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Investigation of drilling fluid loss and its affecting parameters in one of the Iranian gas fields

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Drilling fluid loss is one of the most important subjects in drilling industry causes the time waste and costs increase. As a result of formation and drilling fluid pressure difference, fracture, formation properties and other factors this loss is occurred. Different ways, such as mud weight loss, reducing the flow rate into formation, using the controller loss materials and cement plug are used to avoid this problem. In order to access gas resources of Dahram group. During drilling in the Asmari and Jahrum formation in section 24" in field "A" we encounter the connected numerous sections and fractures. Drilling mud loss is developed due to low fluid pressure of fluids within the pores in comparison with drilling fluid. The mud loss occurs due to several reasons, some of them are geological and the others are drilling factors. For this reason, the study tries to investigate the loss reasons, determination of the areas and given solutions using the daily drilling reports, mud, geology and mud logging report to solve the problem. Drilling optimal parameters and drilling fluid application program for cleaning section 24 are suggested through our aim of loss control.

Keywords: Formation, Drilling fluid, Drilling optimal parameters, Fracture, Fluid Loss.

INTRODUCTION

Drilling fluid loss problem has been evident since the first time of being to drill oil and gas wells. This issue becomes serious when drilling deeper or drained wells were placed on the agenda. Oil companies spent millions of dollars to solve the problems such as stuck pipe, lost rig time, Blowout, the loss of large volumes of drilling fluid and the formation damage caused by loss. Stuck drill string during loss, because of the pressure difference between mud and formation the pipes stuck the in the well. Fishing operation should be done costly to solve this problem. Damage to the layers in many cases, after the well tests indicates that as a result of partial or total loss mud, especially in fractured reservoir, intensity damage to high-permeability production formations. Mud loss can transfer the fine particles into the pores and reduce the permeability of the formation near the well. In addition, the filtration may cause a chemical reaction between the mud and the reservoir fluid compositions through sediment reduce the permeability of the reservoir around the well. To eliminate this problem formation acidizing and stimulation operations have to be performed costly [1,2].

Waste drilling fluid or cement grout in void spaces during drilling operations is called loss. in the industry loss is classified as leakage (less than bbl / hr 10), mild (bbl / hr 10-100), intense (bbl / hr 100-500) and complete (more than bbl / hr 500) [3]. It should be noted that the mud volume reduction from the total volume because of the extraction diminish and filling the new well, is quite different from the loss [4]. Loss is different in type, severity and location of the well. Knowing the type and location loss help to choice the control materials of loss. Loss location is determined by using information from previous drilling, formation changes and different techniques of mud logging report [5]. A systematic approach is known to control loss economically and effectively. This includes both the prevention and treatment [6].

Many parameters may affect the intensity of drilling fluid loss. The fracture pressure gradient of formation, drilling fluid properties, petrology and the type of drilling formation, the existence of fractures and caves in formation, drilling parameters such as pressure and flow rate of the pump and the known and unknown parameters made the anticipation of the amount of fluid loss during drilling of wells in a particular formation, problematic [1,7].

In all of the drilling wells in field "A", loss occurred and caused the waste time so that after the waste time for waiting and remaining the most wasted time dues to loss. And the waste time for the improvement and further drilling some time is more than the section time. During Asmari and Jahrom drilling in section 24" of the field "A" in order to achieve gas resources of Dehram group, we see multiple fractures and joined cavities.

In comparison with the drilling fluid, as a result of low fluid pressure of vein inside the sections, drilling mud loss occurred in this formation. As a section the mud loss occurs due to several reasons,

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some of them are geological and the others are drilling causes. so this study investigates the drilling causes and determination drilling areas and the ways to solve this problem in section 24 at field "A".

