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A Comparative Analysis of the Trouble Time for Conventional and Casing Drilling Wells: A Case Study on the Lobo Trend

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ABSTRACT

Conventional drilling methods have caused the petroleum and gas industry a huge operational and financial challenges. The cost of purchasing, inspecting, handling and transporting the drill string are some of the major challenges. The tripping in-and-out of the drill string whenever the Bottom Hole Assembly (BHA) needs a replacement or when total depth is reached does not only contributes to the Non Productive Time (NPT), but also leads to well control difficulties including wellbore instability and lost circulation. The Trouble Time of wells constitutes the NPT of such wells and includes stuck pipe, lost circulation, well control, mud, cement, directional, mechanical and laydown 7". On the average stuck pipe and lost circulation contributed up to about 74% of the NPT in the heavily faulted Lobo Field. Casing while Drilling (CwD) is an innovative technology to minimize the NPT of well. This process involves simultaneously drilling and casing a well by using the active casing. This paper presents a comparison between the conventional drilling and casing drilling methods applied in the Lobo trend of Webb and Zapata counties located in South Texas, United States of America.

Keywords: *Casing drilling, Non Productive Time, Lobo Trend, Trouble Times*

1. INTRODUCTION

The Lobo field situated in South Texas is known for the Zapata and Webb counties. This field produces gas from sands located at depths between 7000 and 13000feet. The field is shown in Figure 1 below. The production section, which ranges between 15-150 feet, is described as a tight formation with geopressured sands having permeability ranging from 0.1 to 1 millidarcy (mD) [1]. The permeability of the formation, depletion and the induced fracture are the main causes of lost circulation and stuck pipe in the South Texas fields [2]. The Lobo Field development plan was aimed at drilling over 900 wells within a six-year period. By 2001, numerous drilling problems such as stuck pipe, loss of well control, lost circulation and Non Productive Time (NPT) were encountered, making the use of the conventional drilling technique very arduous [3]. Recently, Mohammed *et al* 2012 [4] reviewed the current trends in casing drilling in the oil and gas industry and suggested a future development in the used of casing drilling. The development will improve drilling performances and will save cost in any drilling operation. The core of this development is centred on retrievable casing drilling with focus on liner systems, which could be termed Retrievable Liner Drilling (RLD). The RLD can be viewed as an evolution in the drilling liner technology [2, 4]. The need to address these drilling problems led to the application of casing drilling as an alternative drilling method on the Lobo Field.

This paper demonstrates the benefits gained by drilling the well with the casing drilling process while reducing the wellbore problems experienced. Stuck pipe, flat time at casing point and lost circulation were the major problems affecting the well construction costs in the Lobo Field.

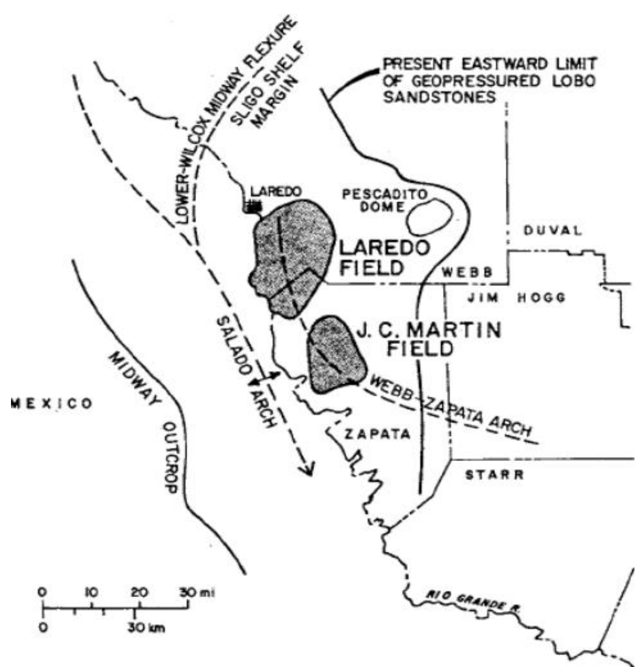

Figure 1. Map of the Lobo trend [5]

