Mono-trip cement-tolerant completions breathe new life into disposable wells

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A NEW COMPLETION method for "disposable" wellbores not only makes them more economically palatable, but also promises to extend their "shelf life". "Harvest" or "disposable" wellbores are a mainstay in the Gulf of Thailand, where wells with marginal economics and life expectancies of 3-5 years abound. The concept also has become prevalent throughout the Asia Pacific region and is growing in other regions throughout the world.

Until recently, the completions, also referred to as "packerless", "tubingless" or "cement-through", posed challenges to operators. These challenges are due to the two-stage completion process that results in additional time and money; and industry-standard productivity- and safety-enhancing components such as safety valves and gas lift devices that were not tolerant of the cement that must be pumped through the tubing and up the annulus.

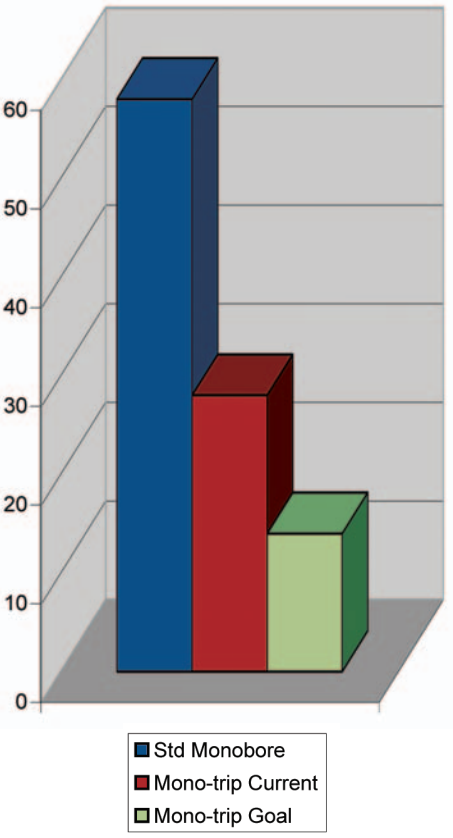
That situation has changed with the development and commercialization of **Baker Oil Tools'** Mono-Trip CemenThru completion system. This system relies on specifically designed cement- tolerant components. It has proven its value in the Gulf of Thailand and offers economically viable completion solutions for enhanced productivity and safety benefits in other world regions.

SEARCHING FOR ALTERNATIVES

Cement-through, disposable wellbores have gained popularity in fields where drilling conditions and completion economics made inexpensive new wells more attractive than workovers. A prime example of an area where cement-through completions are a mainstay is the Gulf of Thailand. Typically, operators in the area have completed wells using a two-trip method whereby the lower completion was cemented in place, and then the upper completion components were installed. Although this two-trip completion provided the desired results, it could be very time consuming and costly. Additionally, because industry-standard gas lift devices were not cement tolerant, there was no reliable method to gas-lift these wells as production levels decreased.

The decision was made to develop a more fit-for-purpose completion system for disposable wellbores that would include all the equipment necessary to safely and economically complete these wells. This system would need to be a true monobore, one-trip completion that would allow cement to be pumped offline, freeing the rig to move to another location on the platform. Components of the system would need to function properly following the cementing operation.

Time Reduction (hours)



The successful application of a true mono-trip, cement tolerant monobore completion system can reduce time and cost while enhancing safety and eliminating additional trips into the well.

THE DOWNHOLE SAFETY VALVE

The first challenge in developing a fit-for-purpose cement-through completion system was to design a downhole safety valve that could operate properly after having a large volume of cement pumped through the ID. Tubing retrievable, surface-controlled subsurface safety valves (TRSCSSVs) are required in virtually every offshore environment, making this a key component of any completion. Originally, TRSCSSVs were designed using a concentric piston that was part of the flow tube assembly. Over time, the rod piston design has become industry standard. Downhole safety valves based on the rod piston design remain 98% free of cement following the cement pumping operation. However, the goal for the new, one-trip disposable wellbore completion was 100% cement tolerance.

