Real Time Hole Cleaning Monitoration

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Abstract. *Hydraulics and hole cleaning are a challenge in Extended Reach well drilling. This article highlights the benefits of the use of real time hole cleaning monitoring tools (pressure while drilling sensors and cuttings flow meters) in an onshore ERW project in Brazil. Time and cost reduction, operational safety and wellbore quality are the main goals.*

Keywords: *ERW, drilling, PWD, horizontal wells.*

1. Introduction

The present article aims to highlight the relevance of real time hole cleaning monitoring information gathered by two different tools: PWD (Pressure While Drilling) and CFM (Cuttings Flow Meter). The analysis refer to two extended reach wells (here called wells A and B) drilled onshore Brazil.

The development of this onshore field is considering challenging regarding drilling hydraulics aspects and represent an important learning step for possible offshore ERW drilling. That was the reason why these scenario was chosen for this study and both services were contracted during the drilling phases of both wells.

Figure 1 illustrates the directional path for well A. Both wells presented similar path design, differing only in extension and in reservoir TVD.

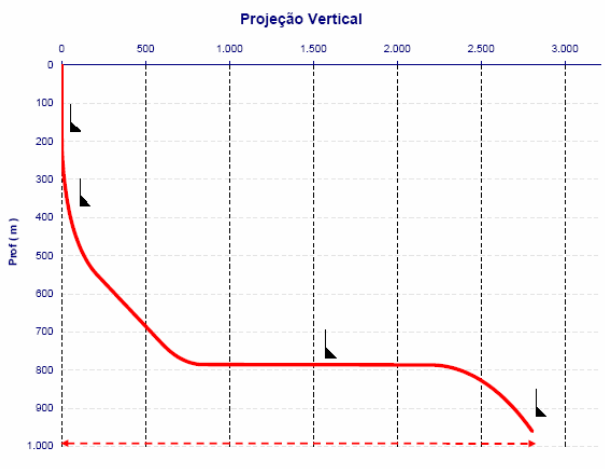

Figure 1. The directional path for well A.

A brief description of both tools follows:

1.1. PWD - Pressure While Drilling

O PWD is a tool which sends to surface, in real time when the pumps are on, downhole annular pressure values. Together with other operational parameters (such as flow rate, pipe rotation, bit rate of penetration internal drillstrig pressure, etc), downhole annulare pressure are valuable information for problem anticipation and remediation. With proper PWD data Interpretation, the operator can save drilling time and reduce costs. Figure 2 illustrastes a PWD tool.

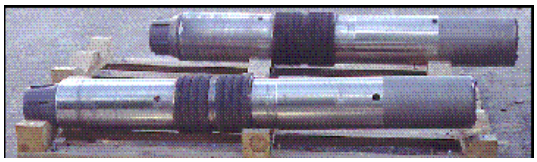

Figure 2. The PWD Tool.

PWD analysis can anticipate and avoid important drilling problems. An abnormal pressure increase can indicate, solids accumulation, which directly affects hydrostatic pressure. Several other indications can be observed, such as:

- Significative increases in downhole pressure while drilling high angle wells may denote cuttings bed formation.
- Abrupt pressure peaks during backreaming operations denote annular pack offs, probably in the Bottom Hole Assembly section of the drillstring.
- Abrupt pressure decrease may denote gas influx.

The use of such tool became routinary in offshore wells in Brazil, while the cost constraints normally restrict its use in onshore wells.

1.2. CFM - Cuttings Flow Meter

O CFM is a tool which aims the collection and quantification of cuttings flow rate which leave the shale shakers. The cuttings are weighted by the CFM devices as illustrated in Fig. 3. CFM operators, determine the fraction of liquid in the samples, aiming the closure of a material balance.

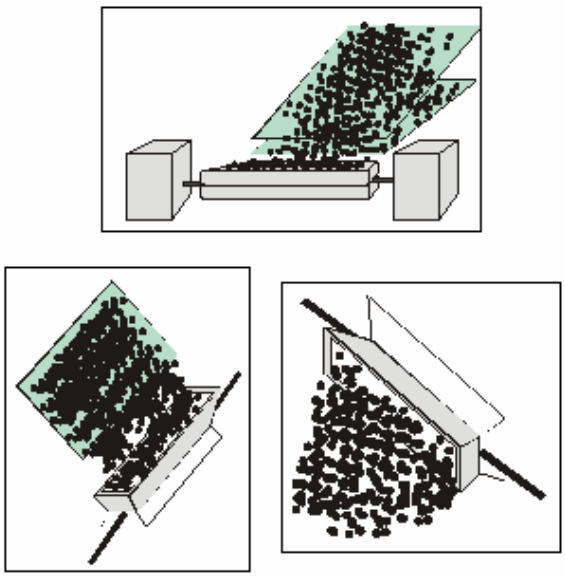

Figure 3. The concept of the CFM.

