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Upstream Digital Transformation Through Corrosion, Erosion, and Sand Monitoring

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ABSTRACT

Corrosion and erosion are undesirable by-products of Oil & Gas extraction activities, and one of the main concerns of production engineers. Gravel pack, sand screens, as well as costly chemical injection interventions require investments worth millions of dollars. Unfortunately, corrosion and uncontrolled sand production still generate loss of containment events in upstream activities, forcing operators to set conservative production rates due to the lack of accurate and easy-to-interpret information.

To remain profitable in the Oil & Gas market, operators realize that delivering cost improvements while increasing throughput is key to achieve a healthy financial situation. Corrosion, erosion, and sand production control consume extensive capital and operating expenditures. Despite this, uncontrolled corrosion and sand production generate loss of containment events, forcing operators to set low production rates that delay the returns on project investments. This paper will outline how pervasive sensing technologies deliver Digital Transformation's promise to upstream operators. The paper shares insights on how deploying a combination of non-intrusive sand, erosion, and corrosion monitoring technologies provides a full solution that saves millions of dollars in lost revenue and reputation costs as well as improves safety.

Keywords: Analytics, Digital Transformation, Big Data, Corrosion Monitoring, Erosion Monitoring, Erosion-Corrosion, Sand Monitoring, Digitalization, Pervasive Sensing, Industrial Internet of Things, Flowback, and Upstream

SAND PRODUCTION IN OIL AND GAS

Sand production is an enormous challenge for oil and gas operators that limits throughput, decreases uptime, increases risk, and jeopardizes safety conditions. Sand-related problems are known to surge not only with the maturity of reservoirs but also with the increase of water breakthroughs and during flowback operations. Moreover, based on operational experience, operators have realized that sand production could be regarded as being inevitable in reservoirs with low formation strength (<1000 psi) across the lifecycle of the well.

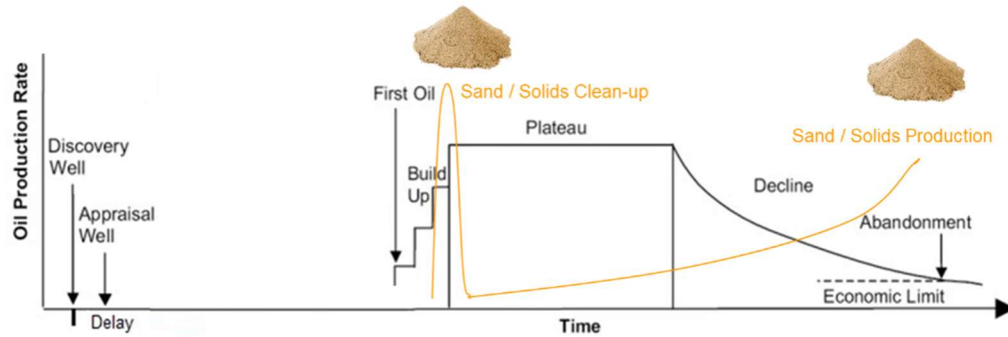


Figure 1: Well lifecycle and sand production

High fluid velocity also plays a fundamental role in the production systems, fostering piping metal loss due to corrosion and erosion. Furthermore, corrosive agents such as water, carbon dioxide, and salts containing Cl^- , HCO_3^- and SO_4^- ions will generate an exceptionally corrosive environment for the equipment used to transport hydrocarbons. The corrosive degradation experienced by flow lines is accelerated by the erosive mechanism attributed to the sand impingement from the moving slurry, resulting in a synergistic and even more aggressive effect known as erosion-corrosion¹. The previously mentioned phenomena is a form of tribo-corrosion material loss mechanism caused by flowing fluid (in the presence or absence of solid particles) damaging both the surface layers (e.g. passive film or corrosion products) and the base metal. This process receives great attention because of its destructive nature and the fact that this regime of degradation becomes more common due to sand production and the increasing severity of conditions attributed to extracting oil from deeper wells.



Figure 2: Erosion-corrosion degradation (Xinming Hu, Richard Barker, Case study on erosion–corrosion degradation of pipework located on an offshore oil and gas facility)

The fear of severe damage caused by the above-mentioned mechanisms has curtailed production from potentially high-capacity wells in offshore and onshore developments. In the case of corrosion failures, a certain degree of control can be achieved using chemical inhibitors, increasing the project's operating expenses (OPEX). However, the erosion failures couldn't be avoided, but are mitigated by reducing the oil and gas flow rate. Unfortunately, deploying the previously mentioned strategy only reduces the early revenue from the loss of potential production, following the recommendations of API RP14E and others.

INTEGRATED SAND, EROSION, AND CORROSION MANAGEMENT

Sand and other solids cause a wide variety of problems that include but are not limited to erosion, corrosion, and solids deposition in pipe and vessels for topside and subsea assets. High velocities will generate substantial integrity implications on pipes, fittings, and valves. On the other hand, even if production engineers decrease flow velocity, sand and other solids will deposit in specific locations, such as primary gas-liquid separators, causing a pressure drop along the line and increasing the risk of stuck pigs during scraping or cleaning activities. Furthermore, smaller particle sizes will carry over hydrocarbon, its corrosive components, and water across the flow lines, separators, and valves.