2. TROUBLE TIME

The trouble times at Lobo field is reflection of the non productive times (NPT) of the wells. The trouble times for Lobo field are shown in Figure 2. As shown in Figure 2, the trouble times are the when activities being carried out prevented the well from productivity. These times includes stuck pipe, lost circulation, well control, mud, cement, directional, mechanical and laydown 7" (Figure 2). Stuck pipe and lost circulation are the major NPT of the Lobo field wells. Between 2000 and 2001, lost circulation increases from 36% to 39% of the NPT, while stuck pipe increases from 34% to 37%. On the average stuck pipe and lost circulation contributed to about 74% of the NPT in the heavily faulted Lobo Field. Other various percentages associated with landing the 7'' casing and also well control difficulties contributing significantly to the trouble time fraction are also shown in Figure 2 [6]. From the analysis on the wells drilled traditionally in the Lobo Field between 2000 and 2002, the trouble time encountered resulted from inadequate well control, stuck pipe and lost circulation. As a result, a 5-well CwD pilot program began in 2001. The success recorded by the operator led to the expansion of the CwD program to design three rigs specially for casing drilling [7]. In terms of economic value, the conventional rig incurred a total cost of $314,000 resulting in a trouble cost of $184,000. Due to theses losses, the well was re-entre using a casing drilling process and the troublesome intermediate section was drilled and the problem fixed for just a trouble cost of $7,000.

