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Managing sand through flow control in the modern completion

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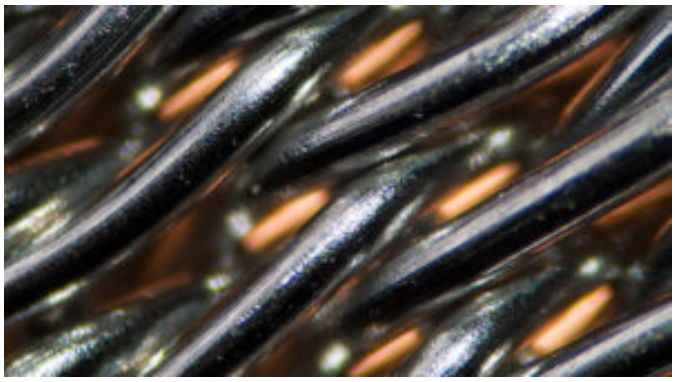
Operators are currently searching for improved ways of working smarter and more cost efficiently while still enhancing production.

A key question in the drive for enhanced production is how best to control and manage sand. Controlling the flow of unconsolidated sand into the well is one of the most critical challenges in any sand face completion. The failure to address it correctly can have a significant impact on productivity, well life, completion equipment life, and safety through the erosion of surface equipment as well as the environmental and financial impact of disposing of large quantities of sand.



Inflow control devices can be installed as a standalone option or in conjunction with a sand screen such as the FloMax Dutch Weave sand control screen (Image courtesy of Tendeka)

In unconsolidated formation, high flow rates and draw-down pressures, pressure depletion, and water production trigger sand production. Besides prematurely killing well production, excessive sand production can cause erosion and the blockage of downhole hardware, which can damage or disable downhole and surface equipment.

Drilling technology has advanced to such an extent that horizontal and multilateral wells are now the norm, with greater reservoir penetrations and lower drawdown pressures. This increased length and uneven pressure profile along the well bore has resulted in an increase in sand control issues such as installation risk due to extreme drag and water influx due to reservoir heterogeneities.

Controlling the sand

The first step in any sand control application has to be a detailed exploration of the characteristics of that formation. There are various methods used to determine the optimum sand control methods for each well. Establishing the formation sand grain size is essential to sand control selection, and laboratory technology is used to help establish the most suitable sand control method.

Traditional completion methods that allow sand-prone reservoirs to be exploited often dramatically reduce production efficiency and are being replaced by a number of technologies that keep formation sand in place without unduly restricting productivity.

Most options for completing sand-prone reservoirs offer physical restraint of sand migration. These include:

- Resin injection, where a resin is injected into the formation to cement the sand grains in situ;
- Gravel pack, where a gravel slurry in a carrier fluid is pumped into the annular space between a centralised sand screen and the open hole, creating a granular filter;
- Standalone screens, which are simple installations suited for uniform formations, typically where the uniformity coefficient is calculated as less than three; and
- Inflow control device (ICD) screens, deployed to reduce or delay an influx of water but with added sand control benefits such as reducing annular flow to near zero.

Go with the flow

More recently, great emphasis has been placed on extending production by using ICDs in conjunction with sand screen technologies. This type of completion solution has been most prominent in the Middle East and North Sea but is now gaining greater recognition elsewhere.

Passive ICDs are used to enhance the performance of horizontal wells in unfavorable environments such as non-uniform permeability and/or pressure along horizontal sections. The advent of passive ICD technology has dramatically improved well productivity and wellbore cleanup, resulting in increased recovery and its associated benefits.

An ICD is deployed as a part of a well's completion to create an evenly distributed flow profile along the zone creates a localised restriction to flow that is predetermined during the completion design. This restricted flow creates an additional pressure drop. The resultant evenly distributed flow profile can reduce water or gas coning and sand production and solve other drawndown-related production problems.

Standalone ICDs can be spaced throughout the completion liner adjacent to the production or injection reservoir. They can be paced on every joint or run in combination with blank joints to provide the desired well compartmentalisation and inflow profile.

A well-designed ICD completion assisted by wellbore hydraulic modeling can promote production from the entire length of the lateral and mitigate the effect of the severe pressure gradients, eliminates cross-flows existing in openhole completions and, in certain cases, significantly reduce water cut.