DESCRIPTION OF ISSUE

Field "A" placed in the northern part of the Persian Gulf. This field is the largest known gas field with estimated reserves of 14 trillion cubic meters (8% of the world's proven reserves of natural gas) and 17 billion barrels of natural gas liquids and 5 billion barrels of condensate, which is followed by the line in Qatar, called North Field. Development of field "A" is divided into several areas of development or planed phases. A total of 24 phases, between 1990 and 1992 a total of 4 exploratory and descriptive wells were drilled in the main phase. This field is geology placed on the bulging bow which is always higher than the surrounding areas. Therefore sediments residual speed on it is less than the surrounding areas, so the sediment thickness of various layers of the geological periods on the scale with the surrounding is less.

The hydrocarbon field was formed in the Permian and Triassic period and includes Dalan and Kangan formation. The highest point of the reservoir is approximately at a depth of 3,800 meters above sea level. Reservoir thickness is approximately 400 meters.

The Fars group formation such as Asemary and Jahrom exist in this section. Jahrom sediment cycle,after upper certaceous series movements in the early Tertiary, the Zagros was covered with a progressive Sea. Sachun formation in coastal areas, carbonate formation in shallow areas and pabdeh shale formation in deep areas were deposited. Asmari cycle in late Eocene-oligocene, northeast of Lorestan and internal platform of Fars remained out of the water but Fars and Khuzestan, deep sedimentary Pabdeh formation continued. At the end of the Oligocene as a result of slow and limited progress of the sea, the small Asmari cycle, chatian age, was formed.

In oligocene-miocene boundary, in the areas of Ahwaz, sandstone was deposited as Ahvaz sandstone from Asmari formation. The lower limit of Jahrom formation in sample section is harmonically placed on silt and dolomite of sachun formation. Jahrom formation is placed above the Ilam formation in the field "A" Existence of Glakonit at the end of Jahrom formation shows this boundary. According to the study [8] the formation's age in two section around Shiraz related to Paleocene to Middle Eocene. Upper boundary of Jahrom formation with Asmari formation is erosive discontinuity so that in the cutting sample of the boundary there are limestone and conglomerate with irregular layered iron compounds. But in the field, Asmari and Jahrom are considered together but empirically the border is placed at the change location of limestone to dolomite and dolomitic [9].

METHODOLOGY

Development of field "A" is divided into several areas of development areas or planned phase that drilling wells in phases 13, 22 and 24 were studied.in phase 13 there were 4 places and in total 48 wells were drilled, in phase 22 there was and 11 drilling wells and in phase 24 there were 2 places and 20 wells were drilled. In this study, the daily reports of daily drilling, geological and mud logging of wells in the section 24" , following the analysis of the loss reasons, determination of the loss areas and provide solution to prevent it. We aim to control loss, give the optimal drilling parameters and the best drilling program for section 24" to increase the speed for drilling, give the best applied program of drilling fluid and reduce costs.

Drilling in the section24"

After placing the casing 32" at the depth of 172 meters, the section 24" was drilled by insert bit size 24. Drilling the section was done by sea water and pumping cells with high viscosity to clean the section. Drilling in the Fars group is slow due to the pre predominant lithology of the marl and marl sticky. But drilling in Asmari formation has higher speed because of the lithology of calcic - dolomite and at Jahrom formation drilling is slow and done with a special program, due to falling Dolomites and the possibility of mud loss, the stuck pipe and the closed well wall. These programs are used to control the weight on bit, maximize the mud pump with Hi-Vis pumping and lubricants with pumping loss controller materials. after arrival in Ilam Formation drilling was continued for about 30 meters and casing shoe of5/8 18 " was placed in this formation and cementing operations were done based on plan.

Loss in the section 24"

At first using the daily drilling reports, mud drilling and geological drilling wells, all drilling parameters and mud properties were extracted and through the mud logging reports, affecting parameters on the loss size were noted and they have been set as table. The diagram related to the amount of loss and the influencing loss factors to the depth was plotted and the results were adapted with the lithological data. Accordingly the Asmari-Jahrom formation is created by two mainly parameter: lithology and drilling parameters.

