TENDEKA

Going Wireless

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Intelligent wells use valves or chokes in the reservoir section that can be operated from the surface. For over 15 years, they have been used in fields across the world for the more effective exploitation of resources through shut-off of unwanted production, improved water injection placement and modification to hydrocarbon inflow profiles to increase recovery factors.

Intelligent completion technology is currently controlled from the surface using multiple hydraulic and/or electric control lines, which must pass through the wellhead into the completion annulus, along the length of the completion, through any packers and into the reservoir section where the monitoring and control devices are located. While this technology has been successfully implemented in low complexity wells, there are some limitations associated with the use of control lines. Such examples include the compatibility with complex well architectures, potential well integrity issues due to feedthrough connections, and the significant amount of hardware required which can make it uneconomical for marginal fields.

Shifting away from conventional technologies

Wireless completions equipment is becoming more common, from drill stem testing to multi-node intelligent completions. The move from conventional equipment with no communication mechanism and modern control line-based systems, to a wireless system is ongoing and presents several key advantages in efficiency, performance and safety.

All completions incur significant costs, but, when used, one of the key items to consider is the control line for downhole communication and actuation. Costing several dollars per foot, even single control line strings can add significant costs to a project, while triple or more bundles for hydraulic control can add over US$1million to a project cost once the additional hardware, man power and rig time are factored in.

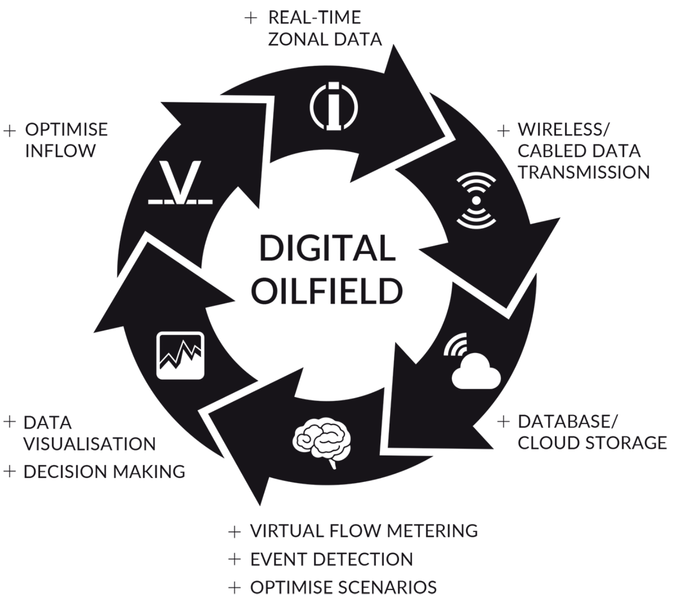
While control line systems typically require increased Capex, the alternative of a conventional completion system can often lead to savings on equipment nullified due to increases in Opex and deferred production through increased intervention and poor reservoir performance.

Wireless intelligent well technology will extend the operating envelope for advanced completions to allow for interval control where this currently cannot be achieved. Independent valve assemblies without control lines can be rotated in the well during deployment and function without physical connection to the surface. Single critical point failure modes are eliminated and inflow control can be achieved in the laterals of multi-lateral wells or at the furthest extent of a long openhole lateral. Well construction costs are reduced as cost savings in control lines, downhole connection and completion times are made, and basic top hole workovers can be performed more simply and cheaply without affecting the advanced completion functionality. The addition of real time data can lead to informed decision making, while the ability to act immediately and without intervention leads to an optimal production environment.

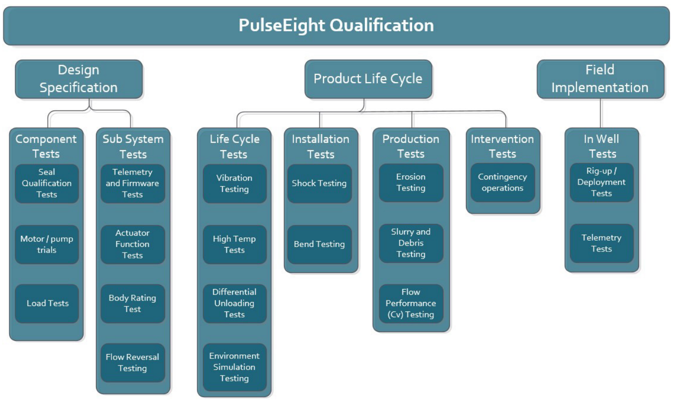
Wireless systems can help to provide a hybrid of key features whereby the completion is kept simple, allowing for a quick and safe installation. However, they also offer the communication mechanism required to monitor and control wells effectively.

Advanced technology

PulseEight intelligent well technology provides cable-free control and monitoring solutions for a wide range of applications. Each independently-acting device provides an infinitely variable choke and seal with pressure and temperature measurements for optimum control.



Tendeka's digital well management process.



PulseEight qualification overview.

The all electric system is microprocessor-driven and can be programmed to function based on wirelessly transmitted instructions from the surface or to respond autonomously to the well's environment. For example, it can detect well shut-ins, changes in well pressure or meter mass flow rates. The wireless communication uses a semi-duplex pressure pulse telemetry that is suitable for multi-phase fluid environments. The telemetry utilises the existing wellhead equipment to interface with the downhole valve.

Once in the well, the device can be actuated from the surface using pressure pulse commands. These commands are typically generated using the surface choke, and the size of required pressure change can be established using well modelling prior to deployment.

Flow from the reservoir enters ports in the tool and flows to surface. The device creates a downhole pressure response by briefly choking the flow, with the response being viewed at surface. Six pressure pulses are identified on the surface recorder. The time between the pulses is analysed to give a unique binary code that is then decoded to provide pressure and temperature readings, as well as tool status information. To communicate from surface down the well to a device, a number of pulses are created at the wellhead.

