TECHNOLOGY ENHANCES CANYON FRAC FLUID RECOVERY AND PRODUCTIVITY

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ABSTRACT

The main purpose of staged fracture treatments is to selectively treat all the zones of interest rather than performing a single treatment. Historically, cast-iron bridge plugs were used to isolate previously treated zones. After all desired intervals were stimulated, the plugs were drilled and the well brought on to production. However, cast-iron bridge plugs do not allow the lower zones to be flowed back until the plugs are drilled out of the wellbore. In the Sonora Area Field in West Texas (Sutton County), an operator was encountering a lower percentage of fracturing fluids recovered and decreased initial production rates. After a discussion with the service company, a new method of zonal isolation, which included immediate flowback, was successfully tried and adopted to solve this problem. This method included using conventional fracturing fluids with composite bridge plugs to achieve an improved flowback of fluid and enhanced well productivity. This paper details how this problem was successfully addressed.

INTRODUCTION

Two aspects were recognized as problems with the completion methods in the Canyon sands within the Kelly lease of West Texas. First, fracturing fluid recovery from the treatments was not as good as the tight rock in this formation should yield. Second, the time for the completions was longer than desired and killing the wells before running production tubing was reducing the effectiveness of the treatments. A more effective completion method to enhance the recovery of the load water would possibly increase hydrocarbon production.

In 2000, the treatments for the first nine wells on the Kelly lease utilized cast-iron bridge plugs for isolation of the intervals of Canyon sands (C1, C2, C3, C4, and C5). The number of stages varied from three to seven steps depending on the geology of each well. The process of fracturing the wells was usually completed in one day. The drillout of the plugs and cleanup of the wellbore could take from one to two days, depending on the number of plugs that were used to isolate intervals and then would be drilled and removed. Each plug could take anywhere from 1 to 2 hours to drill with tubing and a pulling unit. Drilling five or more plugs caused the process to carry over to the next day to finish. The average time to production included 5 days for drilling, 1 day for perforating the first zone, 1 day for the treatment, and 2 days for drilling plugs and running tubing for production.

The current process includes perforating all the zones with 1 shot per foot (spf) and pumping multiple-stage fracturing treatments using composite fracturing plugs (CFPs) for treatment isolation. Three to nine zones have been treated with three to seven fracture treatments per well. This technique has decreased the "days to sales" with better initial and sustained daily gas production. Figure 1 shows the reduced completion days and Figure 2 shows the first 457 days of production for the Kelly lease's wells normalized to the start of each well's date of first production.

GEOLOGY AND MINERALOGY

The Kelly lease is located approximately 20 miles south of Sonora, Texas in the Val Verde basin of the larger Permian Basin. The field was first drilled in 1950s to the Strawn limestone and Canyon sandstone formations covering over 3,800 square miles. By the 1990s, most of the lenses had been drilled, including the C1 through C5 sands with the Strawn limestone as the deepest target pay.

The sands were formed as submarine fans during the Late Pennsylvania-Early Permian depositional era. Usually, the fan channels are lenticular and less than 1 mile in width. Sheet-like fan lobes extend for only several miles in each lens. The lenses have mineralogy consisting of siderite, chlorite, quartz, calcite, feldspar dissolution, kaolinite and illite, and ankerite.[3]

The Strawn limestone consists of multiple lime stringers bounded by tight shale. The Strawn usually can be located at a depth of 8,800 to 9,200 feet with nearly 200 feet of gross interval. The Canyon sands are located from 2,500 to 8,500 feet. Both formations are not homogeneous and correlations are decent at best between wells.

The Kelly lease targeted only the Canyon sands from an average depth of approximately 6,350 to 5,250 feet. Typically, the area included six stringers of sands of interest with a net pay of 100 feet. The average porosity is 10% with a permeability of 0.025 to 0.25 md. Openhole logs depict gas by the crossover between the density and neutron readings. A clean sand is also indicated by gamma ray reading of less than 65. The initial bottomhole pressure (BHP) was between 1,500 and 2,000 psi.