The result is the dry solids flow rate which leaves the well along the time. The comparison with the theoretical cuttings generation curve allows the estimation of the amount of solids which stay on the well.

There are 3 weak points in the analysis:

- There is an uncertainty associated with differences of measurements
- It is complex to understand where in the well the solids accumulate
- Hole enlargement has an impact on the results

Despite of the limitations, CFM data can give good indications of hole cleaning at attractive costs for onshore applications.

2. ERW Drilling Onshore Brazil

During the drilling of wells A and B, PWD and CFM tools were important information for time optimization. The wells were drilled with short times, if compared to similar wells in the area. Unnecessary backreaming practices were eliminated, resulting in cost reduction.

Historically, trip out operations were performed with backreaming to guarantee eventual cuttings bed removal. Relying on CFM and PWD data, the practice was observed only when the tools indicated its necessity. Both tools provided a clear view of the solids transport process in the wells: Constant annular pressure in both rotating and slide drilling indicated no or small cuttings bed formation (if a relevant cuttings bed was formed, it would be re-suspended with the rotary motion of the drillstring and annular pressure would immediately increase). Normal torque and drag responses also re-inforce the thesis of clean hole. At the same time CFM data indicated good and constant recovery rates. Although in some sections recovery rates were slightly lower this, according to the operators experience, would not justify a backreaming operation.

In some situations, trip out operations started with backreaming and, since CFM and PWD responses indicated no abrupt change, the procedure was considered unnecessary.

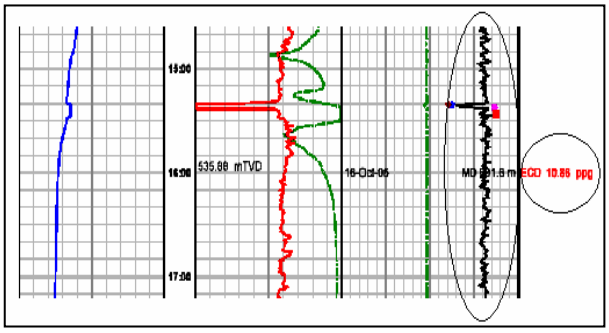

Figure 4. Constant Down hole pressure (circled) while alternating rotary and sliding drilling modes indicate that no cuttings bed was formed.

The Fig. 5 illustrates the CFM responses. The black curve shows the theoretical cuttings volume generated by the bit. The red curve shows the real solids volume recovered in the shale shakers. The slow deviation between the curves denotes slight accumulation.

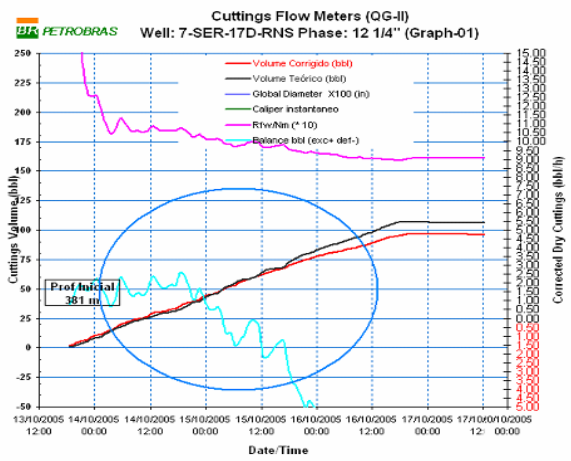

Figure 5.CFM data shows slight solids accumulation.

Since the accumulation rate was small, the operators concluded the hole cleaning conditions were satisfactory. If the tendency to deviation was maintained a hole cleaning problem would be detected, and consequently, different operational procedures would be recommended.

In other situations, both tools indicated the necessity of back reaming. At the end of the 12.25 in phase of well A, for instance, CFM indicated sever solid accumulation. PWD indicated increased in annular pressures when the string was rotated, suggesting the presence of a reasonable cuttings bed. Base on the indications, a backreaming was performed at the end of the phase. During the backreaming trip both tools responded to solids unloading the well.

