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Is It Possible to Ignore Problems Rising During Vertical Drilling? A Review

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Abstract: The drilling process in petroleum industry is directly proportional with economics and if even a small problems encounters on any point during drilling will might results a commercial loss (i.e. economics and time factor). This study is based on the study of all those hindrances/problems often encounters during vertical drilling and ways to combat against those problems. Now, these days although the drilling have been an advanced practice but the problems are still of same nature like (bore-hole instability, loss-circulation, drill pipe sticking, gas cuts in a shallow formation, salt dome, kick and back flow). This study focuses above problems which are not natural but it is due to human error or may be the improper handling of the tool during the operation but these are critical with reference to the time factor and also budgeting is there. So, if these occur then the possible remedial actions in order to save the time factor as well as the economics are kept and handled accordingly. This may involve, the proper design of drilling components regarding given geophysical data of formation, proper usage of drilling fluid to avoid bit balling, formation sloughing, maintaining hydrostatic pressure and proper usage of blow out preventor to control abnormal pressures, so that a good drilling performance will be taken into account by setting up a benchmarking process that is termed to be as "a necessity for survival".

Key words: Drilling parameters, drilling problems, vertical drilling, well planning

INTRODUCTION

Problems associated with the drilling of oil/gas wells are due to the lithology of the subsurface formation that generate disturbance due to stresses around the borehole created by the borehole itself and may be the interaction of the drilling mud with the formation. Earth stresses, together with formation pore pressure, attempt to re-establish previous equilibrium by forcing strata to move to wards the borehole.

Borehole is kept open or stable by maintaining a balance between earth stresses and pore pressure on one side and well bore mud pressure and mud chemical composition on the other side but when this balance is disturbed then well-bore problems may be encountered.

During drilling operation, some bore-hole problems occurs in different sections and those are discussed systematically as formation problems like stuck assemblies, fishing, bit balling and kicks (Fig. 1) (E.van *et al*., 2001; Ola Vestavik *et al*., 2009) When these problems are encountered then drilling process can not be further progressive and large expenditures of time and money are usually required to overcome the problem (Rahil *et al*., 2007).

The drilling problems related to formation are:

- Hole stability (sloughing shales and fractured formations)
- Lost circulations
- Unconsolidated zones/In-competent sections
- Overpressure formations (Kick occurs)
- Blow outs (termed to be as disastrous)

Such type of formation problems occurred are usually referred to as unstable well bores. To control these problems, treatments and controlling methods are necessary and those treatments/methods have been discussed in this study as:

- In-competent formation
- Treatment of lost circulation
- Controlling kick
- Cleaning Well bore

Borehole stability problems: While drilling operation is in progress then the borehole stability is a major concern caused due to type of formations at the targeted depth. Hole instability is not as dangerous as abnormal pressures but nevertheless its slows down drilling process and increase drilling cost as well as the time factor. As, borehole stability during drilling and long term screen integrity is dependent on well azimuth relative to in-situ stress field (Halliburton, 2011).
Following are some formations that cause this problem:

- Unconsolidated formation
- Shales

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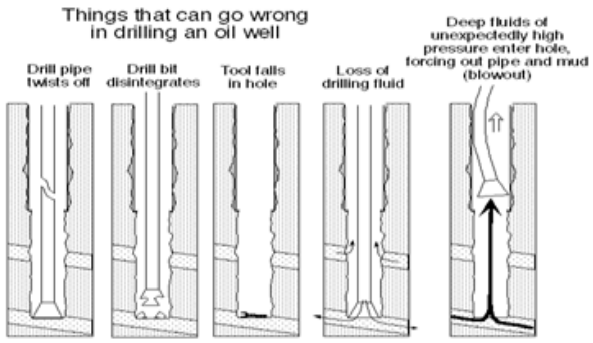

Fig. 1: Some drilling problems, (http://www.gly.uga.edu/railsback/1121PetroleumDrillngBad.jpeg)

When a formation losses its stability then the drilling fluid enters the wall consequently causing:

- Accumulation of caving
- Bridging and filling up the bore hole which necessitate drilling the plugs of carvings to reach the bottom .In its turn drilling the carvings results in bit wear shorter footage per bit slower drilling rate longer rig time

FRACTURED FORMATION

If the formation should fracture near the borehole bottom, the formation fluids must first be circulated out and the fracture zone must then be plugged off. (Giin-Fa *et al*., 2007).

This type of situation is difficult to control. Gas expansion must, therefore be allowed to take place to:

- Reduce the surface casing pressure
- Prevent bursting of casing
- Keep the total bottom borehole pressure below the formation fracturing pressure

One conception of a fracture formation is a large number of different sized blocks stacked together in the formation. When a hole is drilled through a Fractured formation, the lose blocks may fall/cave in the wellbore and this might create a sloughing problem resulting in re-drilling causing loss of time and also the type of drilling mud may be changed depending on the finances/budget at that moment.