Effect of the drilling parameters on the fluid loss

In this section, through study the daily drilling reports and logging of well drilling parameters such

as WOB, ROP, RPM, Flow in and mud weight was extracted and shown in Figure 1 and 2. These parameters versus depth were plotted by Excel in cross plots and the results were compared and discussed. Many drilling factors can increase or decrease the loss of drilling such as WOB, ROP, RPM, Flow in. if the effect of these factors on loss is known, it is easy to control and prevent the occurrence of severe loss. Based on diagram some of these parameters have direct relation with the mud loss and some of them are inverse. For example, if these parameters in A and B wells are compared with the diagram, in both well there will be four loss zones, each of these zones show different factors, including lithological and digenetic factors and drilling parameters. This means that in some of these zones, lithological factors are determining factors and the others intensify the loss degree or vice versa. these four zones are

Zone A'A

This zone started from a depth of about 780 meters and continued to 620 meters, in this zone the amount of loss is insignificant due to not very porous lithology, and the drilling parameters determine the loss degree. In this area lithology related to the dolomitic limestone with anhydrite cement that layers of anhydrite and limestone, argillite can be found among them. As shown in the diagram, the loss degree is below of 50 barrels and drilling parameters such as WOB have an important effect on this section. So the parameter of bit weight must be controlled in this zone because if it is higher than conventional degree, the formation will be broken and cause the complete loss.

Zone B'B

This zone started at the depth of 780 meters and continued to a depth of about 900 meters, the diagrams show that the maximum loss occurred in this depth, and the zones are known as loss zone. Based on the obtained samples in this section and analysis of their lithology we realized that this zone includes some algae and coral reefs that are highly porous. If drilling parameters especially the speed and weight on the bit is not controlled and set out the plan in this depth, enormous costs may be included in addition to many hours of rig time is wasted. Using Draw plots in this zone, it is indicated that the drilling parameters are controlled For example, the drilling rate, weight on bit , and rotation of the drill pipe one minute decreased and flow in increased due to the more mud pumps for cleaning wells. This factor could slightly increase the loss degree.

Zone C'C

This zone started from a depth of about 900 meters and continued to a depth of 1060 meters. In this zone the loss degree is less than 250 barrels. In this zone the loss degree is variable and is a function of lithology and drilling parameters. In areas where the loss degree is high the section porosity figures, fissure porosity and inter granular porosity due to the conversion of calcite to dolomite can be seen. However, in this zone increase the weight on the bit and drill speed make the high loss degree.

Zone D´D

This zone started at a depth of about 1060 meters and continued to a depth of 1150 meters. In this zone sometimes the loss degree reached 400 barrels per hour. As a result of increased amount of anhydrite cement, like the previous zone is not porous, but sugar grained porous dolomite figures help to increase porosity. In this zone More drilling parameters have a significant role to intensify the loss.

Proposed drilling fluid plan and well cleaning in the section 24"

According to the definition 4 the loss area in Asmari and Jahrom and the daily drilling reports of the major oil companies in the other field "A" phases to drill this section, drilling fluid and cleaning plan as well as follows.

Sea water and well cleaning through cells with high viscosity

The seawater is used as the main and cleaning fluid through the cells with high viscosity concerning the areas and the lithology according to the following plan. Since the diameter of the section was large, rubble evacuation and dug wells with high speed combined mechanism and scanning with high viscosity were occurred. Viscous scanning composed of xanthan gum and a pre-hydrated gel .analyze offset well indicates that the main problem of loss is on the bottom of the section so the hydrostatic pressure drop occurred within the well. This hydrostatic pressure drop leads to break the mouth of the well, poor well cleaning, stuck pipe and the close well wall. in order to minimize these problems ,the well should be cleaned at the depth of 780 to 172 meters in which the formation of the Fars and A'A Asmari and Jahrom zone existed. In drilling of 9 meters scan of cell 30 barrel with high viscosity should be pumped to clean wells. At every 14 meters of drilling scanning of pre-hydrated gel should be pumped to clean the walls of the well. At the end