Sidewall cores have indicated low permeability with indications of natural fractures.

COMPLETION OF KELLY TEST WELL #1

In 2001, several wells were drilled on the Kelly lease, including the Kelly test well #1**.** The lower, middle, and upper Canyon sands completion method included wireline perforating, fracturing, and setting cast-iron bridge plugs until all the zones in the wellbore were treated.

On the project's first day, the lowest interval of interest (lower Canyon) was wireline perforated. The next day, the fracturing equipment was rigged up and the first interval fracture treated down the 4 ½ in. J55 casing using 40% CO_2 with a carboxymethylhydroxypropyl guar (CMHPG) base fracturing fluid(Table 1). The CO_2 phase was utilized to help with fluid recovery due to the low BHP of 1,500 psi and to reduce the amount of treatment fluid water that would come into contact with the Canyon sands, displaying water-sensitive clays. The fluid system also contained 2% potassium chloride (KCl) to help reduce swelling of the clays in the formation. A volume of 500 gallons 7.5% hydrochloric acid (HCl) was spotted across the second zone of interest in the flush of the first stage of the fracture treatment. The fracturing equipment was rigged down from the wellhead and the wireline rigged up to run in the hole with a cast-iron bridge plug on the bottom of the perforating guns. The gun assembly and plug were then run in the hole. The bridge plug was set 50 feet below the bottom of the planned second-stage perforations and pressure tested to 3,000 psi to help ensure isolation from the previous interval. The perforating guns were pulled up the hole to the second interval of interest and the guns were fired. A subsequent run was sometimes necessary if more holes were needed for the interval(s) of interest. Then, the second stage was fracture treated. After pumping the second interval's stage, the process of running a plug, perforating, and fracturing was repeated for a total of six stages.

Upon completion of the final upper interval's fracture treatment, the well's upper Canyon zone was flowed to the pit until the well had no surface pressure or until the following day. Procedures then called for a pulling unit to drill the plugs using a 50-quality foam consisting of compressed air and 2% KCl water the next day, taking 15 to 30 minutes to drill each plug. The total time for the process could take 4 to 8 hours before the production tubing could be run in the hole.

The Kelly test well #1 was put on sales with an initial production rate of 350 Mcfpd. Nine other Kelly wells were drilled and completed similarly.

TRANSITION COMPLETIONS

In an effort to reduce the time to sales, the completion methods were altered by using composite bridge plugs (CBP) in place of the cast-iron plugs. The result was a greatly reduced drill time per plug. The CBP took only 15 minutes or less to drill with 2 3/8 in. tubing and a pulling unit. The reduced time allowed as many as five plugs to be drilled and the tubing run in the hole in a single day.

The well's production was going to sales in 2 to 3 days instead of 3 to 4 days. The net result was a savings in total costs, but no gain in productivity. After the plugs were drilled, the effectiveness of the CO_2 was still diminished because the low BHP allowed leakoff to the matrix permeability.

CURRENT COMPLETION METHOD

In an effort to increase the effectiveness of the foamed fracture treatments and the time to sales, the completion methods for Kelly test well #10 were altered by using composite frac plugs (CFPs) in place of the CBP. This arrangement of using CFPs, allowed all the treated zones to be flowed simultaneously immediately after the final stage was pumped[1 & 2]. The effects of the CO_2 phase in the fracturing system were increased by the ability to flow all the zones up the casing as soon as the last stage was finished pumping.

The result was an increased flowing casing pressure during the initial flowback before any of the plugs were drilled. In fact, some of the plugs were not drilled immediately and the well cleaned up by itself up the casing and was produced for several months before workover crews entered the wellbore to drill the plugs and run tubing in the hole.

Additionally the CFP took only 15 minutes or less to drill with 2 3/8 in. tubing and a pulling unit. The reduced time also allowed all plugs to be drilled and the tubing to be run in the hole in a single day.

