A number of variables determine the size of this space-out, but the space-out is needed to guarantee vertical travel for the string to activate the valve. A contaminated sump is therefore left behind at the foot of the liner because the mill cannot reach the bottom to mill and circulate.

This then creates a serious issue for maximizing the long-term productivity of the asset. The properties of any contamination will be highly undesirable in a production phase. Drilling muds are specifically designed for their pore-blocking and sealing properties and need to be kept well away from the perforations at all costs. Future workovers will need to avoid tagging bottom and stirring up this debris into the production zone. In high-angle wells, there is the increased risk of natural migration of debris into the perforations of its own accord. It is highly desirable, therefore, that all potential sources of skin damage are removed.

**DIRTY SUMP SOLUTION**

In the late '90s, Churchill Oil Tools developed the Instant Bypass Tool (IBT), a range of patented valves. It was initially intended for drilling applications, with the design objective of delivering a dormant tool that would provide instant cycling once activated. The technology selected and developed was the Sleeve Activated Valve (SAV) mechanism, which became commonly used in the North Sea for open-hole cleaning when reaching TD. Being through bore until required, the SAV could be quickly activated by pumping down the sleeve at full flow. It then delivered multiple cleaning cycles instantaneously by cycling the pumps.

In 2003, operators such as Chevron, Phillips and Mobil began taking advantage of the SAV in wellbore cleanouts outside of its usual drilling environment. They exploited the unique properties of a tool that could be activated independently of vertical positioning. The benefit of this configuration can be seen in Figure 1b, where the mill is able to clean to the bottom of the well.

A couple of factors do limit the SAV's universal cleanout application. First, the power sleeve uses a choke to power the cycles. Using a choke reduces the system's hydraulic efficiency, and, in
In some cases, this can be below the theoretical level that is required for thorough cleaning. Second, the passage of drop-in sleeves may be obstructed by components placed higher up the string, such as filters. Clearly, if a flow-activated tool were to be universally applicable, it would need to be both hydraulically efficient and remotely controllable with no need for the dropping of activators.

FLOAT-ACTIVATED SOLUTION
As a solution to this problem, Churchill developed the IBT FAV (Float-Activated Valve), a design that uses reverse flow to cycle the valve and has no drop-in components. Sensitive to small volumes of reverse flow, activation is designed to occur with minimal reverse displacement. The tool is also designed not to switch phases during normal flow speed variations in the forward direction. In other words, switching the pumps on and off does not cycle the tool.

The benefits of flow-activated cleanouts were already proven; however, questions remained as to the best methods by which to cycle the tool in a live situation. Since the method is a complete reversal of thinking (as well as flow), it was important to evaluate whether the cycling process itself was feasible.

NEW SOLUTION CASE STUDY
These questions were answered in March 2007 when the IBT FAV was run on the Dragon 313B well. Prior to the live application, it was in-hole tested to evaluate the various methods of operation and establish the optimum cycling procedure for the run.

Each method needs to place a small backpressure on the tool; this will close the float and lift the indexing mechanism in the valve. There are a few ways this can be achieved in practice, one being simply to pump in the reverse direction; others are varying methods on the same theme of creating a reverse U-tube pressure imbalance across the tool.

Reverse pumping (Figure 2a): The assembly was run in hole to varying depths up to 3,000 ft. Seven tests were performed. Reverse pumping at pressures ranging from -120 psi to -500 psi all successfully cycled the tool without need for vertical displacement of the string.

U-tube method (Figure 2b): In a cleanout scenario, the natural U-tube created in the displacement of the heavy contaminated mud by the cleaning pill can be used for cycling. Once the cleaning pill has passed the outer tool ports, pumping is stopped, and opening the bleed-offs allows the U-tube to back-flow and cycle the tool. The advantage of the U-tube method is that it occurs naturally in the process and no vertical displacement is required. In this trial, the U-tube was simulated by using the lift and lower technique.

Lift & lower (Figure 2c): Lowering the drill pipe with a float in the system created the differential U-tube required to cycle the valve. The pipe was then top-filled to release the pressure caused by the air. If the string was already at the depth required, then lifting three stands and lowering back into position produced the 150 psi required to cycle the valve. The lift and lower technique was used to index the tool six times; this indexing also performed with 100% reliability. Between switches, a number of pressure tests were made to check the integrity of the valve in the closed position.
Nitrogen method: If no other solution were available, a third method of creating a U-tube is to forward-pump a small volume of nitrogen or air. Displacing several stands of fluid with the compressed gas would also create a cycling U-tube effect as the nitrogen was bled off.

APPLICATION SUCCESS

The primary objective of this run could not be achieved without the absolute positioning and orientation of the whipstock assembly. The MWD controlling the location process made access with conventional cycling methods completely impossible (Figure 3a). Nevertheless, with no access to the valve and without having to make any vertical movement to the string, cycling was completed successfully by applying a reverse pressure, in this case 500 psi (Figure 3b). The ability to control circulation in this manner was the deciding factor in the successful completion of this project.

CONCLUSION

The float-activated valve adds a fresh perspective to well circulation problems. The testing showed that the three methods of float valve cycling are viable; this will give operators the flexibility to select an appropriate method to fit with application requirements. For example, the lift and lower method will provide cycling without any increase in the overall pressure to the formation, making it ideal for use in open-hole situations. For cased-hole applications, the simplicity of reverse pumping may be preferred for speed and efficiency. The success in the milling application itself illustrates how, even in an environment that is restricted both physically and hydraulically, it is possible to control a circulating valve using this new method.

Finally, for wellbore cleanouts, this offers the serious prospect of making contaminated pay zones a thing of the past, as any barriers to achieving a total cleanout have been removed. The importance of this process is illustrated by the significant efforts that are made to sanitize all top-side equipment and to remove all solids. The IBT FAV provides the opportunity to fully utilize these systems and to apply them to 100% of completion fluids.

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