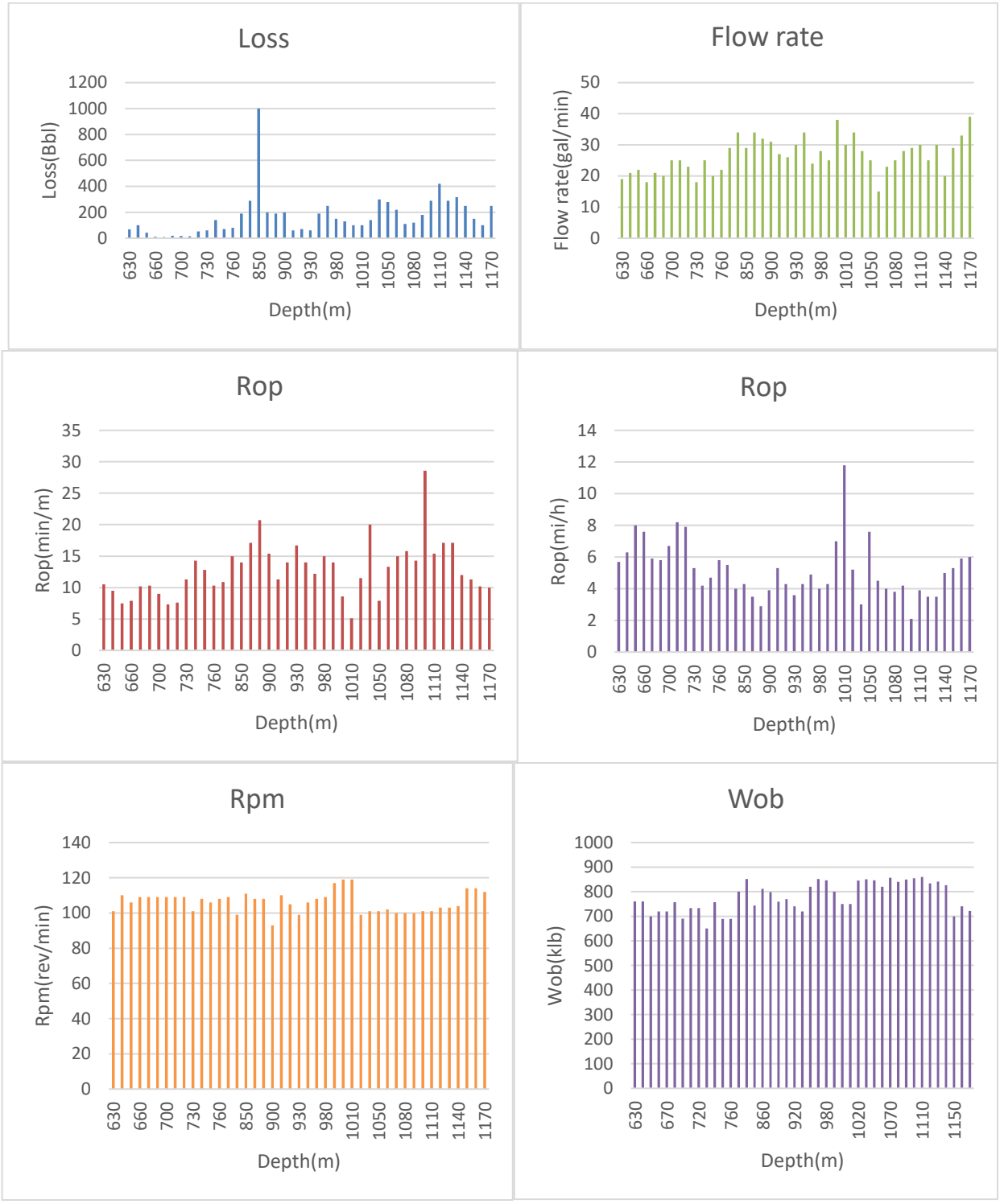

Fig. 1. The effect of different parameters of the depth on drilling in wells A.

