manage erosion risk during peak retrieval in underground gas storage–Erosive potential can increase substantially during peak retrieval periods, resulting in lost production and increased maintenance. Based on the entrained sand rate, operators can regulate the gas retrieval flowrate on critical wells, as shown in the second use case below.

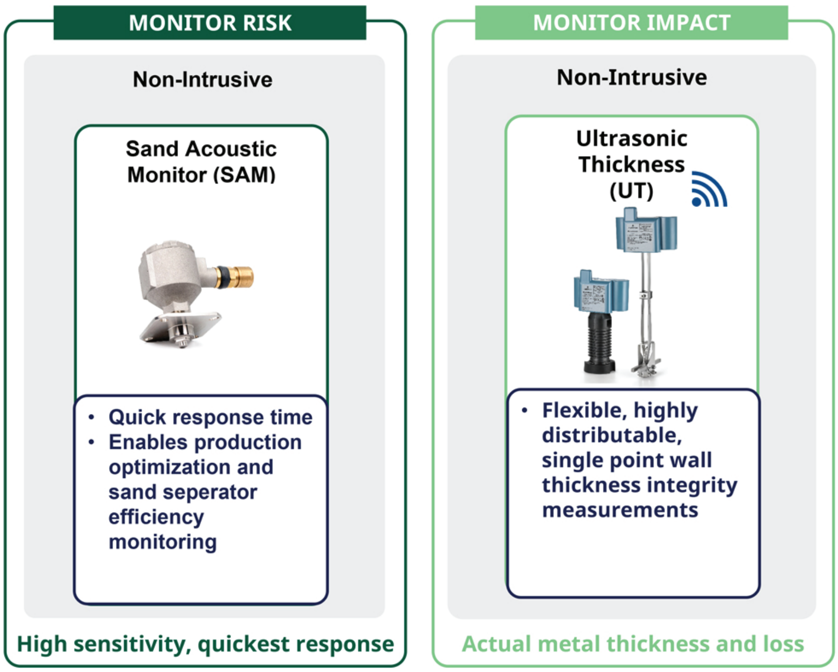

FIG. 2. These two measurement technologies can be used together to improve operations.

EVALUATING EROSION AND CORROSION EFFECTS

In all the above cases, operators can base their decisions on the risk component (i.e., entrained sand is present in the flow and can hinder production or cause a shutdown), but further value can be created from erosion monitoring using ultrasonic (UT) thickness measurement technology. **FIGURE 2** shows commercially available technologies to measure both acoustic and ultrasound, providing the data needed for a combined risk and impact calculation.

Real-time wall thickness monitoring of equipment and associated piping provides valuable insight into the status of equipment and components. The data can be trended against fluid characteristics (i.e., pH, dissolved oxygen, H_2S and CO_2 concentrations, corrosion, scale and inhibitor residuals, etc.) and process data (i.e., pressure, temperature, flowrates, etc.). These trends highlight potential areas of erosion and concern, and they enable preventative measures to be undertaken in a timely manner. This monitoring technology is commonplace in oil refineries, where it is used to measure the impact of corrosion, and it is widely accepted as an industry best practice for upstream oil and gas production applications.[2]

The only maintenance cost associated with online thickness monitoring systems is the replacement of batteries, once every 10 years or so. Mounting flexibility means that as conditions change, such as the corrosivity and erosivity of the fluids, sensors can simply be moved by site personnel while the facility is operational.

It is important to highlight that the loss in the pipe wall thickness is often a result of combined corrosion and erosion damage. Erosive elements or mechanisms, such as entrained sand, accentuate the damage produced by corrosion. The key benefit of UT sensors is that a quantitative measurement of actual wall thickness is supplied, with no inferred corrosivity or baseline subtraction method required. This measurement gives operators a high level of confidence in the health of the asset, and it allows optimization of operating conditions.

The use of acoustic sensors enables the detection of solid particles—including sand—through their unique acoustic signatures. These sensors provide real-time data, allowing for proactive monitoring of sand production. In combination with UT sensors, which provide accurate measurements of material thickness, a risk and impact calculation can be derived. By analyzing the risk value obtained from the acoustic sensor and the impact value obtained from the thickness sensor, an overall assessment of asset health can be determined.

OFFSHORE OIL AND GAS USE CASE

An oil and gas operator in the North Sea was faced with challenges in a mature field due to an increasing rate of sand production and erosion events. In this case, the produced sand caused rapid erosion in pipes, valves and vessels, forcing the operator to produce below the well's potential due to increased required maintenance for the rotating equipment and chokes. Maintenance operations required temporary shutdowns of the well, resulting in lost revenue and increased repair costs.

To increase production without jeopardizing asset integrity, the operator deployed a combination of eight non-intrusive acoustic sand monitors and eight non-intrusive UT sensors, **FIG. 3.**

The acoustic sand monitors provided actionable risk information in the form of instantaneous entrained sand rate data, while the UT sensors provided the metal loss input due to erosion caused by sand production. **FIGURE 4** shows the correlation between the entrained sand rate and metal loss data.

Using insights provided by this data, the operator was able to confidently detect sand bursts and adjust production rate when needed, while continuously monitoring metal loss and remaining asset life. The team increased production 2%, resulting in added revenue of $2 million per year, and they decreased unexpected shutdowns by adjusting the choke to minimum entrained sand and consequent erosion.