Figure 6 shows downhole pressures fluctuation when rotation starts.

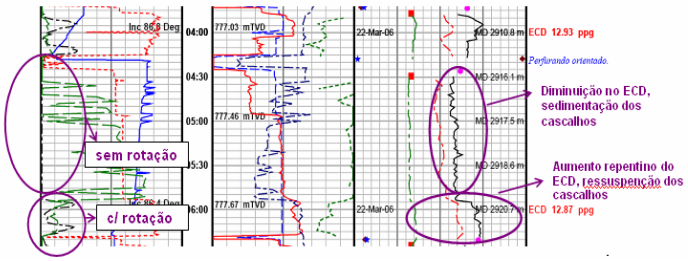

Figure 6. Downhole pressure fluctuations indicate the presence of a cuttings bed.

The end of the 12 ¼ in phase of well b, was also difficult. Excessive drag between drillstring and well walls impeded weight transmission to the bit, resulting in very low rates of penetration, especially in sliding drilling. On the other hand, the sandstone formation did not tolerate long rotative drilling times without loosing inclination. Consequently slide drilling periods occurred frequently and drilling time increased. In order to recover the lost time, high rates of penetration were practiced in the rotating mode. PWD and CFM data supported the decision and part of the delays could be recovered.

The decision of drilling ERWs with large rates of penetrations is risky and could only be performed safety with the real time hole cleaning monitoring support. Figure 7 illustrates CFM data for the phase. Good solids recovery is observed. There are local tendencies to accumulation, immediately reverted in the following period. At the end of the phase, solids recovery was very good, especially due to the very slow slide drilling periods, which enables good hole cleaning. In the final meters of the phase, drilled very fast, the curves tend to separate.

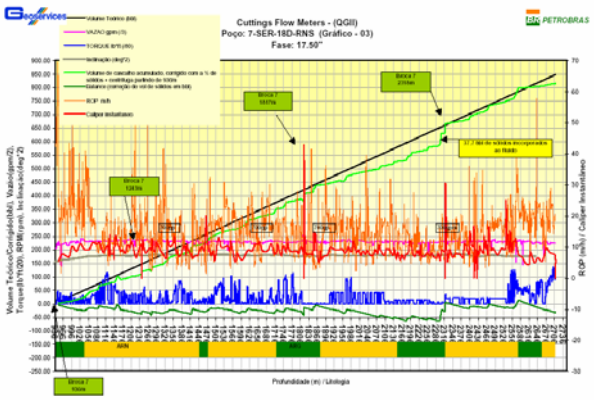

Figure 7. CFM data for the 12 ¼ in phase, well B.

Another important datum provided by the PWD tool is the static pressure during pumps off times. At these moments, annular pressure values reflect only the hydrostatic column, including cuttings loading. These values allow the calculation of solids concentration distribution throughout the well at several moments of the phase. Values larger than the fluid hydrostatics possibly indicate solids accumulation. Solids concentration close to 5% requires hole cleaning procedures.

Figure 8 shows solids concentration variation along the 17 ½ phase of well B. Results are calculated from pumps off PWD data during pipe connections.

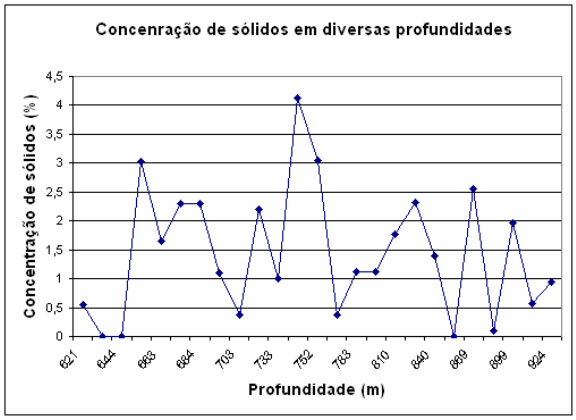

Figure 8. Solids concentration during the 17 ½ in phase of well B.

3. Final remarks

The article details the potential of the PWD and CFM tools to anticipate hole cleaning problems in complex wells. Their use is recommended in critical operations. PWD tools are in current use in offshore drilling while CFM tools may be a cost attractive solution for lower budget onshore projects.

4. References

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