The design engineers quickly determined that the concentric piston design would greatly improve the ability to keep the internal portion of the safety valve free of cement. Modifying the seal configuration formed barriers to prevent pumped cement from migrating to the safety valve's internal components.

Prototype testing of the first safety valve designed with these modifications validated the method's effectiveness. Duplicate tests were performed in an actual well completion scenario. After allowing adequate time for the cement to set, the safety valve was dismantled piece-by-piece and found to be completely free of residual cement in areas that would have an adverse effect on the operation of the valve.

GAS LIFT MANDREL

Gas lift mandrels installed during the initial completion can improve well productivity and economics. However, because industry-standard gas lift mandrels are not cement-tolerant, past practice in disposable wells was to either forego gas lift or perform costly second and sometimes third completion trips to make gas lift possible. Thus, the second design objective of the new completion system was a mandrel with self-cleaning capabilities that would allow a wiper dart to be pumped to the bottom of the completion.

The process began with a series of computation flow dynamics (CFD) simulations to help the design engineers understand the characteristics of cement being pumped at approximately 5 barrels per minute through the completion string. A major concern would be the ability to locate and remove dummies, or live valves, from the offset ID of the mandrel. Another concern was whether industry-standard kickover and pulling tools could reach the valve pocket.

Testing was performed with a goal of introducing turbulent flow areas in the internal sections of the mandrel that must remain free of cement buildup and allowing a wiper dart to pass unobstructed through as many as five mandrels and then latch and seal in the latch collar. The initial test indicated that the current industry-standard mandrel had little to no turbulent flow and a typical wipe plug would not pass through the mandrel.

Adding strategically spaced tool guards to the internal offset section of the mandrel significantly modified the flow characteristics, particularly around the fishing neck portion of the latch. Nozzle holes were placed adjacent to this area to assure that the fishing neck area would be cleaned properly. During the prototype phase, several tests were performed in conditions that simulated cement pumping during the actual well application. Each test confirmed that adding the turbulent flow path assured that not only would the mandrel be clean, but also that the extended wiper would pass through each mandrel in the completion string.

CIRCULATING DEVICE

To address the fact that pumping cement, although accurate, is not an exact science, a hydrostatically closed circulating valve, the HP Defender, was developed to circulate out excess cement. Positioned directly above the packer, the valve is opened via rupture disc technology. After the packer is set, applying additional pressure ruptures one of the two discs and allows circulation and cleaning of the annulus from the valve to the top of the completion. This procedure ensures that any residual cement is cleaned from the annulus to allow uninterrupted gas lift operation.

Once clean, the annulus is closed and additional pressure is applied to shear and shift the outer sleeve of the circulating valve, regaining annulus-to-tubing integrity. A shiftable insert is also incorporated into the design as a backup seal on the ID. This insert can be shifted upward to close using industry-standard wireline accessory tools.

PACKER

To assure a positive seal in the annulus, an element-only mid-stream packer was used. The element-only design (rather than element and slips) was sufficient because the packer is not required to hold any weight or tension. This packer has seen significant use in the Far East with excellent results.

RUN HISTORY

The Mono-Trip CemenThru completion system has been installed in more than 70 wells since its initial design and implementation. A summary of the completion sequence for these wells is as follows:

- Completion string including all components is run in hole to bottom and tubing hanger successfully landed;

• Rig is skidded to complete subsequent drilling operations and offline cementing carried out to correct volume;

• Extended wiper plug is launched and pumped to bottom, landing in latch collar and forming seal for pressure cycles;

• Packer is set using up to three pressure cycles;

• Mulitple pressure cycles assure that excessive pressure is not placed on the circulating valve causing early rupture of the disc;

• Appropriate pressure is applied to rupture circulating valve disc and allow excess cement to be removed from the annulus;

• Once annulus returns are acceptable, appropriate pressure is applied to close the external sleeve on the circulating valve;

• As a redundant seal, the internal sleeve of the circulating valve is then shifted up to close, assuring tubing-to-annulus integrity.

OPERATIONAL ISSUES

As with any new technology, mono-trip, cement-through completions have had a learning curve for operational and procedural issues. Since late 2003, 70 wells have been completed in the Gulf of Thailand using the Baker Oil Tools system. Sixty, or 86%, of these wells have been executed flawlessly. Operational errors, component issues were responsible for 10 of these completions being less than perfect. The majority of these were functional following the cement set.