ICD technology comes in a variety of modes: fixed, adjustable, and with shut-off capabilities in conjunction with sliding sleeve technology.

Tendeka's ICDs can be installed as a standalone option or in conjunction with a sandscreen in a FloRight ICD. By installing ICDs, a predetermined pressure drop can be created between the reservoir and the completion liner. This choking effect creates a back pressure on higher quality sections of the reservoir, allowing tighter sections to contribute and even out the well's inflow profile. This will result in better coning control, therefore delaying water breakthrough.

Tendeka's FloCheck valve allows for circulation to the bottom without an inner string. Once production is initiated, the ball simply comes off-seat.

Additionally, the FloCheck valve allows for full washdown capability without the need to deploy an inner string, the ability to set liner hanger/packers and mechanical packers simultaneously against the valve, fluid loss control, and the ability to pressure-test the full string without setting any additional packers.

This has enabled ICD completions to be installed during periods of high well losses without having to pump a loss control material.

The FloCheck valve also is a convergence technology based on several important lessons learned during the last decade of ICD installations:

- Deploying inner strings is sometimes mandated due to poor hole conditions;
- Low bottom-hole pressure can cause differential sticking due to inability to circulate;
- Low bottom-hole pressure can lead to multiple runs with inner strings to set mechanical packers;
- Inner strings take time to run and can increase weight and stiffness; and
- Fluid loss during running of upper completion is difficult and costly to control.

The valve allow for circulation to the bottom without an inner string, permits the setting of mechanical packers without an inner string enables the spotting of breakers and spacers prior to pulling out, and provides fluid loss control while running upper completion.

When used with ICD technology, FloCheck closes off the nozzle, thus preventing any fluid loss while running in hole. Once production is initiated, the ball merely comes off seat and the cage is shortly eroded on flow, allowing for both production and injection.

The company's ICDs achieve an even, consistent flow of fluid along each interval throughout the completion string, improving performance, efficiency, and production. Combined with a sand screen in an unconsolidated reservoir; the reservoir fluid passes from the formation through the screen and into flow chamber, where flow is regulated by the ICD orifice. Along with other ICDs, the pressure drops in the production zone are balanced, yielding a more efficient completion.

World first in Gulf of Mexico

Tendeka recently deployed the world's first slimhole ICD completion in a sandstone reservoir in the Gulf of Mexico (GoM).

Due to a severely depleted reservoir with difficult drilling conditions, the well was planned as a re-entry out of a 5" liner with a $4^1/_8$" openhole, which negated the use of conventional technologies. Offset wells with sand control equipment installed experienced very high completion skin and used a variety of high-rate water packs, frac packs, and expandable screens.

The company's solution was to provide inflow control screens and swellable packers, which were installed in a $4^1/_8$" openhole section of the well. Coarse metal mesh sand

screens were used to minimise the plugging of sand and mud during well flowback, and the swellable packers were of a slip-on-sleeve design, which were simple to deploy and quick to install. The new FloRight $2^{3}/_{8}$" ultra slim hole ICD screen system was used across the 170m (560ft) zone at a depth of more than 4,000m (13,125ft).

The ICD technology used was based on a recent successful $3^{7}/_{8}$". openhole reentry completion deployed by the company in the Middle East to manage water in an openhole multilateral horizontal oil-producing well. That project was another world first in that it allowed the deployment of passive inflow control devices to manage inflow from two lateral wells connected to the mother bore.

The carbonate well had reached 50% water cut. Limited success was achieved with plugging it back to minimise water production, so it was decided to carry out a workover and install the ICDs to passively control inflow from the laterals, uniformly produce from the mother bore, and reduce the potential for cross-flow between the laterals.

Fourteen Tendeka FloMatik passive ICDs and six swellable packers weer installed to compartmentalise the reservoir, and numerous wellbore hydraulic simulation runs were undertaken to match flow and pressure profiles.

The project saw the ICDs create proportionate inflow along the well and passively control influx from the laterals with no cross-flow or packer leaks. A rate of 4,100 b/d of oil with 0% water cut was achieved, compared to 1,500 b/d before the workover.