COMPOSITE FRACTURING PLUG

The CFP isolated the lower zones from the subsequent upper stage treatments while still allowing the lower zones to be flowed simultaneously with the last stage.

The CFP(Figure 3) is a drillable composite bridge plug with a 1-in. diameter hole through the center. On top of the tool is a tapered seat that holds the special sealing ball. The ball rests on the seat when the plug is in the wellbore, providing a seal to eliminate flow from the top through the CFP. As the subsequent stages are treated, the plug(s) act as bridge plug(s)(Figure 4).

As the well is flowed to recover the fracturing fluid, the ball(s) lift from the seat, allowing flow through the tool from all the treated zones.

The CFP is made of all drillable parts with ceramic buttons in the slip wedges that grab the casing. The drillout time per plug is normally 10 to 15 minutes or less.

GENERAL COMPLETION PROCEDURE

The following is the current completion procedure.

Day 1

1. Rig up the wireline truck and crane.
2. Run a gamma ray log.
3. Perforate the first of six intervals of interest in the Canyon formation for treatment.

Day 2

1. Rig up the fracturing equipment.
2. Treat the first interval.
3 Run a CFP on wireline, and set it above the top perforation of the first interval and below the planned bottom perforation of the second interval.
4. Perforate the second Canyon interval.
5. Repeat this process for the third, fourth, fifth, and sixth Canyon intervals.
6. Flowback the well overnight

Day 3

1. Rig up the pulling unit
2. Kill the well with 2% KCl water if necessary
3. Run in the hole with bit.
4. Drill out the CFP(s) using 50% foam consisting of air and 2% KCl water.
5. Pump off the bit.
6. Land the tubing above the top perforation for production.
7. Flow the well.

IMPROVEMENTS AND BENEFITS

These following elements are essential to the success of the current completion method:

- Immediate flowback of all fractured zones simultaneously.
- Increased fracturing fluid recovery at an increased flowing casing pressure.
- Reduced time for wells completion duration from 1 to 2 days instead of 3 to 4 days.

CONCLUSIONS

- The CFP reduced the completion time for the Canyon sand formation on the Kelly lease by decreasing the drillout time for the plugs.
- Some rigless completions have reduced the completion time.
- Initial production was up 50%, and productivity increased 40% for the first 451 days.

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NOMENCLATURE

Mcfpd = thousand cubic feet per day
CBP = composite bridge plugs
CFP = composite fracturing plugs
spf = shots per foot

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Table 1
Typical Canyon Frac Sequence

Stage	Volume	Fluid	Conc.	Proppant	CO_2 Quality
1 – Breakdown	500 gal	10 lb CMHPG			0%
2 - Acid Spearhead	500 gal	7.5% NEFE Acid			0%
3 – Spacer	1,000 gal	10 lb CMHPG			0%
4 – Pad	6,000 gal	30 lb CMHPG / CO_2			40%
5 - Proppant Laden Fluid	1,000 gal	30 lb CMHPG / CO_2	1 lbm/gal	20/40 Brady Sand	40%
6 - Proppant Laden Fluid	4,000 gal	30 lb CMHPG / CO_2	2 lbm/gal	20/40 Brady Sand	40%
7 - Proppant Laden Fluid	5,000 gal	30 lb CMHPG / CO_2	3 lbm/gal	20/40 Brady Sand	40%
8 - Proppant Laden Fluid	4,000 gal	30 lb CMHPG / CO_2	4 lbm/gal	20/40 Brady Sand	40%
9 - Proppant Laden Fluid	4,000 gal	30 lb CMHPG / CO_2	5 lbm/gal	20/40 Brady Sand	40%
10-Proppant Laden Fluid	4,000 gal	30 lb CMHPG / CO_2	6 lbm/gal	20/40 Brady Sand	40%
11 - Spot Acid	500 gal	7.5% NEFE Acid			0%
12 – Flush	3,560 gal	10# CMHPG			0%