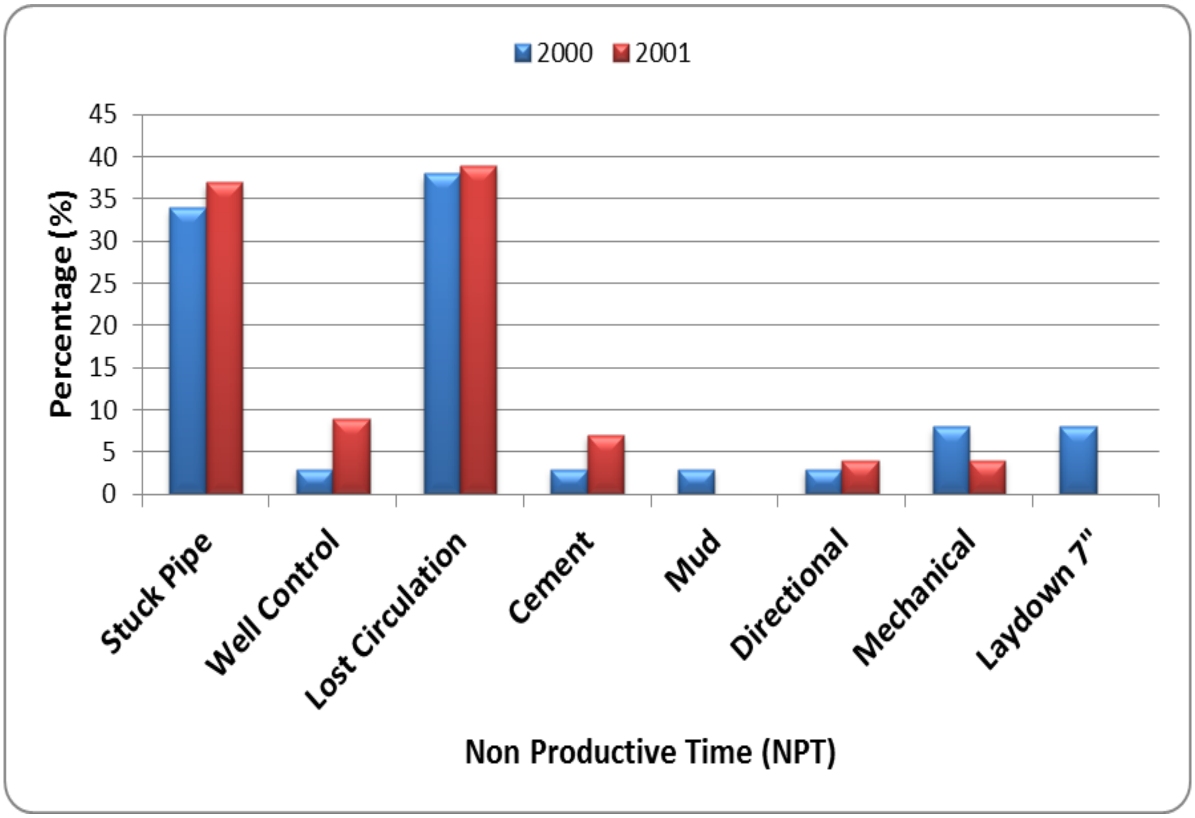

Figure 2. Trouble time for conventionally drilled well

2.1 Well Control

Well control incidents accounted for approximately 8% of trouble time. These challenges usually occur during the tripping of the drill string. Casing drilling eliminates this tripping process, hence minimizing well control problems. Figure 3 shows a graph of measured depth versus drilled time in days taken to drill three wells in the Lobo Field. Two of the wells were drilled by conventional methods while the third was well was casing drilled. The results show that the CwD well had a rate of penetration (ROP) less than the other two wells in the top/soft formation. Irrespective of the lower ROP obtained in the CwD well, it delivered a successfully drilled wellbore, which was not the case for the other two wells [8]. However, when drilling with the 7'' casing, the wells drilled into a carbon dioxide (CO_2) section at about 200ft and a kick was taken in. Well control measures were put in place and although partial circulation occurred as a result of the high equivalent circulating density (ECD), the returns were recovered. The Bottom Hole Assembly (BHA) was finally retrieved and the casing string was cemented in place. A similar condition occurring in a conventional well would have resulted in a likely well loss due to stuck pipe and a side track may have been required to continue the drilling process [8].

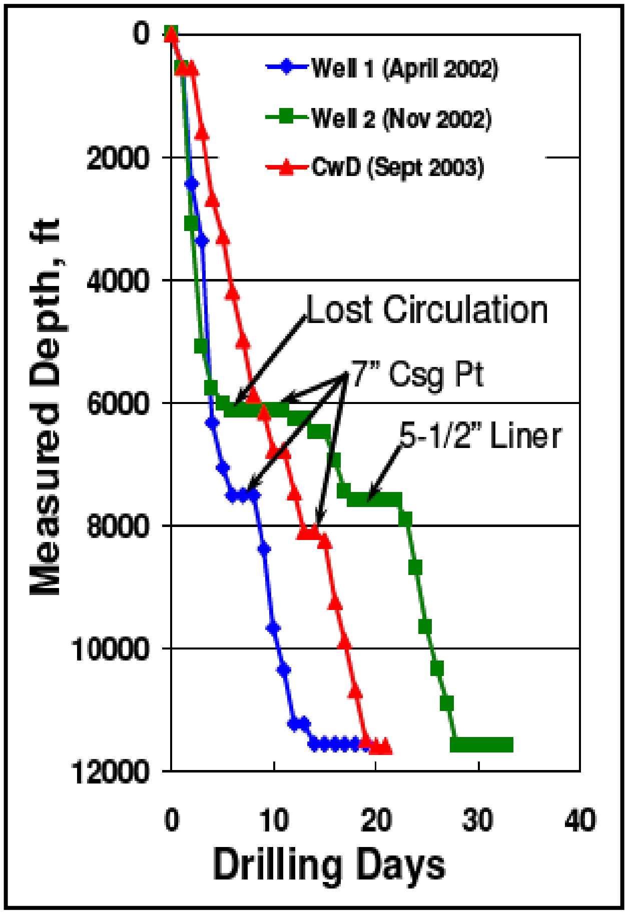

Figure 3. CwD successfully replaces two wells lost while drilling conventionally [8]

2.2 Stuck Pipe

As shown in Figure 2, stuck pipe was the second major cause of trouble time when drilling conventionally at the Lobo Field. The stuck pipe situation was minimal when casing drilling was applied to the field. The only stuck pipe incident that occurred during the drilling of the 125 wells, was during the CO_2 well control difficulty. Also, the stuck pipe did not prevent the retrieval of the BHA and the well was saved. There was no lost time caused by the stuck pipe incident. This would not have been a possibility if the well was drilled conventionally [6].