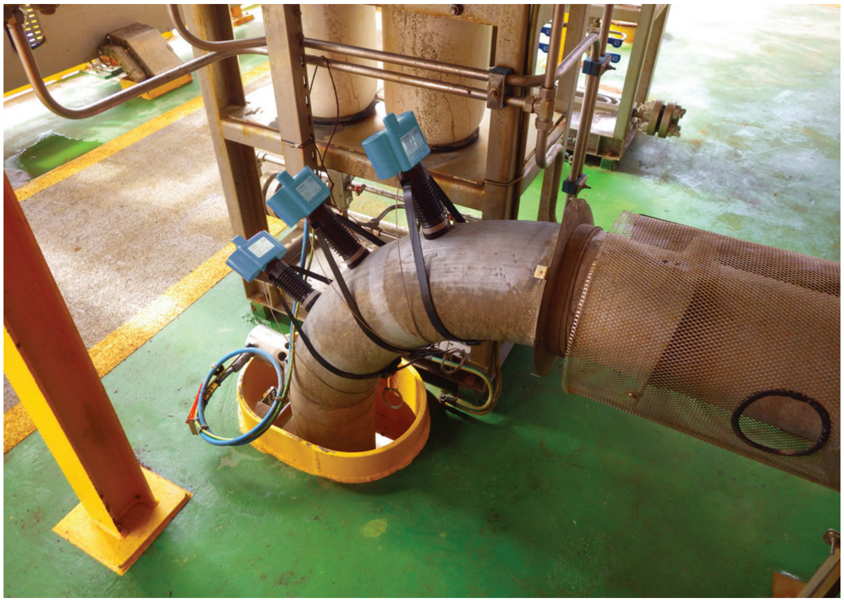

FIG. 3. Wireless non-intrusive thickness sensors installed in an offshore environment.

UNDERGROUND GAS STORAGE USE CASE

Another case study describes the safety and profitability challenges that an underground gas storage facility in Europe was facing because of uncontrolled, entrained sand production, and it shows how a sand monitoring solution helped the operators address these and other related issues.

Natural gas demand often peaks during the winter season due to its use in home and commercial heating, requiring a high volume of gas delivery to the transmission network in a short period of time.

Gas is stored in underground depleted reservoirs or salt caverns, allowing a high volume of storage to meet the demand. Undesirable solids are produced due to the high velocity required during peak retrieval, and at this site, solids had damaged the pipe work and resulted in a loss of containment incident for the largest well. The immediate action was to shut down the well for the rest of the winter season, resulting in substantial lost revenue, along with negative safety and environmental impacts.

To avoid other incidents with the 300 wells at the site, the operator opted for a temporary, non-intrusive sand monitoring solution that was deployed in a few days, with no interruptions to production, and which identified the presence of sand in multiple locations. Alarms were also configured for real-time detection of any small increase in sand production as retrieval rates increased.

Following the successful trial, the operator gained confidence in the sand monitoring solution and proceeded to instrument another 105 wells with non-intrusive acoustic particle monitors before the start of the next cold season. The deployed solution enabled the operator to choke down the production rate when sand production exceeded an acceptable threshold, thus reducing erosion risk during peak season, while mitigating erosion impact on the pipework.

In parallel, the operator is exploring deployment of non-intrusive UT sensors to gain real-time insight on metal loss due to erosion and remaining pipe life.

CONCLUSION

Sand production is a worldwide problem, occurring when the stress on the formation exceeds the formation strengths and results in rock failure. The produced solid particles cause rapid erosion in pipes, valves, pumps and vessels, forcing operators to produce below potential, while increasing required maintenance and repair activities.

Traditional manual sand and erosion measurement techniques may provide a good characterization of the solid particles (i.e., particle size and type), but the data gathered are infrequent and unrepeatable and can easily generate blind spots, leading operators to increase or decrease production rates within the wrong operating windows. The data from manual measurements will always be information of the past, so it does not give operators an opportunity to react in time to mitigate erosion risk.

If erosion is more serious than operators expect it to be, then they are likely to experience leaks and loss of containment. On the other hand, if the actual erosion rates experienced are less than anticipated, then operators may have been able to produce more and deliver better profitability. To increase production without jeopardizing asset integrity, oil and gas operators across the world are opting for online monitoring solutions that can provide them with clear insights into what is happening inside the pipe so that they can act with confidence.

FIG. 4. This conceptual representation depicts a combined solution with non-intrusive thickness sensors and acoustic sensors.

This article presented a practical solution for effective sand management by incorporating two complementary non-intrusive erosion monitoring solutions: acoustic particle sensors and UT sensors. The benefits of combining these two technologies include enhanced asset integrity, reduced downtime and improved maintenance planning. Additionally, the ability to monitor sand production and erosion in real time empowers operators to optimize production rates, while ensuring asset integrity. **WO**

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ANCA DIENES is a global product manager in Emerson's Corrosion and Erosion business unit, with over 13 years of experience in customer care and pricing. She supports new product development, translating customer requirements into engineering insights to build competitive products that are aligned with Emerson's vision of growth. Ms. Dienes studied mechanical engineering and management at Technical University of Cluj-Napoca, in Romania.

WILLIAM FAZACKERLEY is a global product manager in Emerson's Corrosion and Erosion business unit, with over 10 years of experience in IT and software development. He specializes in digital transformation, working closely with customers to guide the strategic direction of Emerson's product portfolio. Mr. Fazackerley studied computing and Applied ICT at Central Sussex College.