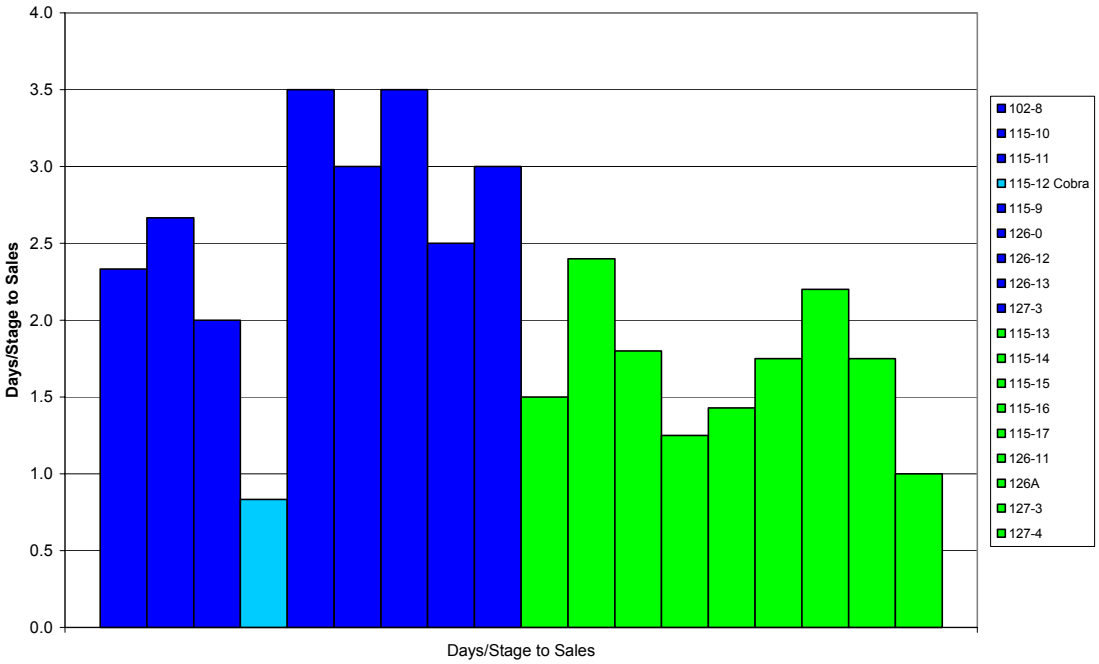

Figure 1 - Canyon –Kelly Lease Project

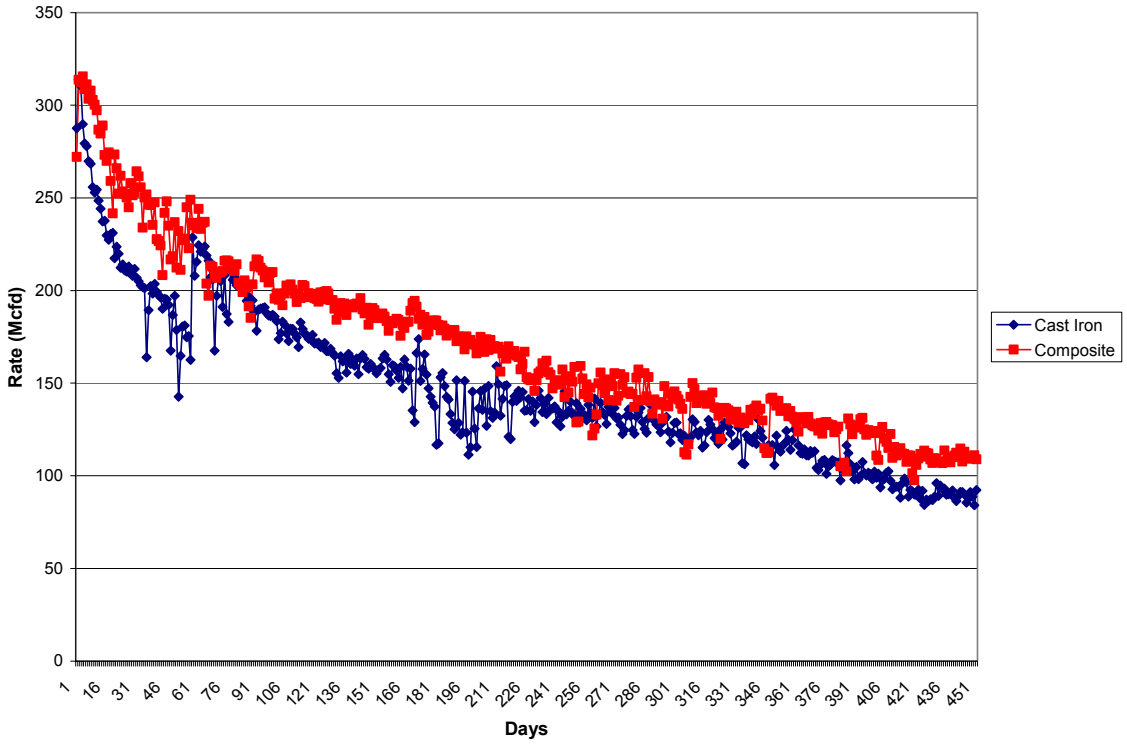

Figure 2 - Comparison of CFP vs. CIBP production