stand of the drill pipe with high viscosity was pumped in 30 barrels and the mud was circulated for 5 minutes. Then 40 barrels of pre-hydrated gel were pumped and mud was recirculated for 15 minutes. The drilled distance back reamed and reamed down at the flow rate of 700 gallons per minute with the drill pipe rotation rate of 30 rpm and at the bottom of the well, 30 barrels of pre-hydrated gel were pumped and when the it exited from bit the flow rate stopped and the new stands were prepared and drilling continued. At a depth of 780 meters the well cleaning way should be changed. Based on the depth of about 780 meters to a depth of about 900 meters of B'B zone and according to the results, this zone is made of some algae and coral reefs that are highly porous that is the main reason of the loss. But based on the current situation there are two methods to control or minimize the loss. The controlled drilling

Parameters are used according to the cleaning following plan. Otherwise if the full loss is occurred the cement plug will be placed and then the cement and the formation is drilling. it leads to control the loss. C'C zone started from a depth of about 900 meters and continued to a depth of 1060 meters. In this zone the loss degree is variable and as a function of geology and drilling parameters. The loss was

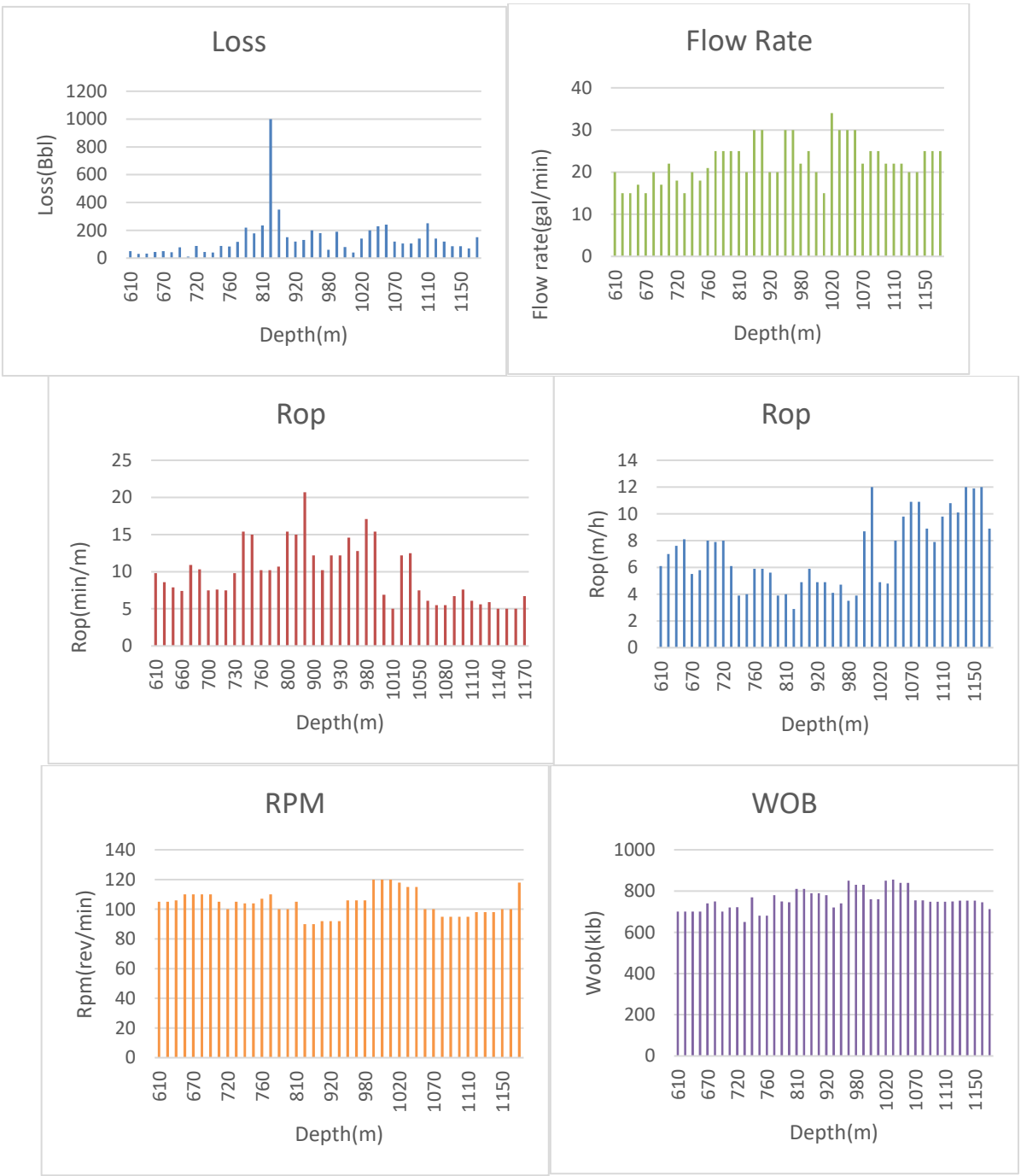

Fig. 2. The effect of different parameters of the depth on drilling in wells B.

prevented by controlling the drilling speed. D'D zone started from a depth of about 1060 meters and continued to a depth of 1150 meters. This zone like the previous zone was not porous due to the increased amount of anhydrite cement, but sugar grained dolomite figures increased porosity. In this zone, the drilling parameters intensify the loss degree.it can be reduced by controlling the drilling speed. From a depth of 780 to 1150 meters the cleaning program was at every 5 meters of drilling wells in which scanning of cell of 30 barrels with high viscosity was pumped to clean wells.

