A CASE HISTORY OF A SUCCESSFUL COILED TUBING CLEANOUT OF A DEEP HIGH PRESSURE GAS WELL

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Loving County, Texas has seen increased activity with current gas prices. Wells are drilled to depths of more than 18,000 feet. Reservoir pressures are as high as 16,000 psi with bottomhole temperatures up to 260º F.

Production has ranged 250 MCFD to 30 MMCFD. Multiple stage Frac jobs, usually 4 or 5 stages, are typically performed. Each zone is perforated and stimulated using composite bridge plugs (CBP) to isolate each zone.

After the all the zones of interest are fractured, high pressure coiled tubing is used to clean out bauxite and to mill up the CBPs. The wells are usually completed with 5.5" casing and 5" liner from around 12,000' to total depth. This paper will explore how a unique process was used to successfully remove bauxite with 1.75" (OD) HP Coiled Tubing inside of 15,554' of 6.56" (ID) casing. Challenges included fluid selection, annular velocities and limited flow rates through the coiled tubing. The design and execution of this process will be discussed.

INTRODUCTION

Cleaning debris out of a wellbore has been the most common application for coiled tubing since it was first introduced to the industry in 1962 and it is still a major function of this tool. There have been many changes and improvements to the pipe, equipment and job design capabilities over the years. As with nearly all sectors of the service industry, it has been only in recent years that we have seen technological changes in coiled tubing services. In the past, "rules of thumb" were utilized for most coiled tubing cleanout operations. Included in these were; annular velocities of 10 inches per second in vertical completions, 36 inches per second in deviated and horizontal completions, annular velocities two times the settling velocity, circulating 2 bottoms up and taking bites until reaching a desired cleanout point. Using these "rules of thumb" resulted in having the coiled tubing unit return to finish the job on more than one occasion.

These outdated methods didn't take into account the many parameters that need to be considered when removing debris and/or fill from a wellbore. One method that has been employed, with great success in a vertical wellbore, is the use of stable foam. Stable foam works in vertical wellbores because it is a laminar flow fluid made up of two-phase bubbles. These bubbles consist of a gas as the inner phase and a liquid as the external phase. In a stable foam (65 – 94Q) these bubbles are small and held close together by surface tension resulting in a fluid with excellent solids transport efficiency.

In recent years there has been much research directed toward improving the efficiency of coiled tubing cleanouts. From this research a new wellbore cleaning process has been developed. This process involves new software and specialized jetting tools to achieve 100% solids removal in most wellbores be it vertical, deviated or horizontal. The process has been used successfully worldwide. Horizontal and deviated wells are considered more difficult to cleanout than vertical wells due to slip and sliding of the particles back down the wellbore in the build section. There have been several papers written describing the development and description of this process and these can be found in the list of references at the end of this paper.

This process allows the use of small diameter coiled tubing to clean almost any wellbore with the same efficiency as larger coiled tubing. Small coiled tubing is restricted to low pump rates, <1bpm to 1.5 bpm. In large diameter completions, these lower rates can not achieve annular velocities capable of removing solids.

The solids removal software is also a total net flow management program. It simultaneously calculates where the fill is and the location of the fluid, its pressure and whether there will be loses to the formation. The solids removal software allows the engineer to model the whole job from start to finish and optimize the fluid volumes and minimize the time spent in the well.

The process involves running in the hole (RIH) then penetrating the fill at a calculated speed. At total depth or the target depth, a short circulation phase is utilized before pulling out of the hole (POOH) is started. A POOH rate or wiper trip speed, is determined for each section of the wellbore configuration. The wiper trip speed is optimized such that all solids are kept above the end of the coiled tubing. During the wiper trip from the target depth, the tripping speed can be significantly increased with the use of rear facing nozzles. When RIH into the fill, high energy forward facing nozzles are used to help break up any hard or packed fill so that it can be circulated out of the wellbore. When POOH the wiper trip speed may be increased if rear facing nozzles are used. Every wellbore configuration has it's own optimized wiper trip speed(s).

Historically, viscous gels have been used to cleanout wellbores. Viscous gels can reduce friction and exhibit greater carrying capacities than that of water at low shear rates. However, shear rate is very high in the coiled tubing and the viscosity associated with viscous gels can result in high friction pressure.

A CASE HISTORY

The subject well, as stated at the beginning of this paper, is located in Loving County, Texas. The well was to be frac'd in two stages. In the first stage, perforations were from 17,239' to 17,426'. Perforations in the second stage were from 16,985' to 17,180'. The lower zone was frac'd and under flushed so that a CBP would not be required to isolate between frac stages. While RIH with wireline to perforate the second stage, bauxite was tagged at 16,900'. This occurred 85 foot into where the second stage was to be perforated. The desired top of the bauxite plug was 17,235'.