Of the wells classified as less than flawless, the problems encountered and the measures taken to address them are outlined here:

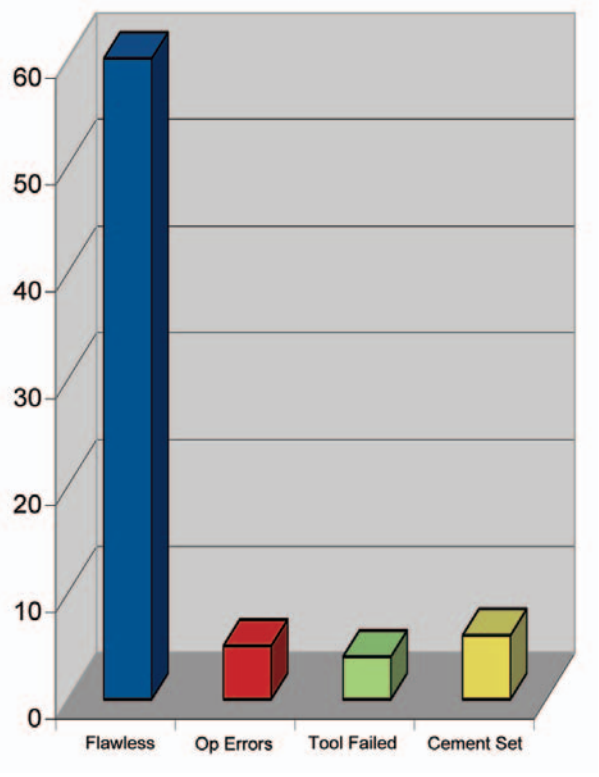
• Plug failed to launch stuck in cementing head. Setting packer with slickline plug did not actuate circulating valve.

Adapted cement head to accommodate extended wiper plug.

• Wrong bonnet installed. Subsurface safety valve closed; thermal expansion actuated packer and ruptured disc to circulating valve.

Reviewed procedures.

Mono-Trip Run History



Since late 2003, 70 wells have been completed in the Gulf of Thailand using the Mono-Trip CemenThru Completion system. Of these, 60 (86%) were executed flawlessly while operational and component issues were responsible for 10 of the completions being less than perfect.

• Packer or circulating valve not set due to inadequate tubing pressure.

Worked with operations to assure adequate tubing pressure.

• Well circulation problem could not set packer; left as non-gas lift well.

Reviewed procedure. Lost circulation identified as root cause.

• Packer set on first attempt; could not close circulating valve.

Additional training.

• Unable to close circulating valve due to inadequate annulus pressure .

Pressure loss in annulus identified as root cause.

• Packer not set as disc partially ruptured. Used slickline to close inner sleeve.

Excessive pressure cycles caused rupture disc to partially open.

• Problem with leaking subsurface safety valve. Shut in well to monitor tubing and annulus pressure.

Unidentified problem with subsurface safety valve.

• Packer not set. Left as standard monobore completion.

Issued First Alert. Root cause identified as excessive movement during packer setting. Decision made to add hold-down slips to mid-string packer.

Operational and procedural issues for the new system continue to be evaluated and improved to ensure ongoing success.

RISK, COST REDUCTIONS

The successful application of a true mono-trip, cement-tolerant, monobore completion system has the added benefits of reducing time and cost, enhancing safety and eliminating additional trips in the well. The system can eliminate 18-24 hours of rig time per well, a major cost factor when completing wells with short life expectancies. Reducing the number of trips further improves well economics.

Similarly, reducing completion time and requiring only one trip in the well significantly reduces opportunities for accidents. The fact that fewer service personnel are required is an additional safety benefit. Finally, fewer accessory tools reduce the risk of fishing operations, which can be costly and time-consuming.

Short-life wells with marginal economics require a "most bang for the buck" approach. The mono-trip, monobore, cement-through completion meets that requirement and extends the productive life of these wells through the use of a proven gas lift system. ■