Carbonate reservoirs hold approximately 60% of the world’s proven conventional oil reserves, of which about 50% feature natural fractures, with significant accumulations across the Middle East in particular.

Common challenges of these carbonate reservoirs are high heterogeneity caused by complex pore and fracture systems, oil wet rock, and low reservoir energy resulting in low recovery factors. The optimum drainage strategy is frequently horizontal production bores to increase reservoir contact, and water injection wells to improve oil sweep. The benefits of water injection can be diminished by the presence of highly conductive fractures or fracture corridors in the injection well within the reservoir. These can create thief zones connected to production wells, reducing sweep efficiency and resulting in early water breakthrough in the production wells.

In response to these challenges, Tendeka has launched FloFuse - a new technology to optimise water injection. As an addition to an extensive range of advanced inflow control technology, FloFuse can increase oil recovery by improving injected water conformance in fractured reservoirs or by ensuring effective placement of matrix stimulation acids.

Current challenges
Injection Control Devices (ICDs) have been proven in application to improve water conformance by balancing frictional losses and reducing outflow into large fractures. Figure 2 illustrates an outflow profile for:

1. A barefoot completion with no outflow control
2. An ICD completion with uniform ICD setting across the well
3. An optimised ICD completion with the flow area adjacent to the fractures reduced by a factor of 10.

FloFuse - optimising oil production
FloFuse eliminates the requirement for integrated sliding sleeves, enabling the optimised ICD completion configuration to be achieved autonomously. The FloFuse is a biased open autonomous ICD which functions when a trigger flow rate is exceeded to limit the flow area to that compartment. The effect is to provide a two-setting inflow control device which can be optimised for flow distribution into the fracture/matrix structure and ensure effective injection when highly conductive fracture paths are encountered. The key benefits of this are:

- optimised ICD completion for water injection into fractured reservoirs
- reduced risk of poor conformance due to complex fracture structure
- no requirement for logging and intervention
- simple life of well, completion design and construction

The flexible design of the FloFuse means that multiple settings are available for both valve positions, which are field adjustable. There is an added optionality to provide a check valve feature to prevent backflow and crossflow. FloFuse is configured to be interchangeable with Tendeka’s full range of ICDs providing a high degree of flexibility and efficient inventory management.

The challenges and solutions described for water injection into fractured carbonate reservoirs are mirrored in the production wells. The potential for FloFuse to address these challenges is currently being evaluated – watch this space.

Fractures may be identified during drilling as loss zones or with image logs but due to the complexity of the reservoirs and the extent of natural fracturing, there is inherently a high degree of uncertainty in attempts to identify thief zones prior to completing the wells. This results in a high risk of a non-optimised completion leading to poor water conformance and ineffective sweep.

One method commonly applied to overcome this issue is to integrate sliding sleeves with ICDs to enable the thief zones to be isolated. This requires the well to be logged to identify the sleeves to be closed and then a shifting tool to be deployed to close the sleeves, eliminating flow to the fracture compartments entirely.
FloFuse - optimising oil production

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Tendeka & Carbonate Reservoirs