Based on the above-mentioned facts, oil and gas operators require a holistic sand management approach to avoid:

- Choke erosion and deposition in flowlines
- Reduction in flowline capacity, leading to increased pressure drop and under-deposit corrosion and erosion-corrosion

- The potential source of erosive components and slugs (if operating conditions change suddenly)
- Blockage of pipeline inspection gauges during flowline cleaning operations
- Blockage of in-line instrumentation, leading to incorrect process data

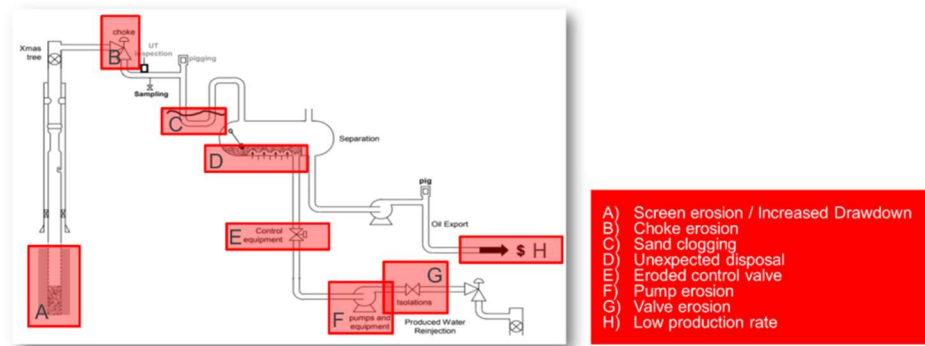


Figure 3: Sand, erosion, and corrosion critical locations in upstream facilities

It is worth noting that taking a conservative downhole sand control approach can affect inflow into the well-bore and pressure conditions in cyclones that prevent them from achieving a suitable separation operation

To mitigate the erosive and corrosive impact of sand production, oil and gas operators deploy integrated sand management programs. These programs contain processes and practices that include but are not limited to sand production potential prediction, field processes to prevent formation failure, downhole equipment to prevent formation material from entering the wellbore, monitoring techniques to detect when and where sand is produced, monitoring techniques to quantify metal loss, and topside equipment for handling produced sand. Based on the above, an array of issues and solution strategies must be considered².

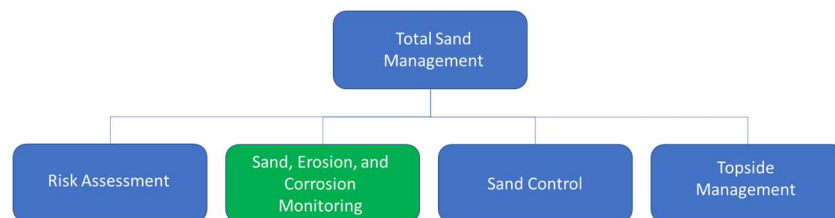


Figure 4: Total sand management building blocks

The total sand management concept enables the completion engineer to delay the sand control deployment to a later stage of the well's production life and determine the need for sand control. Developing an appropriate strategy that is fit-for-purpose is important to empower managers of

complex fields to improve intervention and production efficiency through continuous process optimization and reduce non-productive time. This requires a total integrated sand management strategy that encompasses production sand rate estimation, sand monitoring strategy, control methods (surface or subsurface), and topside facility management. Sand production, corrosion, and erosion monitoring provide not only correlated integrity-critical measurements but, most importantly, operational insights that enable a successful strategy and throughput increase³.

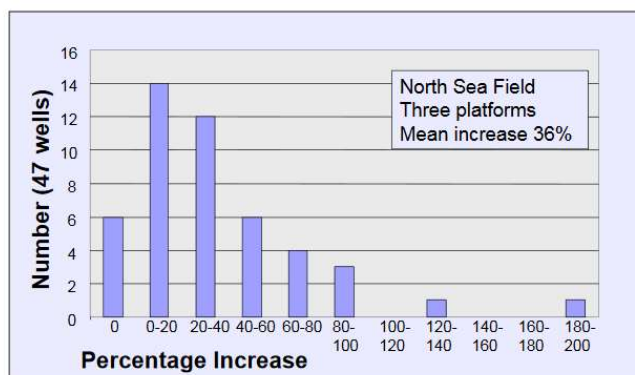


Figure 4: Production increase due to well testing in the North Sea field (Johan Tronvoll, The tools of sand management)

DIGITAL TRANSFORMATION STRATEGIES FOR UPSTREAM OPERATIONS

Adopting digital technologies is helping every industry to re-define its operating boundaries through the availability of actionable information. The oil and gas industry is no longer a laggard and is taking the pole position in deploying state-of-the-art sensing, communication, analytics, and workflow technologies in the field and their corporate offices. Oil and gas players that have successfully adopted digital technologies will increase their resilience and weather the severe and volatile downturns that the hydrocarbon extraction industry faces.

While oil and gas exploration has enjoyed a central role in data acquisition and analysis, production is currently enjoying the highest number of digital initiatives in brown and greenfield developments. New initiatives not only make use of sensors in wells and production equipment but also break silos by storing and sharing data in the cloud, blurring the limits between reservoir, production, integrity, and corrosion silos.

Unfortunately, not all digital initiatives are successful. The digital world changes rapidly and an intricate web of interdependent technologies often makes it extremely difficult for the industry to select the right use case, tools, and return. For example, Gartner's Hype Cycle has cited more than 200 technologies from 2000 to 2016. Over 50 specific technologies appeared for just one period and others took years to achieve mainstream success. If the operator adopts an unproven technology, there is a high risk of sunk and switching costs, non-scalable deployments, and marginal to no payback⁴.

Because of this, quantifying and focusing on tangible bottom-up value drivers helps oil and gas operators to deploy a framework that is repeatable and scalable. The framework should include essential topics such as an increase of production rate, cost per barrel, safety, and others that must establish a solid monetization logic through an SME-validated business case⁵.