Innovative Sand-Screen Technology Resolves Offshore Nigeria Water-Injection Issues

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During continuous injection, reservoir solids usually remain within the reservoir. However, prolonged or abrupt well shut ins can trigger intense transient flow phenomena like water hammer, backflow, and crossflow, causing fines and matrix sands to migrate and accumulate in the wellbore (SPE 187103). As a result, the accumulation of debris can markedly reduce structural integrity and the overall long-term viability of enhanced oil recovery (EOR) from the injection wells.

This issue had become particularly evident in an offshore field situated in the southern region of the Niger Delta. Over time, buildup in the well led to a substantial decrease in injection rates, which had significantly shortened the operational lifespan of the wells to just a few years at the anticipated injection rates. Various remediation technologies were attempted, such as tubing-installed valve and backflow-restrictor technology but both proved ineffective in resolving annular-flow and crossflow issues.

To prevent potentially expensive and complex interventions, sidetracking, or wellbore abandonment, further analyses by the operator, SNEPCo, concluded that an effective solution necessitated deployment as close to the sandface within the injector wells as possible. The Cascade system, a check-valve system developed by TAQA Well Completions (formerly Tendeka), was then successfully deployed in three wells to maintain the required injection volumes for efficient pressure maintenance and reservoir sweep.

Non-Return Valve Screen Technology

Establishing a reliable flow-control system for the lower completion requires engineering the checkvalve components to seamlessly integrate within the sand-control screens for deployment across multiple zones of the injection tubing.

The non-return valve (NRV) employs a three-component design comprising a valve body, valve insert, and ball. Ball check valves are installed on the screen base pipe under a shroud that allows the injection of fluid into the reservoir and prevents any backflow from the reservoir during shut ins. The system features a flow-control check valve integrated within traditional sand screens that do not alter completion geometry (Fig. 1). With a metal-to-metal seal, it essentially isolates fluid in the completion annulus and locks injection water into the formation.

The NRV has been designed to handle a variety of well conditions including erosion, plugging, temperature, and repeated checking cycles. All flow-control device components are manufactured with high-alloy stainless steel and tungsten carbide components to resist tortuous downhole conditions for up to 15 years.

Developed in 2018, more than 2,000 of the valves have already been successfully installed in several wells globally. As this new sand-control technology can autonomously and immediately isolate the reservoir from the wellbore during shut ins, the technology offers additional benefits.

- Non-intrusive nature for intervention tools
- Unhindered access to the lower completion sandface during injection and intervention
- Durability throughout the well's operational life
- Compatibility with openhole standalone screens, gravel-pack completions, direct wrap or metal mesh screens
- Cost-effectiveness compared to other options

The solution involves the implementation of an advanced flow-control mechanism to effectively manage the transient flow effects associated with water hammer, crossflow, and backflow. By safeguarding the integrity of injector wells and minimizing the negative impact on reservoir performance, the technology aims to ensure sustained well performance and prolong the operational life of injection wells. This, in turn, leads to improved hydrocarbon recovery and overall, optimized reservoir performance.

Restoring Flow Control

Located approximately 120km from the southern Niger Delta shoreline, the field extends to varying depths between 950 and 1500m. It includes 12 significant reservoir intervals, primarily composed of sandstone. Oil extracted from the producer wells is conveyed through an offshore floating production, storage, and offloading unit, and treated water is reinjected into the reservoirs to maintain pressure levels and support oil production activities. Reliable and robust performance of the injection wells is vital for EOR.