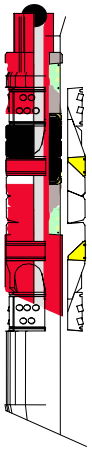

Figure 3 - Composite Frac Plug

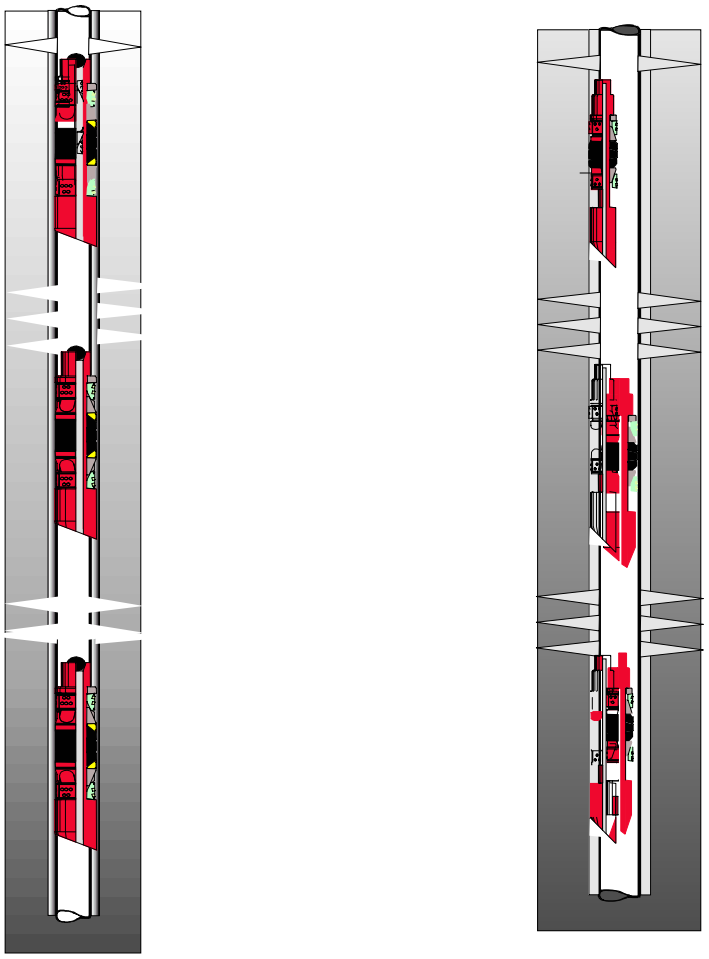

Figure 4 - Stacked Composite Frac Plugs