The choices for cleaning out 345' of bauxite were limited. The primary challenge was the wellbore completion (see table 1). Coiled tubing was selected as the cleanout tool due to its speed and economy relative to other cleanout tools. Since the bottom hole pressure (BHP) was expected to be as high as15,000 psi, a high pressure coiled tubing was required. The string selected was 1.75" 100K material. This 19,300' string was tapered from 0.156" wall to 0.175" wall.

The circulation software was used to maximize the cleanout. Pumping 10 lb/gal brine (not optimized with solids removal program) down the HP string, the rate was limited to 2 BPM. At 2 BPM the velocities in the 1.75" coiled tubing x completion annulus, were not going to clean the 3.56 specific gravity bauxite with 10 lb/gal brine at 2 BPM (figure 1). Foam was ruled out because the circulation pressure at surface was predicted to be 15,900 psi for a 0.70 Quality Foam using the circulation model.

The solids removal model was used to optimize the cleanout. The model subsequently predicted that all the bauxite could be removed at a rate of 2 BPM, using only 10 lb/gal brine water. After washing through the bauxite to 17,258', including stretch, (measured depth was 17,236') the rear facing nozzles were activated after a short circulation period and the wiper trip was executed per the model's procedure.

For a look at the Solids Removal software pre-job analysis see Figures 2 and 3.

RESULTS

The BHP was lower than expected and actual job data such as circulating pressure, WHP and pump rates were entered into the model real time to optimize the cleanout. Real time optimization allowed the cleanout to be completed 8.3 hours sooner. When wireline was RIH to perforate the second stage, the top of the bauxite was tagged at 17,252'.

CONCLUSIONS

1. Solids can be effectively removed from deep, large diameter completions with smaller diameter coiled tubing.
2. Non-gelled friction reduced water can be used to remove solids from deep, large diameter completions.
3. An efficient wellbore cleanout is possible with the use of rear facing jets.
4. A solids removal software program together with an engineered down-hole jetting nozzle, make coiled tubing cleanout an efficient operation.
5. The results of this job validate the solids removal program for cleaning out vertical wellbores.

REFERENCES

1. Li, J. and S. Walker: "Sensitivity Analysis of Hole Cleaning Parameters in Directional Wells", SPR Journal pp 356-363, December 2001.
2. Walker S. and J. Li: "Coiled Tubing Wiper Trip Hole Cleaning in Highly Deviated Wellbores", SPE 68435, presented at the 2001 SPE/IcoTA Coiled Tubing Roundtable held in Houston, Texas, 7-8 March 2001.
3. M. Ovesen et al. "Efficient Sand Cleanouts in Larger Wellbores Using Coiled Tubing: A New Approach Making an Old Problem Simple", SPE 81727 presented at the SPE/IcoTA Coiled Tubing Roundtable held in Houston, Texas. 8-9 April 2003.
4. Li J., G. Wilde: "Effect of Particle Density and Size on Solids Transport and Hole Cleaning with Coiled Tubing", SPE 94187 presented at the SPE/ICoTA Coiled Tubing Roundtable held in Houston, Texas, 12-13 April 2005.
5. Gilmore T., Leonard R., Steinback S., "Software, Fluids and Downhole Tools for Successful Sand Clean Outs in Any Wellbore geometery Using Small Coiled Tubing",presented at the 2005 Annual Technical Conference and Exhibition held in Dallas, Texas, 9-12 October 2005.

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Table 1
Tubular Geometry

Type	O. D. (in)	Wt. (lb/ft)	I. D. (in)	Top (ft)	Bottom (ft)
CSG	7.75	41.6	6.56	0	1,529
CSG	7.65	39	6.625	1,529	11,285
CSG	7.75	46.1	6.56	11,285	15,554
LNR	5	21.4	4.126	15,554	15,585
LNR	5	23.2	4.044	15,585	17,591