In each 9 meters of drilling of the hydrated gel scanning was pumped to clean the walls of the well .At the end the stand drilling pipe of 40 barrels with high viscosity was pumped. Then the mud circulated for 10 minutes and then50 barrel of pre-hydrated gel were pumped. The mud re-circulated for 20 minutes

to of the flowers have become. The drilled distance back reamed and reamed down at the flow rate of 800 gallons per minute with the drill pipe rotation rate of 30 rpm and at the bottom of the well, 30 barrels of pre-hydrated gel were pumped and when it exited from bit the flow rate stopped and the new stands were prepared and drilling continued. The maximum level of 2000 ppm hydrogen sulfide has been recorded in offset wells. To protect the drill pipes, CONQOR 202B should be used as a protective element, which used as a Slough spray while raising the pipes. The Table 1 shows the optimal properties of section mud.

Yield point, of a pre-hydrated gel should be kept between 25-18 to prevent the close of the wells that can be caused by the additional accumulation of particles around the BH.

Table 1: Properties of section mud.

pH	Funnel viscosity (sec/qt)	Mud Wt. (ppg)	Depth TVD (m)	Mud System
7	26	6.8	1150	Sea water
5.10-10	<120	6.8	1150	PHG Sweeps
6-8	<100	6.8	1150	Polymer Sweeps(Hi-Vis)

The use of bentonite based mud

This mud is an appropriate chance to prevent the rise of hydrogen sulfide is a good option But due to the fact that excessive weight gain goal, regardless of lithology feature will be off Due to the large volume of drilling sections in the mud weight increased the loss. Because of the costly drilling fluid and the complete loss at second zone is generally this way is not used.

