Swellable packers provide breakthrough in Saudi Arabian horizontal slim-hole well

By Adib A. Al-Mumen, Mohammed I. Al-Umran and Pradeep Agrawal, Saudi Aramco; Thomas Jorgensen and Peter E. Smith, Halliburton

A MATURE WELL in a carbonate reservoir in Saudi Arabia was no longer producing and was sidetracked in a workover operation to regain production. This article describes the usage of swellable packers to isolate a detrimental water-producing fracture encountered during drilling of a 3 7/8-in. slim-hole horizontal in a naturally fractured carbonate reservoir. No means of open-hole/slim-hole isolation were available prior to the introduction of swellable packers. The packers were successfully run, and the well was brought into production at good rates and low water cut.

WELL HISTORY

Natural fracturing is believed to pervade most carbonate reservoirs due to the brittle nature of these rocks. Today, most production wells are drilled as 6 1/8-in. horizontals and completed with 4 1/2-in. inflow control devices and open-hole packers to delay and manage water production. A number of workover wells are drilled with smaller bit sizes. Consequently, this requires slimmer completion equipment to complete the wells in an optimum manner.

Well A was drilled in 1999 as a 6 1/8-in. open-hole high-slanted (83°) producer and completed with 7-in. packer and 4 1/2-in. tubing. In 2005, the first workover operation was carried out to revive the well, which was dead as a result of excessive water production.

A window in the 7-in. liner was cut after de-completing the well and setting a whipstock. A 2,200-ft, 6 1/8-in. horizontal sidetrack was drilled in the formation, and the well was completed with 7-in. packer and 4 1/2-in. tubing. The well was found dead after only one month of production.

An acid job was subsequently carried out to restart the well; however, it was unsuccessful. Surface and downhole bailer samples were collected, and lab tests suggested that an adjacent reservoir was dumping water into the formation.

Another workover operation was planned and carried out in 2007. A balanced cement plug was set to abandon the existing lateral. A window in the 7-in. liner above the reservoir was cut, a new 6 1/8-in. curve section to the top of the formation was drilled, an expandable liner run and set and a 5 1/2-in. horizontal hole was drilled. If needed, the well would be completed with inflow control devices and open-hole packers.

After the 5 1/2-in. shoe was milled out and a negative test was performed after displacing the well to water, the well flowed water from the reservoir. A 4 1/2-in. scab liner was run to isolate the leak in the 5 1/2-in. liner from 6,398 ft to 6,720 ft. A 3 1/2-in. open hole was drilled to TD at 8,800 ft. A fracture was encountered at 7,586 ft with total losses. The remainder of the lateral was drilled with water with no returns. The well was not logged since no caliper was available at that time for this hole size.

SLIM-HOLE WELL DESIGN

Swellable packers were successfully run and revived production.

Figure 1: The 2 3/8 in. x 3.5 in. swellable packer differential profile for a mature well that was no longer producing. Packers were successfully run and revived production.

The potential consequence was excessive water production and loss of the lateral, resulting in a costly workover operation. The 3 7/8-in. open-hole drilled out of the 5 1/2-in. expandable liner with the 4 1/2-in. scab liner inside was to be completed with 2 3/8-in. pre-perforated pipe, 2 3/8-in. blank pipe and four swellable packers; two swellable packers to isolate the water-bearing fracture, one swellable packer to further compartmentalize the open hole to potentially improve the inflow profile and one swellable packer to isolate inside the 4 1/2-in. scab liner as a liner top packer. The 2 3/8-in. liner was to be dropped off in the horizontal with a hydraulic disconnect tool.

SWELLABLE PACKERS

Swellable packer technology has been rapidly taken up by the oil industry. Since its introduction after the millennium, thousands of units have been delivered worldwide, and the application envelope is continuously being widened. Swellable packers are run in open hole and cased hole, in ERD wells, in multilateral wells, in conjunction with intelligent completions, in hydraulically fractured wells, in combination with cement, etc, in producers and in injectors in low-temperature to HPHT fields.
Swellable packers for Well A

The 3 7/8-in. open hole in well A was to be completed with 2 7/8-in. pipe. Hence, swellable packers built on 2 3/8-in. pipe was preferred. Since no caliper was available, a fairly long packer element was also preferred to obtain a good seal in case of any enlarged hole at the setting depths.

A maximum of 1,000-psi differential pressure was expected. The design chosen was 3.5-in. OD swellable packers with 5-m long elements manufactured on 2 3/8-in. pipe. These packers would hold 1,000-psi differential pressure in borehole excess of 4.2-in. borespace (Figure 1).

**Job execution**

The 3 7/8-in. hole was drilled to TD at 8,800 ft with total losses after the fracture was encountered at 7,586 ft. A wiper trip was performed and run without incident from the 4 1/2-in. shoe to TD. The 2 7/8-in. completion liner comprising a 2 7/8-in. guide shoe, 2 3/4-in. pre-perforated liner, 2 7/8-in. blank pipe, 2 7/8-in. swellable packers and 3.20-in. OD hydraulic disconnect tool was run on 2 7/8-in. jointed drill pipe to TD (Figure 2).

Four swellable packers were run. Two were spaced out and placed at 7,549 ft and 7,647 ft to isolate the water-producing fracture with blank pipe in between. The third swellable packer was placed at 8,188 ft to compartmentalize the open hole between the fracture and TD. The fourth swellable packer was placed inside the 4 1/2-in. seabed liner as a liner top packer. At TD, water was circulated at a low rate to clean the ID of the drill pipe to limit the risk for the drill pipe to hang up. Up and down weights were taken, and the ¾-in. bull was dropped. The ball seated, and 3,000-psi pressure was applied to shear the shear pins in the hydraulic disconnect tool. A reduction in up-weight indicated positive release, and the drill pipe were pulled out of hole.

The upper completion was run, and the well was flowed for cleanup. The well was secured and shut in, awaiting flow-line hook-up.

The well was brought on production in November 2007 and contributed 3,400 bbl/day of oil with 3.9% water cut, verifying that the fracture was isolated with the swellable packers.

**Future slim-hole swellable packer applications**

The success of the case history described here enables Saudi Aramco to drill 3 7/8-in. slim-hole wells with the confidence that there is a means for open-hole isolation in that or other hole sizes, if required. Swellable packer technology will also be used in future wells to accomplish other objectives. Currently, two similar but different applications are being prepared for:

1. **Coil tubing deployment of swellable packer straddles through-tubing to isolate watered-out perforations.**

2. **In cases where 4 ½-in. completions have been left high (stuck) in the 6 7/8-in. open hole and there is a long interval of good sand below the bullnose, the bullnose will be drilled out, and 2 3/8-in. sand screens will be run through the 4 ½-in. completion and into the open hole to keep the borehole from collapsing.** A swellable packer will be run above the sand screens and set inside the 4 ½-in. completion to stop the flow of solids in the 2 3/8-in. x 4 ½-in. annulus.

The use of a swellable packer as a liner top packer is not only limited to slim-hole type applications. In applications where instant anchoring is not required, this can prove to be a greatly simplified solution that reduces risk and cuts the capital cost of running and setting a traditional liner top packer and hanger.

**Conclusion**

Well A was dead, and a workover operation was undertaken to recover productivity of the well. The successful installation of swellable packers in the slim-hole horizontal 3 7/8-in. open hole has given Saudi Aramco a method for isolation in this hole size, which was not available previously. Further similar workover operations can now be undertaken as water-bearing fractures encountered during slim-hole drilling can be blanked off. Swellable packers enable the operator to successfully complete such challenging wells in other fields.