Despite the implementation of sand screens and frac-pack/gravel-pack installations in the wells, the buildup of formation solids, primarily induced by the effects of water hammer and crossflow—and to a lesser degree backflow—

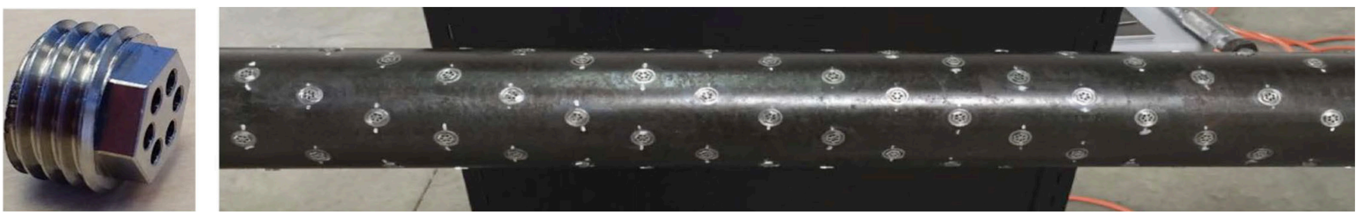

Fig. 1—The check valve and configuration on a joint of the screen.

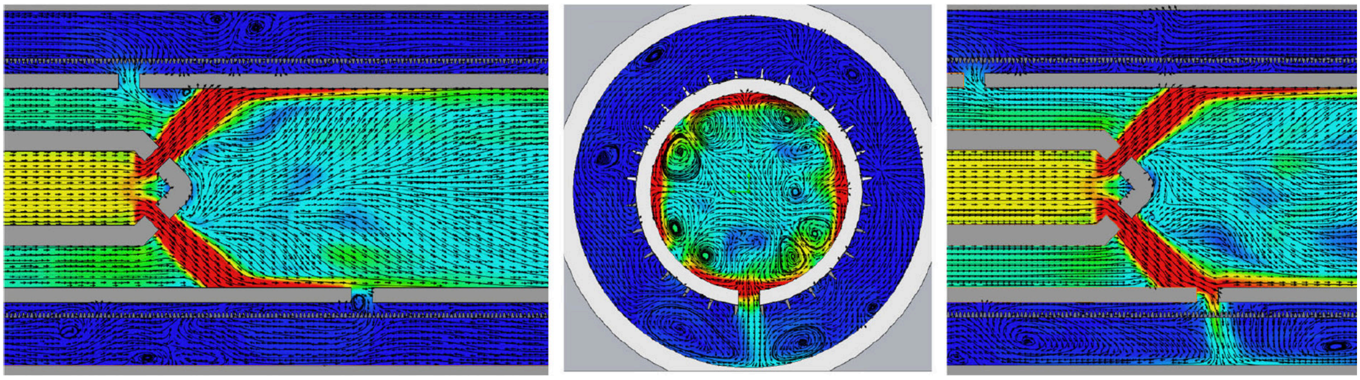

Fig. 2—CFD modeling evaluated how valve density affects the performance of the planned jetting tools designed for near-wellbore stimulation after completing the lower completion phase.

had compromised the integrity of several injection wells in the field. The impact is often characterized by elevated bottomhole injection pressure, screen blockages, erosion of downhole equipment, and restricted pressure support for the associated production well(s). Over time, prolonged exposure had led to deterioration of the wells and subsequently, reduced operational lifespan. It is especially prevalent in horizontal wells due to their 0absence of a sump and those with high flow rates and elevated permeability.

Design and Installation

During the initial phase of NRV screen installation, three high-rate wells were selected.

- Well X-72: openhole length was 1107ft measured depth (MD), and the NRV screen straddled a total length of 969ft MD
- Well X-73: openhole length of 1,674ft MD, with a net screen completable length of 738ft MD
- Well X-76: openhole length of 2,176ft MD, with a net screen completable length of 1,468ft MD.

The number of valves was determined based on the expected injection rate. In a deliberate attempt to address erosional issues and restrict flow velocity according to flow tests, a limit of 40 BWPD per valve was established. The anticipated injection rates for these wells reach up to 30,000 BWPD, requiring the inclusion of approximately 750 individual valves arranged in a spiral configuration along the base pipe. However, to accommodate higher flow rates and account for the impact of chemical treatment and stimulation, an adjustment was made to the quantity of valves per screen.

To evaluate how valve density affects the performance of the planned jetting tools designed for near-wellbore stimulation after completing the lower completion phase, comprehensive CFD modeling was conducted (Fig. 2). This aimed to thoroughly examine the consequences of different valve densities, specifically the number of valves per unit length of the screen.