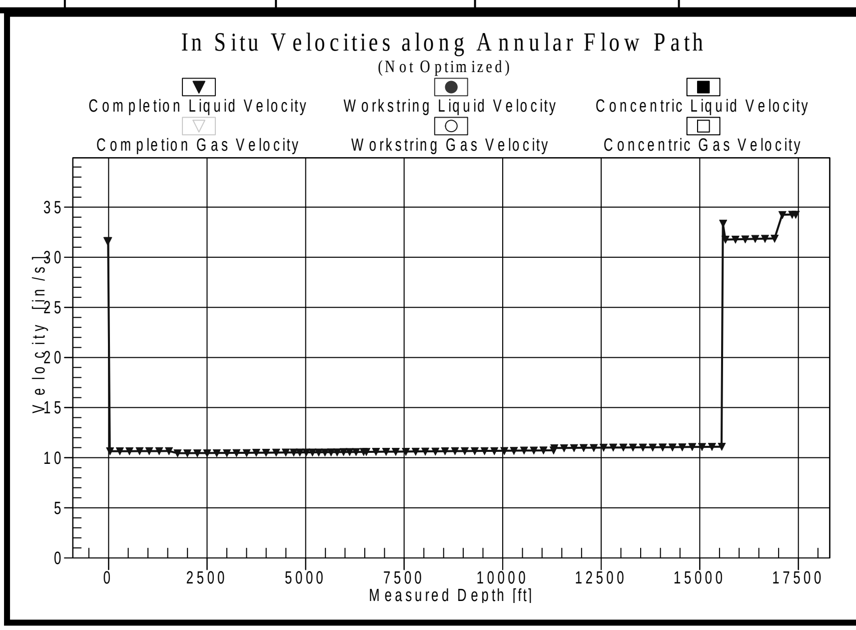

Figure 1- Annular Velocities

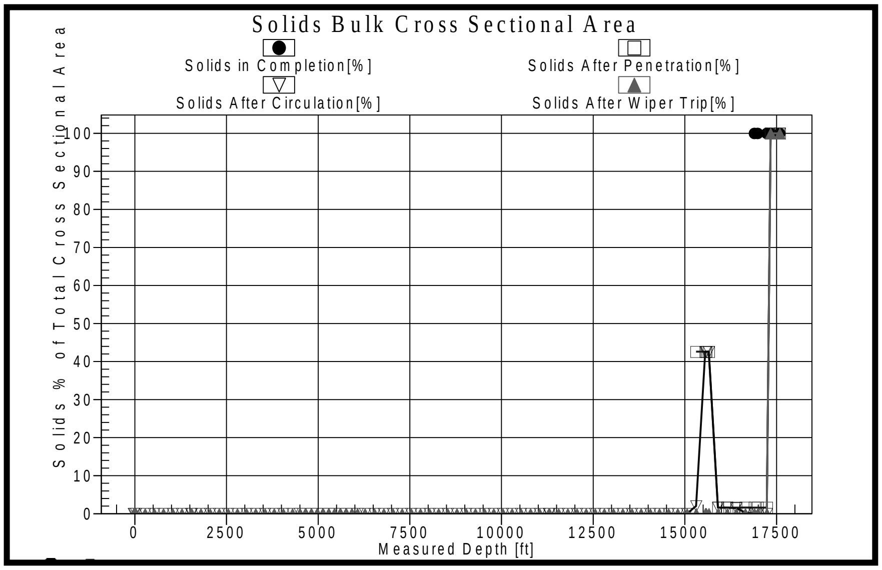

Figure 2- Solids Area – The Complete Cleanout Process

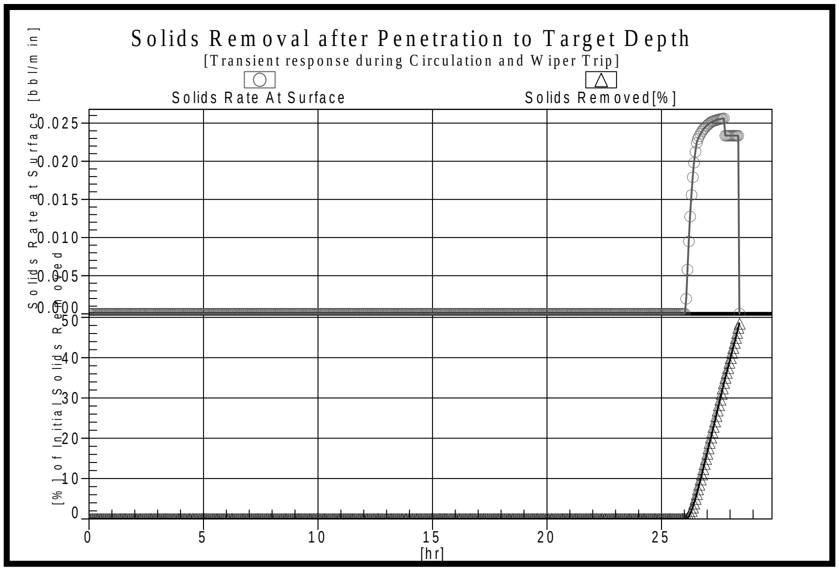

Figure 3 - Percent of Solids Vs Time

Solids Removal software program analysis

- Initial volume of solids in the well, 11.4 bbl
- Penetration time, 54 minutes
- Volume of solids remaining in the well after penetration to 17,235’, 11.4 bbl
- Specified circulating time to avoid losses, 30 minutes
- Solids remaining after circulation, 11.4 bbls
- Wiper trip time, 27.9 hours
- Solids remaining after wiper trip, 5.9 bbls
- Total time, 29.3 hours