2.3 Lost Circulation

Lost circulation was the most significant problem experienced during the conventional drilling of the Lobo Field. The intermediate casing interval is usually drilled through a shallow faulted low-pressure section before getting to the casing point in a pressure transition region. In the Lobo field, it was necessary to set the intermediate casing shoe in the transition region to enable the penetration of the production sand with one casing interval. Utilizing an additional casing string could largely reduce this hazardous scenario, but at an increased cost. The introduction of casing drilling in the field led to the elimination of lost circulation and avoided the use of an additional casing string [8]. Figure 4 below shows four drilled wells on the Lobo Field; one of the wells was casing drilled and the other three conventionally drilled. The conventional wells experienced serious loss circulation problems, which could not be treated with lost circulation pills and needed the loss section to be cemented off. The first well lost about 150bbl/hr while drilling with 8.7ppg mud and the casing had to be set at 6,917ft instead of the planned casing point of 8,000ft. The second well was also drilled in a similar manner except that the 7'' casing reached about 5,145ft before a liner was needed. The casing depth for the 7'' casing was reached in the third well though the BHA was stuck during the process of tackling the lost circulation issues. The persistent lost circulation prevented the fishing of the stuck pipe and the well was side tracked [6]. The CwD rig was moved to another location close to the three wells and the two more water pipelines were connected to the rig. The well was drilled with the casing drilling procedure. Although negligible losses occurred while drilling with 10.5ppg mud through the weak zone, these were healed quickly after the casing passed the section and no more losses occurred. The 7'' casing was set at the intended depth of 8,103ft within 10days compared to the first well which took 19 days [8].

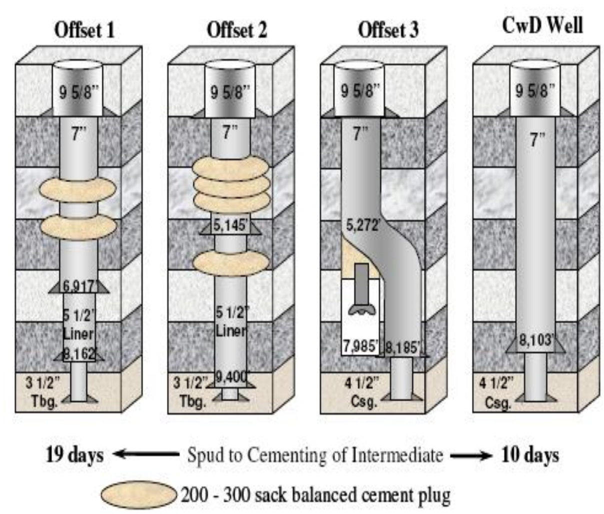

Figure 4. Casing drilling eliminates lost circulation problems [8]

2.4 Flow Regime

The flow rates used in drilling conventionally are usually higher than those for casing drilling. For instance, during the conventional drilling of one of the Lobo Field wells, the intermediate section was drilled with 450 to 500 gal/min, which is much more than the flow rate of 300gal/min for the casing drilled well. The annular velocities and the ECD for both cases also vary as shown in the Tables 1 below. Tables 1 highlight the parameters; flow rate, standpipe velocity, annular velocity, surface density, annular friction, ECD and how they differ for casing drilling and conventional drilling respectively. These results were taken at same depths for the different sizes of drill pipe used in both cases.

Table1.Hydraulics per interval (CwD and conventional well) drilled at Lobo field [3]

Parameters	CwD Well			Conventional Well		
Hole size (in.)	12¼	8⅜	6¼	12¼	8⅜	6¼
Drill pipe size (in.)	9⅝	7	4½	4	4	4
Interval depth (ft)	550	8000	11500	550	8000	11500
Flow rate (gpm)	550	300	225	660	500	225
Standpipe velocity (ft/sec)	750	1300	1800	1400	2000	3000
Annular velocity (ft/sec)	257	253	295	122	203	241
Surface Density (ppg)	8.8	10.5	14.5	8.8	11.0	15.0
Annular Friction loss (ppg)	0.7	1.0	2.0	0.1	0.3	1.2
ECD (ppg)	9.5	11.5	16.5	8.9	11.3	16.2

Pump pressures are higher in the conventional well because of the smaller diameter of the drill pipe compared to the diameter of the casing. During the drilling of the intermediate and surface intervals, the mud pumps for the CwD rigs function with lower horsepower since they are required to allow fluid flow through a drill string with a larger internal diameter (ID). The hydraulic horsepower exerted on the bit is much greater than that on a conventional well and should be observed to avoid a 'pump-off' condition at the bit face. However, the drilling parameters for the production sections in the conventional well drilled with 4'' drill pipe and the CwD well drilled with 4½ are similar due to the closeness in their sizes [3].