Constructed on a robustly walled base pipe, the flow-control system features an assortment of valves accompanied by a sand screen to strain out any solid particles. Moreover, the precise sizing and placement of the valves were crucial to ensure they sit flush with the pipe, enabling the creation of a direct wire wrap screen over them without any interference (Fig. 3).

The valves are installed on various lengths of screens (range 3 joint, 20ft and 15ft) and with various valve densities to fulfill the requirements of each well.

Well Performance and Results

The active gain-loss trend exhibited a declining pattern during acid stimulation operations, indicating losses through the NRV screens. As reflected in the recorded losses, deployment operations were conducted successfully, thereby affirming the valves capacity to facilitate injection into the formation.

Notably, no fluid return was detected during acid stimulation, affirming the proper functioning of the check value to permit fluid flow in one direction and thereby, preventing backflow. To further validate the valves functionality, downhole gauges were employed to record pressures at the reservoir depth.

The results show the wells have achieved the targeted rate and desired performance during injection. The wells were reinitiated and systematically increased to the present

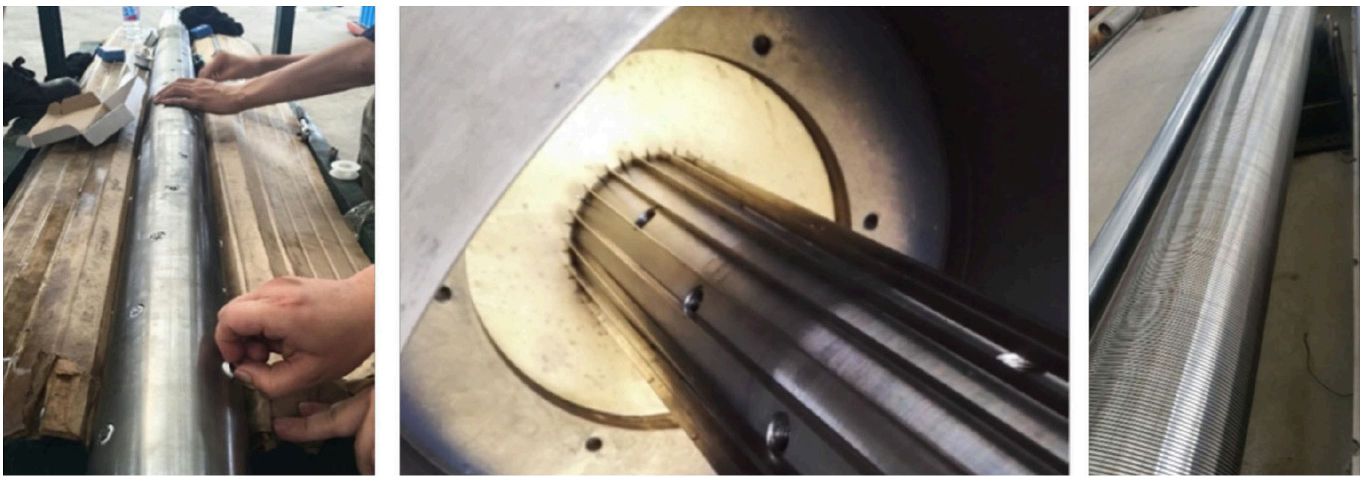

Fig. 3—Valve insertion (left), screen wrapping (middle), and final product (right).

injection rate of 30,000 bbl of water per well per day. This demonstrates that the screens have successfully averted the mobilization of fines from the reservoir into the wellbore due to backflow, a challenge encountered in other wells completed earlier in the field.

Novel completion technology holds substantial potential to effectively prevent premature failure in injection wells caused by crossflow and backflow. Furthermore, the solution provides protection against the harmful impacts of water hammer by immediately and autonomously blocking pressure waves from entering the lower completion. The innovation ultimately enables operators to reduce expensive interventions, improve operational efficiency, and eliminate injection-well losses, previously unavoidable in unconsolidated formations in the southern part of the Niger Delta.

AUTHORS

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