Each device responds to a unique pulse sequence and takes action to open, close or choke or to amend any variable.

In addition to this direct surface-controlled operating mechanism, PulseEight can be configured to work autonomously based on changes in downhole conditions. Computer models can be used to build an optimal inflow profile and the device can be programmed to target a fixed differential pressure through the valve. This computer model can be kept updated with the downhole pressure data sent from the valve, and the valve's programmed parameters can be adjusted while in hole to suit the updated output from the model. This offers an additional benefit over hydraulic control line valves as autonomy leads to faster decision making and implementation of optimisation techniques.

Application areas

Pressure and temperature profiling

For improved reservoir understanding, Tendeka's PulseEight system can be installed in the production tubing and configured to send pressure and temperature data to surface, providing real time information without the need for a costly workover. This can provide great value to operators in multiple situations, such as monitoring of flowing bottom hole pressure and efficiency of injection methods.

The device can also cover the functionality of a conventional memory gauge by recording high resolution data to memory, which can be downloaded once the device is recovered to surface.

Variable interval control

The system has a variable choke that can be set to target a fixed flow area or pressure drop across the valve, which is useful for reducing and improving water cut and improved recovery factors. When set across an oil producing zone with an increasing water cut, the valve can be moved to a choked position to even out the inflow profile and control the coning effect. The effectiveness of this can be estimated through modelling at a variety of flow areas. The valve can be adjusted once installed to optimise the model, and, over time, to adjust the profile as the production regime changes.

Reducing the water cut allows oil production from that zone to continue for longer, beyond the point where it typically would have been isolated with oil in place due to water handling costs.

Multi-lateral control

Multi-lateral technology has been developed to improve reservoir exposure from a single slot/bore, significantly reducing field development costs. This allows for efficient well construction and performance.

The device provides flow control without the requirement for downhole cables and wet connects, making them compatible with complex junction structures and aiding deployment methods by allowing rotation of the string during run in hole. It can be installed at the top of each lateral branch to allow production rotation of each lateral for individual contribution analysis. Moreover, it can be used for individual zonal control within the lateral itself. Each valve can be discretely controlled to manage water/gas conning and balance the inflow profile.

Water and gas shut-off

In applications where there are multiple stacked zones with water influx occurring in the lower zone, solutions to increase recovery by producing the upper zones harder can often be counterintuitive as it leads to an increase in the coning on the lower zone and causes the zone to water out faster.

Tendeka's PulseEight device permits the ability to isolate a producing interval and shut it off completely, allowing for rapid control of high water cut/oil gas ration zones. By having the device above the lower zone, it can be remotely activated to isolate that zone, so that the upper zones can be produced as required. The lower zone can then be simply opened afterwards if the water is assumed to have fallen back. The same routine can be followed for treatment and stimulation of the upper zones to enhance production.

Remote barrier for management of frac hits

During offset frac operations, many operators are forced to shut-in wells to minimise the effects of potential frac hits. This can require the use of a wireline set plug in each well, every time a nearby frac operation is planned.

The PulseEight device can be cycled several times remotely from the surface, eliminating the need for multiple interventions and reducing both the costs and risks associated with doing so. The device can also log high resolution pressure data which can be downloaded when the device is recovered from the well. This can be used to help in understanding the severity of the frac hit and its effect on the reservoir.

Autonomous gas lift

If placed across a gas producing zone, Tendeka's device can be used to regulate the inflow of gas to aid lifting of a lower producing oil zone. The device can autonomously regulate the gas inflow to a set rate or be instructed to shift based on surface production data for optimal well performance.

The system is compatible with existing wells and can be retrofitted into place on a single intervention run. This provides a simple solution for wells that were initially producing unassisted but have suffered from declining reservoir pressure. The same principles can be used for liquid unloading in underperforming wells.

A downhole regulator for optimal gas hydrate prevention

Gas hydrates can begin to form across the surface choke or any other restriction when certain temperature and dP conditions are met. Surface mitigation of this effect usually requires costly surface heaters and use of chemical injection. However, PulseEight can be used to move the point of pressure and temperature reduction downhole where the Joule Thompson cooling effect will be less of an issue. By programming the tool to target a fixed downstream pressure, PulseEight can actively respond to changes in well conditions and adjust to maintain optimum conditions.

Autonomous crossflow prevention during well shut-ins

Crossflow is a condition that occurs in multi-layer reservoirs with compartmentalised wells, where by flow from the high-pressure zone migrates to the low-pressure zone, typically during well shutins. This can lead to filter cake build up, reduction in permeability, and general formation damage, as well as inaccuracies in well modelling. Tendeka's device can be used to automatically detect well shut-ins and react by closing the valve to isolate the zone or zones below. When the surface choke is re-opened and the upper zones begin to flow, the device will detect flowing conditions and open the downhole valve. This provides autonomous prevention of crossflow from a simple wireline set device.

The future

The uptake of new technology in the oilfield tends to be slow due to the significant perceived risks and the financial costs that are incurred if equipment fails downhole.

To minimise risks and deliver a reliable system to market, PulseEight has undertaken a robust and staged qualification programme, including component testing, system testing and field testing. Having the ability to test the system in live well scenarios has been invaluable in proving the communication mechanism over long distances and under flow regimes that would have been impossible to recreate in a lab environment.

While the immediate future for this technology will be to extend the operating envelope for intelligent completion technology and address some of the applications mentioned in this article, the longterm aim for the technology is to form part of fully digital oilfield. This would involve a set of 'goal-seeking' devices being installed in a well and communicating with each other, as well as with surface, to provide a fully autonomous, optimal production environment.