Sloughing shales: As shale is a sedimentary rock formed by the deposition and compaction of sediments over period of geological time having the primary composition of clays, silt, water and small quantities of quartz and feldspar. Depending on water content, shale may be high compacted rock or a soft unconsolidated rock, normally described as mud or clay shale. Shale may also exist in a metamorphic form such as slate, phyllite and mica schist.

In oil well drilling, two types of sedimentary shales are normally encountered unconsolidated shale (or clay) and compacted shale and drilling these may results in sloughing or caving of the shale selection. Drillers normally refer to the type instability resulting from drilling shale selection as sloughing shale.

Water sensitive shale formation: Shally earth formations are drilled or otherwise treated with reduced difficulty through the use of water-in-oil invert emulsion fluids wherein the aqueous phases of the emulsions possess particular water vapor pressures relative to the formations which they contact.

The aqueous vapor pressure of an oil-base fluid containing dispersed water is controlled to prevent damage to water-sensitive shale formations by monitoring the vapor pressure of the aqueous phase of the fluid and maintaining a vapor pressure depressant in the aqueous phase in a concentration sufficient to substantially prevent the migration of water from the fluid to the formations. The aqueous vapor pressure of an earth formation is determined.

A method and apparatus are disclosed for determining the compatibility of a well/borehole fluid with a water-sensitive subsurface formation where in a substantially unaltered sample of the formation is immersed in the fluid and the direction and extent of water migration between the well/borehole fluid and the sample are logged.

This method shows that improved water-in-oil invert emulsion fluid compositions for drilling and other oil fields uses are obtained wherein the aqueous phases of the emulsions possess particular water vapor pressures relative to the formations which they contact.

Lost circulation: Lost circulation is defined as the partial or complete loss of drilling fluid during drilling operation while circulating or running casing. When the hydrostatic pressure of mud exceed the breaking strength of the formation which creates cracks along which the fluid will flow. Stress plays the role for the entry of the drilling

Fig. 2: Lost circulation (Halliburton, 2011)

mud/fluid in the formation from both the axis (horizontal as well as the vertical (Fig. 2) (E.van *et al*., 2001).

For lost circulation to occur the size of the pore opening of the induced fractures must be larger than the size of the mud particle and hence it can result in severe well control incidents. (Giin-Fa *et al*., 2007; Bennion *et al*., 1998)

This problem is the most costly mud-related drilling problem because it creates a loss to the rig time but also to the large volumes of expensive drilling fluids in the formation. It can also results in severe well control incidents. (Giin-Fa *et al*., 2007)

Incompetent section (formation): Unconsolidated gravels, conglomerates and bolder frequently occur at shallow depth penetrated by the conductor hole .So, due to the existence of these formation, conductor pipe/casing is planned to run.

Gravel and small conglomerates are relatively easy to drill but some time are very hard to circulate or wash out of the hole, especially if water is being use for the drilling fluid .If gravel is allowed to accumulate on top of the bit, it can stuck the drilling assembly (Rabaa *et al*., 2009).

Kicks: Technically, a kick occurs when formation fluids flow into the borehole. However, in practices there are cases where the formation fluid can flow into the well bore without creating a serious condition such as gas seeps and minor water flows.

These conditions indicate a near balanced or possibly under-balanced condition and often occur in low-permeability formations. The flow of fluid into the well bore usually is restricted by the low permeability and the low pressure differential into the well bore(Bennion *et al*., 1998).

Therefore, a more practical definition of a kick is a condition where formations fluids flow into the well bore at rates detectable at the surface and create a looming blowout condition.

Detecting a kick: The first step in controlling a kick is to detect it either very shortly after it occurs or before a large volume of formation fluid has flowed into the well bore. Prior mud-weight and pore-pressure plots, shale density, drilling rate are such type of data indicating, if the hole is being drilled through formations have an increasing pressure gradient and in this case, the operator/driller should be alert for a pending kick.

Also during the tripping operation, the major indication for the kick is the volume of drilling fluid used to fill the hole in order to replace the space created after removal of steel from the bore hole. (Schubert *et al*., 1998).

The severity of the kick depends mainly on the following:

- Pressure differential between the formation and the hydrostatic pressure caused by the mud column
- Formation permeability
- Amount of formation exposed to the well bore
- Rate and the type of fluid flow into the well bore before the well is shut in (i.e., oil, gas, or water)

This severity is indicated by the Shut-in Drill Pipe pressure (SIDP) and the gain in pit volume.

