STUCK PIPE PREVENTION IN GEOTHERMAL DRILLING

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ABSTRACT

Stuck pipe is one of the main issues in the geothermal drilling industry mainly due to the nature of geothermal field and this has to be resolved. In this paper, we will be using basic scientific methodology of problem solving to resolve the issue.

Step 1 is to define the problem, which is the stuck-pipe incident in this case. Step 2 is to identify causes. Fundamentally, there are three basic causes of stuck-pipe: wellbore integrity (pack-off), differential sticking, and hole geometry. It is known that stuck-pipe in geothermal well is mostly caused by pack-off. The nature of geothermal field are having subnormal formation pressure and having existing natural fracture. Whenever this subnormal pressure fracture is intersected, partial or lost circulation would occur. Cutting will then build up across the wellbore and ready to pack-off the drill string at any time (stuck-pipe).

Step 3 is to formulate the solution. Several solutions have been initiated by the team. Introduction of aerated drilling to minimize the overbalance between wellbore ECD and formation pressure which will help to cure the lost circulation, Use of UBD Pro software to model the aerated mud while drilling, better solid control system, and casing program optimization. Step 4 is to implement the solution. The team has put continuous effort to implement and monitor the proposed solution during the drilling campaign.

Step 5 is to evaluate the solution. Statistic has shown the number of stuck-pipe incident has decreased significantly from campaign to campaign. During the last 2012/2013 drilling campaign where 15 wells were drilled, number of stuck-pipe incident was very minimum. However, we believe zero incidents are attainable. Therefore, the team is still evaluating and improving.

1. INTRODUCTION

Stuck pipe has been one of the most common and serious geothermal drilling problems and being classified as one of the main difficulties because it happens regularly and lead to the loss of drilling time and money. Besides that, the stuck pipe incident leads to another problem. The biggest problems that commonly occurs as the result of stuck pipe are induced kicks, lost circulation, equipment failure, lost the well and personal injury.

Due to the importance of preventing this problem, it requires the extra efforts to analyze the root cause, make best decisions to formulate strategy to minimize the stuck pipe occurrence and evaluate the strategy.

Scientific approach, systematic process of analyzing, formulating, implementing and evaluating decisions, have been used in Chevron Geothermal to prevent the stuck pipe. Scientific Methodology is consisted of five critical areas that cover how the team define and access the stuck pipe problem, define the root causes of stuck pipe, formulate the strategy to reduce the stuck pipe, implement and execute the coherent strategic plan, evaluate the strategic decision and make corrective adjustments for prevent stuck pipe in the future. The sequence of scientific methodology is essential to decide the appropriate strategy to develop into action and then to be controlled.

This paper presents about stuck pipe during drilling geothermal well with aim of defining problem, identifying the root cause of stuck pipe problem and formulating the strategy for drilling geothermal well using scientific approach. The value of thinking strategically has significant impact on reducing the stuck pipe.

Scientific approach has been applied for reducing stuck pipe during Salak Drilling Campaign 2012-2013 and the result has proven a success of 2012-2013 Salak Drilling Campaign. During the last 2012/2013 drilling campaign where 15 wells were drilled, number of stuck-pipe incident was very minimum. However, it is believed zero incidents are attainable.

Statistic has shown that the reduction of stuck pipe event reach ~84 % compared to the last drilling Campaign, Darajat Drilling Campaign 2008-2009.

2.1 DEFINE THE PROBLEM

The first step of scientific approach is to identify and assess the stuck pipe problem. If the stuck pipe is not clearly and properly defined, it will be more difficult to solve. The stuck pipe problem will leads to another problem such as lost circulation that could lead the blowout, wellbore collapse, equipment failure, personnel injury, lost well which gives enormous financial burden on the final cost of constructing the well. Besides contributing to the high cost of geothermal well, it also affects the geothermal project economics.

The definition of “when” and “how” the pipe becomes stuck will be the main concern in drilling team when dealing with the stuck pipe problems. Stuck pipe occurrences are unplanned incidents requiring extra efforts for drilling team to gather the information and using information resources and knowledge assets strategically to make best strategy and implementation to reduce the stuck pipe. If succeed to define the problem, it will help drilling team in cost reduction for drilling operation (tripping, fishing, etc.), cost reduction for drilling mud due to the lost circulation, minimizing time for drilling a well and minimizing damage of BHA and surface equipment. In this paper, obviously the main problem is stuck pipe incident.

2.2 IDENTIFY CAUSES

The second step is to integrate different perspectives on defining causes of stuck pipe. Identifying and evaluating causes is a must prior to formulate the solutions.

There are three fundamental causes of stuck pipe;*Pack off and/or bridging, differential sticking and wellbore geometry*. These causes are defined as downhole force that is preventing the pipe from being removed from the well.

John Mitchell described those causes as bellow:

1) *Pack-off and bridging* occurs when cuttings, caving, or junk in the well that wedges itself between drill string and wellbore. Most of pack-off or bridge sticking occurs while pulling out of the hole.

2) *Differential sticking* occurs when drill string is forced into the filter cake against permeable formation by differential pressure. The high friction between drill string and formation will make the pipe cannot be moved. Differential sticking occurs after drill string has been static for a length of time

3) *Wellbore Geometry* occurs when there is a conflict between the shape of BHA and the shape of Wellbore. The drill string must be moving up or moving down to become stuck due to a wellbore geometry.