3. EQUIVALENT CIRCULATING DENSITY (ECD)

High ECD is usually developed in small annuli, comparing the annular capacity of a conventional well to that of a CwD well. This concern is addressed by avoiding rheological parameters or hydraulic properties that could increase the ECD above the fracture gradient. Low solids or solids free fluids have been used in the drilling operations noting that the design of the fluid will be affected by the elevated hazard caused in the small annulus. From the results obtained with casing drilling in the Lobo Field, it can be seen that high ECD is instrumental in reducing losses and achieving good wellbore pressure management. For CwD, the surface density is usually 0.5-1.0lb/gal less than the mud weights employed in conventional drilling and is altered to produce the intended ECD [3].

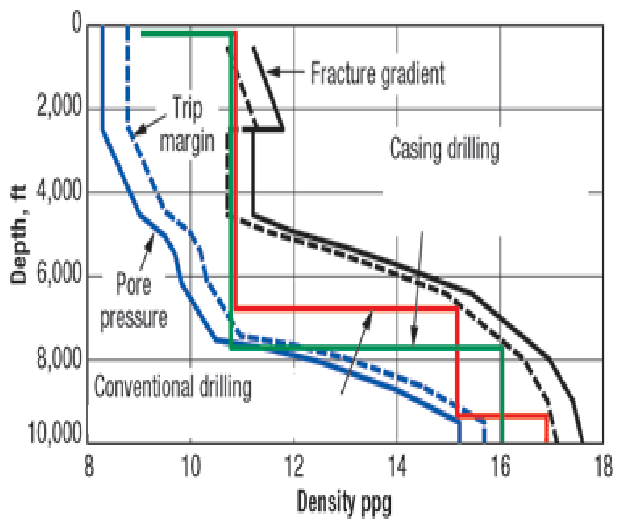

Figure 5. ECD Graph for the conventional drilling and casing drilling in Lobo Field [3]

4. FURTHER DISCUSSIONS AND CONCLUSIONS

The application of casing drilling in the Lobo Field proved to be a more effective and beneficial drilling technique than the conventional method in the areas of cost reduction, personnel safety, elimination of NPT and wellbore problems. The setting of the 7'' casing string at the casing point which was achieved in 10 days with the casing drilling method, took 19 days with the conventional method. This value shows a reduction of about 50% in time for that particular operation which invariably reduced rig cost. Reduced tripping of pipe brought about by casing drilling eliminated NPT. Pipe tripping increased the swab and pressure fluctuations, which contributed to the cause of well control incidents in the Lobo Field. Wellbore problems such as lost circulation was reduced by the smear plaster effect of casing drilling which resulted in the embedded drilled cuttings forming an impermeable cake in the formation. For the few occasions where the casing got stuck prior to reaching the setting depth, the BHA was successfully retrieved, and the casing cemented, allowing drilling activities to continue to the following hole section. The experience in the Lobo Field showed that there is a lower risk of getting the casing stuck during casing drilling than getting the drill string stuck during the conventional drilling.

Furthermore, the depth versus density graph presented in Figure 5 shows that the casing drilling process did not require any trip margin and eliminated the need for a casing string to reach the total depth (TD) unlike the conventional drilling technique. The elimination of the casing in drilling the production zone resulted in savings of about $240,000 [6]. The depth versus density graph in Figure 5 shows the fracture gradient, pore pressure and mud weights for the two different drilling scenarios shown. The casing drilling method provides a better operating window for the mud weight and the fracture pressure, unlike the conventional drilling technique and is thus, more reliable when drilling through areas of thin pressure margins. Finally, the higher annular velocity values for the casing drilling shown in Tables 1 shows that casing drilling provides better hole cleaning than the conventional drilling method.

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