Blowouts: Blowouts seldom occur but when it occurs, that is because of improper prevention or may be the equipment and operating procedures are not adequate to control the pressure and volume of the formation fluids. There can be many reasons for a blowout but unfortunately most of these are probably caused by a lack of planning and preparation.

A large volume of formation fluid can flow into the well bore before it is detected when the sensors or alarms malfunctions. If this volume is large enough, it can cause a blowout before the well can be shut in. The hoisting equipment fails which is probably of closing the well in with the bag-type preventer which has a lower pressure rating than pipe rams. Therefore, the bag-type preventers have a higher risk of failure leading to a blowout-especially under high-pressure conditions.

The weaker formation at the base of the surface casing can break down and begin to take fluid while circulation out the kick. This can cause an underground blowout.

This dilapidated type of casing can burst while circulation out the kick, casing either an underground blowout or a blowout to the surface.

CONTROLLING (DRILLING PROBLEMS)

In-competent formation: A thick viscous spud mud may be needed to carry the material out of the hole .If gravel is allowed to accumulate on top of the bit .It can stuck the

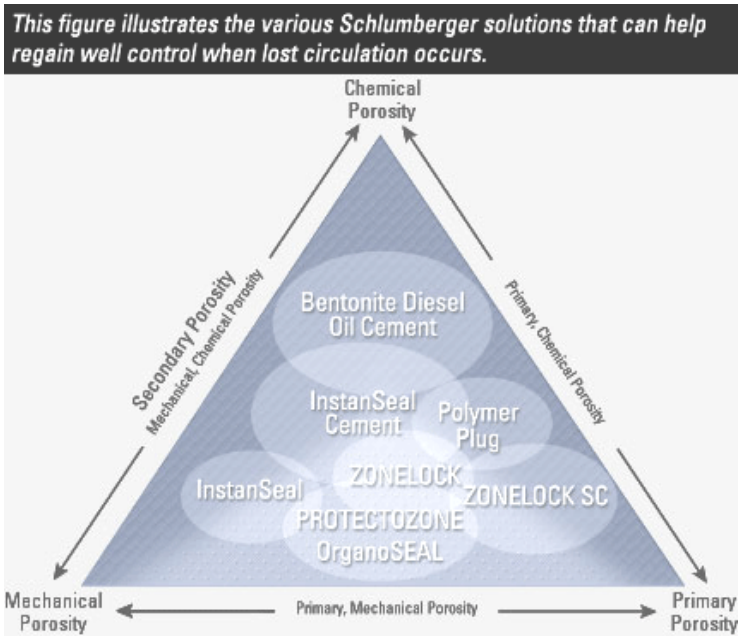

Fig. 3: Treatment of lost circulation (Schlumberger, 2011)

drilled assembly .The normal procedure of drilling gravel and small conglomerates is to drill a short distance into the formation and pick up the drilling assembly until the bit is above the formation. There is reamed back to bottom clean out casing and another short section is drilled.

The assembly is then picked up, and the operation is repeated. It may be necessary to increase the viscosity of the mud to circulate the material out of the hole with high pressure. The reaming, drilling a short distance, pick up, and circulating procedure is repeated until the gravel stop caving and hole remains open or clean.

The gravel will stop caving into the hole when the gravel in to the formation has reached a stabilized angle of repose .It may take some time to be cleaning out before the gravel stop caving.

Treatment of lost circulation: As, the indication of loss circulation/kick is observed by the acoustic sensors/alarms fixed at the mud pit showing the loss/gain in mud pit volume (there is a loss in the volume in case of the lost circulation). (Schubert *et al*., 1998).

Here, prevention of lost circulation is achieved by improving the well bore strength is accomplished by designing and applying Well-Set treatments that increase the hoop stress around the well bore. (Halliburton, 2011).

The goal of Well-Set treatments is to increase the hoop stress (and thus the well bore pressure containment ability) in the near well bore region. This is accomplished by placing a plugging material in an induced fracture that prevents further pressure and fluid transmission to the fracture tip, while at the same time widening and propping the fracture. (Halliburton, 2011).

Chemical lost circulation treatments that form a deformable, viscous and cohesive material (e.g., Flex Plug® sealant) also may have the ability to improve the well bore pressure containment as long as they can increase compressive stress at the fracture face. (Halliburton, 2011).

Some other remedies for lost circulation as recommended by Schlumberger are given as under (Fig. 3); (Schlumberger solutions/treatment for lost circulations, 2011):

- Bentonite diesel oil cement
- Instan seal cement
- Polymer plug

Controlling kick: The operational procedures to close in the well as described for blowout drills are started as soon as the monitors/sensors indicate a kick (Schubert *et al*., 1998). The well should be completely shut in with all personnel at reassigned stations within 60-90 sec after the alarm is sounded.