Based on those description, pack-off and bridging tend to be the most serious stuck pipe in drilling geothermal well because based on the analysis and statistic, pack-off and bridging is the most frequent cause of stuck pipe in Chevron Geothermal Indonesia.

Whenever drilling geothermal well, fault of fracture are to be penetrated and typically causes loss of circulation due to

the nature of sub-pressured reservoir geothermal. Cuttings that previously held by the drilling fluid are now falling down. If the cuttings are not removed from the well properly, they settle around drill string and will stuck or pack off BHA. Inadequate hole cleaning contribute to major portion of pack-off stuck pipe. Factors that affect to hole cleaning in vertical wells include mud weight, pipe rotation, ROP, cutting size, fluid rheology, etc.

2.3 FORMULATE THE SOLUTIONS

The third step is generating solutions for reducing the stuck pipe from the cause of stuck pipe. Once the solutions have been identified, a method of evaluating them and selecting the most appropriate one needs to be used to arrive at decisions to reduce the stuck pipe.

After the root cause has been identified in the second step, it is time to formulate solutions to prevent the stuck pipe. Several solutions that drilling team has initiated during Salak Drilling Campaign 2012-2013 were:

- Implementation of aerated drilling
- Improvement in pressure profile modelling.
- Better solid control system
- Casing program optimization

Aerated drilling is now used extensively in many locations. The idea of aerated drilling is to reduce the ECD of fluid system. It is very typical reservoir that has subnormal pressure; when this subnormal pressure is intersected, loss circulation will occur due to high overbalance. Introducing the air into the system will minimize the overbalance and reduce the possibility of lost circulation.

Still related to above, understanding geothermal reservoir pressure and ECD under various mud ratios is the key point for aerated drilling optimization. Drilling team usually uses UBD Pro software and several scientific formulas to make the aerated drilling in Salak Drilling Campaign 2012-2013.

Beside the implementation of aerated drilling, the better solid control acts as the main concern in drilling team. Inadequate solids control leads to other problem such as thick filter cake, high surge, and swab surges, slower drilling, bit and collar balling, equipment wear, lost circulation. All of these problems can contribute to stuck pipe. Adequate solids control equipment specified for the well is important to prevent the stuck pipe.

After the well path is selected, a casing program optimization to reduce the stuck pipe is designed during Salak Drilling Campaign 2012-2013. Drilling team focuses on the casing program through the placing of the casing shoe at the Top of Reservoir (TOR) and selection of liner point. Ensuring the casing is not stuck is the main priority in casing program. This becomes more likely with less annular clearance around the casing. Well bore geometry, cutting beds in high angle holes are the causes for sticking casing.

2.4 IMPLEMENT THE SOLUTIONS

The fourth step is putting the strategy in place and getting the individuals in team to go all out in executing the function part of strategic place successfully to reduce the stuck pipe.

During Salak Drilling Campaign 2012-2013, Air drilling had been utilized during Salak drilling campaign 2012-2013. PWD to measure real time ECD, UBD Pro software to simulate pressure profile under various air mud ratios and several scientific formulas had all been used to support the implementation. Beside of those solutions, drilling team has also do improvement in solid control system and casing program optimization in place.

2.5 EVALUATE THE SOLUTIONS

The last step outlines comprehensive look-back process covering all aspects of reducing stuck pipe compared to the initial plan. The Drilling Geothermal team establishes processes that identify areas where success was achieved, opportunities for improvement exist, how these lessons / best practices shall be incorporated in future well designs/operations. After the evaluation process, the corrective adjustments are desirable. Strategy may need to be modified because it is not working well or because the changing conditions.

During the final step, drilling team try to evaluate the effectiveness of the strategic plan to prevent the stuck pipe in Salak Drilling Campaign 2012-2013. The utilization of aerated drilling in addition to other improvement such as Improvement in pressure profile modelling, better solid control system and casing program optimization in Salak Drilling Campaign 2012-2013 has proven to help maintain circulation despite low pressure zone has been penetrated and this eventually has reduced the number of stuck pipe significantly. It is estimated reduce ~84 % of number of stuck pipe event compared to the last drilling Campaign, Darajat Drilling Campaign 2008-2009.

During the last 2012/2013 drilling campaign where 15 wells were drilled, number of stuck-pipe incident was very minimum. It is believed zero incidents are attainable. Therefore, continuous improvement must always be taken

3. CONCLUSIONS

1) Result has shown that the number of stuck pipe incident has reduced significantly compared to past performance. During Salak drilling campaign 2012-2013, there were only 7 stuck pipe event as compared to incident during Darajat Drilling Campaign year 2008-2009 that were 44 stuck pipe event.
2) Scientific Methodology is consisted of five critical areas that cover how the team define and access the stuck pipe problem, define the root causes of stuck pipe, formulate the strategy to reduce the stuck pipe, implement and execute the coherent strategic plan, evaluate the strategic decision and make corrective adjustments for prevent stuck pipe in the future. It is highly recommended to use the scientific approach and methodology to solve the problem.
3) Further study should be made to better understand pressure profile in geothermal well.

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