RESULTS

According to the above statement, section 24 started at the depth of 172 meters after cement drilling of section 32 starts and continued to 1150 meters which is the Fars formation. This formation was made of limestone, marl and clay limestone. The loss did not occur in this formation and its drilling rate was proper and the drilling can be occurred with no problem at the rate of 25 -15 m. But it should be noted that because of clay limestone and the use of the seawater as a drilling fluid, the formation was swollen, that makes the closed walls. So no time should be given to wells and drilling was done as soon as possible to prevent the walls tight hole. Usually at a depth of 620 meters we entered into Asmari and Jahrom formations which most problems of drilling occurred in this part of field "A" gas. Most oil companies drill the Fars and Jahrom formation without using engine to avoid waste and saving the possible cost. Accordingly, four zones of loss were defined. Each of them was affected by one of the loss factors such as Lithological and digenetic and drilling parameters. Many factors increased or decreased the loss which can be defined as dependent or independent parameters. The weight on the bit, flow in and the pipe rotation in minute are the dependent parameters and the rate of drilling and the output pressure pump were defined as independent parameters. It should be noted that the dependent parameters were the function of the weight on the drill and the flow. So zone A'A started at a depth of 620 meters and continued about 780 meters .In this zone, the loss degree was insignificant due to the lithology and more drilling parameters determined the loss degree. So the drilling rate was at 8-6 meters per hour and weight on bit should be corresponding to the drilling rate, flow in was 800 gallons per minute and drilling pipe rotation in a minute was determined based on BHA. If the engine was used in well the rotation would be rpm 40 and otherwise 110-90 rpm. B'B zone started at a depth of 780 meters and continued to 900 meters, the maximum loss degree was occurred in this depth so this zone is known as the loss zone. This zone includes some algae and coral reefs that are highly porous the drilling speed was 6.4 meters per hour. The corresponding weight on bit with the speed drilling should be controlled. If this action was done out of the determined depth, there would be the enormous costs. It should be noted that the rate of flow in about 800 gallons per minute was suitable. If the flow rate became low, the well cleaning was not done properly that could stick pipe. C'C zone started from a depth of about 900 meters and continued to a depth of 1060 meters. The loss degree was variable and as a function of geology and drilling parameters in this zone. In areas where the loss degree is high, the section porosity figures, fissure porosity and inter granular porosity due to the conversion of calcite to dolomite can be seen. However, in this zone the increase weight on the bit and the high drilling speed increased the loss degree. The drilling must be controlled at the drilling rate of 7-5 meters per hour and the weight on the bit was corresponding with the drilling speed and flow in of 850 gallons per minute that would be the ideal. Zone D'D started at a depth of about 1060 meters and continued to 1150 meters. Sugar grained Dolomite figures increase the porosity. The drilling parameters in the

zone intensified the loss degree. The most loss was occurred due to lithology type.

Two proposed programs are given for the main drilling fluid and cleaning wells. The justifiable use of sea water as the main fluid and cleaning programs are offered which is the best choice to reduce the cost and increase the drilling speed.

CONCLUSION

According to the division of the loss areas and its selection and optimization of drilling parameters in each section and the application of the proposed mud plan and cleaning wells can be expressed as the following results:

1. Comparison the affected drilling parameters at wells A and B with the related diagram of the loss degree in section "24, show that there are four zones, each zone indicates the factors such as lithological and digenetic factors and drilling parameters. This means that in some of these zones, lithological factor and other factors are determining factors and the others intensified the loss degree or vice versa.

2. Many factors can increase or decrease the loss that the most important include the weight on bit, drilling speed, drill pipe rotation in one minute, flow in and the mud weight. Through study the effect of these factors on the loss can be easily to control the loss due to the influence of various parameters or even prevent the occurrence of acute loss.

3. Drilling parameters can reduce or increase the loss which is defined as the dependent and independent parameter. The drill pipe rotation in one minute as independent parameters and the rate of drilling and output pump pressure are defined as the independent parameters. Note that the dependent parameters are the function of the weight of the drill and the flow in.

4. The optimal method to fluid loss control is the application of controlled drilling parameters of weight on bit, flow in and drilling speed.

5. The loss control indicates the logical consequence with the pump pressure. So based on the specific areas the increased and decreased flow in should be controlled. The cleaning wells should be considered to prevent the possible problems.

6. According to two proposed drilling fluid plan, using sea water as the main fluid and cleaning wells in different geological zones the best choice to manage the loss and drilling speed is proper.

7. Since increasing the mud weight is one of the reasons to occur the loss, the use of the Betonite based mud due to the higher weight than the sea water and increased weigh during drilling due to high volume of cuttings and its high cost, this type of fluid is not recommended.

8. The pre-hydrated gel with high viscosity is used to clean the well it is the best choice to clean wells.

9. There is an inverse relation between the loss degree and fracture pressure. If the pressure of the fracture is low the loss degree will be high.

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