The kick is controlled by the first closing in the well. Then lighter kick fluids must be circulated out of the hole and replaced the heavier mud. This overbalances the formation pressure and holds the formation fluids in the formation so that drilling operations can be resumed, known as circulating out the kick. Operations must be circulated carefully to contain the pressure used in order to prevent breaking down other formations or causing lost circulation and other problems.

A kick may be indicated by a drilling break, but this does not necessarily occur. For this case assume the hole is being drilled normally and one of the sensors sets off the alarm. The driller immediately shuts off the rotary and starts to pick up the pipe. The pump is shut off while pipe is moving upward. The upper drill pipe rams are closed as soon as the bottom Kelly connection is above the preventer rams. This usually occurs when the Kelly drive bushings are lifted out of the rotary 1-3 ft. In the mean time each crew member goes to his appointed station, and the well is completely shut in 50-sec after the alarm first sounds.

It is significant to note that when the alarm sounds the driller immediately begins pulling the assembly up and lifting die Kelly up the preventer section. He does not question the alarm but immediately starts the procedure to close in the well.

After the pipe has been picked up and the well is shut in, each crewmember looks at the equipment near his area or station to see if there are any leaks. The driller checks and finds that the drill pipe has 500 psi pressure and the annulus or casing pressure is 800-psi. These are recorded on the report as the shut-in drill pipe and casing pressure.

The kick is circulated out of the hole after the mud in the suction pit has been weighted to the correct density. Valves are opened and closed as necessary to connect the annulus to the hydraulically actuated adjustable choke in the choke manifold. The mud pump is started slowly, and the adjustable choke is opened slightly simultaneously. The mud pump speed is gradually increased until the pump is running at one of the slow pump rates selected earlier.

The selection of the pump rate depends on operating conditions, such as the viscosity of the mud, the volume of formation fluids in the annulus, and the type of formation fluid- whether gas, oil or water. One of the most important objectives in circulating out a kick is to maintain sufficient pressure in the well bore so formation fluids are retained in the formation.

The kick may be circulated out in one circulation, but in some cases it may require two circulations under pressure. After the hole has been circulated with heavier mud, the well is effectively dead and the preventers can be opened. At that time the circulation rate is increased to normal.

The drilling assembly is moved and worked as soon as the preventers are opened. If the drilling assembly becomes stuck while circulating out the kick, it is then worked to release it. If this is ineffective, the assembly must be fished out of the hole.

Drilling operations are resumed after the kick has been circulated out, the mud is circulated and conditioned, and the hole is stabilized.

Cleaning well-bore: The main cause of borehole caving is lack of suitable drilling mud. This often occurs in sandy soils where drillers are not using good bentonite or polymer. The problem can be seen when fluid is circulating but cuttings are not being carried-out of the hole. If you continue to push ahead and drill, the bit can become jammed, the hole will collapse when you try to insert the casing or a huge portion of the aquifer may wash-out making it very difficult to complete a good well. The solution is to get some bentonite or polymer or if necessary, assess the suitability of natural clays for use as drill mud.

Borehole caving can also occur if the fluid level in the borehole drops significantly. Therefore, following a loss of circulation or a night time stoppage, slowly re-fill the borehole by circulating drilling fluid through the drill pipe (pouring fluid directly into the borehole may trigger caving). If caving occurs while drilling, check if cuttings are still exiting the well. If they are, stop drilling and circulate drilling fluid for a while.

Sometimes, part of the borehole caves while the casing is being installed, preventing it from being inserted to the full depth of the borehole. When this happens then casing must be pulled out and the well re-drilled with heavier drilling fluid.

CONCLUSION

Following points are taken into account as the best solution of the generalized vertical drilling problems:

- The proper geophysical study with geological suggestions of pre-existing strata near by new concession.
- Follow up of design of well planning before preparation of drilling accessories.
- Proper usage of standardized API tagged casings, drill pipes and drill collars.
- Continuous study of returned drilling cuttings at the surface to avoid gas cuts to know how the sudden litho-logical changes.
- To keep smooth penetration rate, proper usage of drilling fluid is very important parameter to bring the cuttings at the surface.
- To control the formation pressure, ideal BOP's and drilling fluid must be used.

RECOMMENDATIONS

- To avoid differential sticking, it is better to use spiral drill pipes/drill collars which can be helpful in easily rotation and POOH (pull out of hole) operation and the design of spirals should be sharp like a cutting blade.
- While drilling incompetent formations, it may be necessary to increase the viscosity of the drilling fluid/mud to circulate the material out of the hole with high injection/circulating pressure with a back

up of water as driving medium and by this action, the time consumption is less as compared to the injection/circulation of drilling mud alone.

- Caliper log must be run just to be familiar with the borehole condition (e.g., caving, sloughing etc.), so that the proper maintenance would be performed in the mean time.

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