Examining the effects of different types of drilling fluid additives on preventing fluid-loss and selecting the appropriate fluid to maximize productivity and enhance its quality

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Abstract

Drilling mud is an important fluid in drilling operations and is directly related to drilling problems. If the drilling mud does not have the proper properties, it would be difficult to drill in the drilling operation. Thus, the need to use fluids limiting operational problems, and improving drilling and saving time and money is clearly felt. Moreover, today the phenomenon of fluid-loss of drilling into cracked formations has become a major challenge for the drilling industry. Heavy costs such as loss of drilling time, excessive consumption of materials, unprofessional control techniques and low productivity are of the problems needed to cope with this problem. The study type is applied and descriptive-analytic regarding research method conducted in case study design. Data collection method is documentation and library study. The study first explained the types of drilling mud and its additives and its impact on drilling quality. Then, it was concluded that knowing the type of drilling fluid and its additives and its choice to reduce the cost of drilling and increase the efficiency have a great impact on the drilling quality. Moreover, the effect of polymer additives, nanocomposites and industrial powders on the reduction of loss was investigated showing that the addition of nanocomposites and polymeric materials reduces the thickness of sludging and fluid loss and also increases the viscosity of drilling mud and can be very effective in increasing productivity and reducing costs.

Keywords

Drilling mud, loss, pumice, productivity, polymer additives, nanocomposites

Introduction

The main task of drilling mud is to carry drill leftovers to wellhead. One of the main duties of this fluid is to create a float for the equipment and tools inside the well so that by floating the components reduce the weight of them, so the pressure on the drill strings is greatly reduced. With the advancement of the oil industry, drilling fluids have changed their primitive form and carry out more and more tasks. Among the drilling fluid roles today, the cleaning of the bottom of the well and the carving of rock digs to the surface of the earth, cooling and lubrication of drilling tools such as drill and drill pipes, maintaining the well and creating an unutilized floor penetrating the walls, preventing the entry of pressured floors into the well, preventing the deposition of rock and aggregates, the weight of the drilling mud (when the drilling bit is still standing) and many other things [1-2].

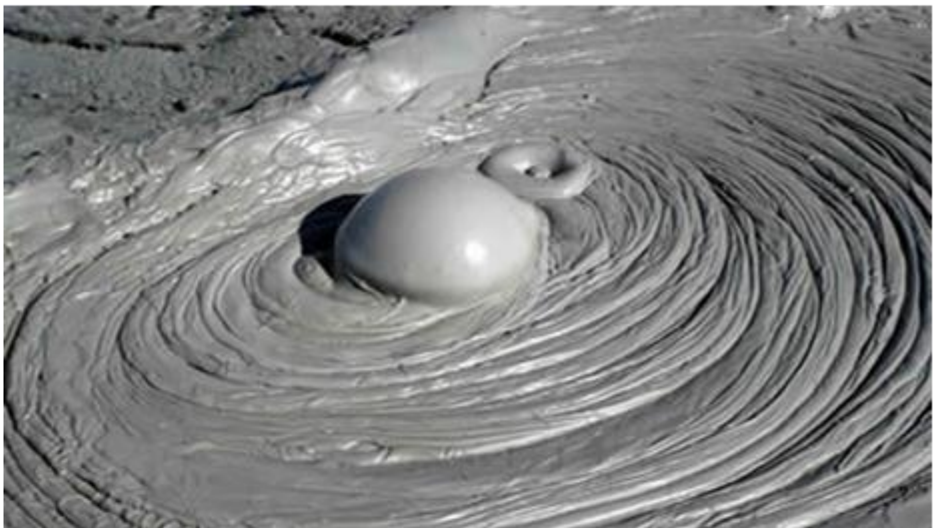

Figure 1: An example of drilling mud

Drilling mud is considered a major flood in drilling operations with direct effects on drilling problems. If the drilling mud does not have the proper properties, it would be difficult to drill in the drilling operation. Thus, the need to use fluids that limit operational problems, improve drilling and save time and money is clearly felt.

2. Drilling fluid

The drilling fluid refers to gas, liquid, or mud that flows in the drilling system. Drilling fluids, which are mainly used to create safety, increase efficiency, efficiency and increase economic efficiency in drilling, especially drilling of oil and gas wells, are generally divided into three groups of gases, fluids and drilling mud. Each type of drilling fluid has advantages and disadvantages, so selecting the best and most efficient drilling fluid depends on several factors. For selecting the best and most suitable drilling fluid, one can identify all effective factors and score each of them according to a scoring system, and finally, based on the sum of scores obtained from the effects of different factors select the fluid with the highest score as the most suitable drilling fluid. The factors affecting drilling operations include the type and method of drilling, the type and type of rock layers, transportation, cost, and the environmental impact [3].

3. Loss

The loss of drilling mud or cement slurry in empty spaces inside the formation during the drilling operations is called loss [4]. The problem of mud loss has been evident since the beginning of drilling operations for oil and gas wells. This problem became more serious when digging deeper or depleted wells was put on the agenda [5]. Oil companies spend billions of dollars annually on solving loss

problem. Problems such as pipes clogging, loss of tower time, eruption of wells, loss of large amount of drilling mud and damage to the formation are caused by loss [6]. During the loss, due to the difference in pressure between the mud and the formation, the tubes may get stuck in the well. To solve this problem, costly maintenance operations must be carried out. The results of well-testing in split reservoirs show that in wells with partial or total flood loss, severe damage has been incurred to the production formations [4]. Mud loss can cause the transfer of fine particles into pores and reduce the permeability of the area around the well. Moreover, filtering of mud may cause chemical reaction of the mud with the reservoir fluid compounds and reduce the permeability of the reservoir around the well with the formation of sediment. In order to overcome this problem, it is necessary to stimulate costly operations and acidification [7-8].
Loss in the drilling industry is divided into four types: leakage less than (10 bbl / hr), full (over 100-500 bbl / hr), severe (10-100 bbl / hr) and partial (500 bbl / hr) [4]. It should be noted that reduction in the volume of mud from the total volume due to the reduction of the mud extract and the filling of the new well is quite different from that of loss [9]. The variability in the type, intensity, and location of occurrence in the well is different. Knowing the type and place of loss helps choose the right material for controlling losss. The location of loss is determined by using the wells adjacent to the drilling information, the fabrication changes, and the various methods of charting [10]. A systematic approach is known for economic and effective control of the effects of loss (including both prevention and treatment) [11]. Various variables such as fracture pressure gradient, characteristics of drilling mud, lithology and type of the excavation, the existence of gaps and caves in the formation, drilling variables, such as pressure and pump rates, and many known and unknown variables that make predicting the amount of mud loss difficult [12] affect excavation-mud loss severity.

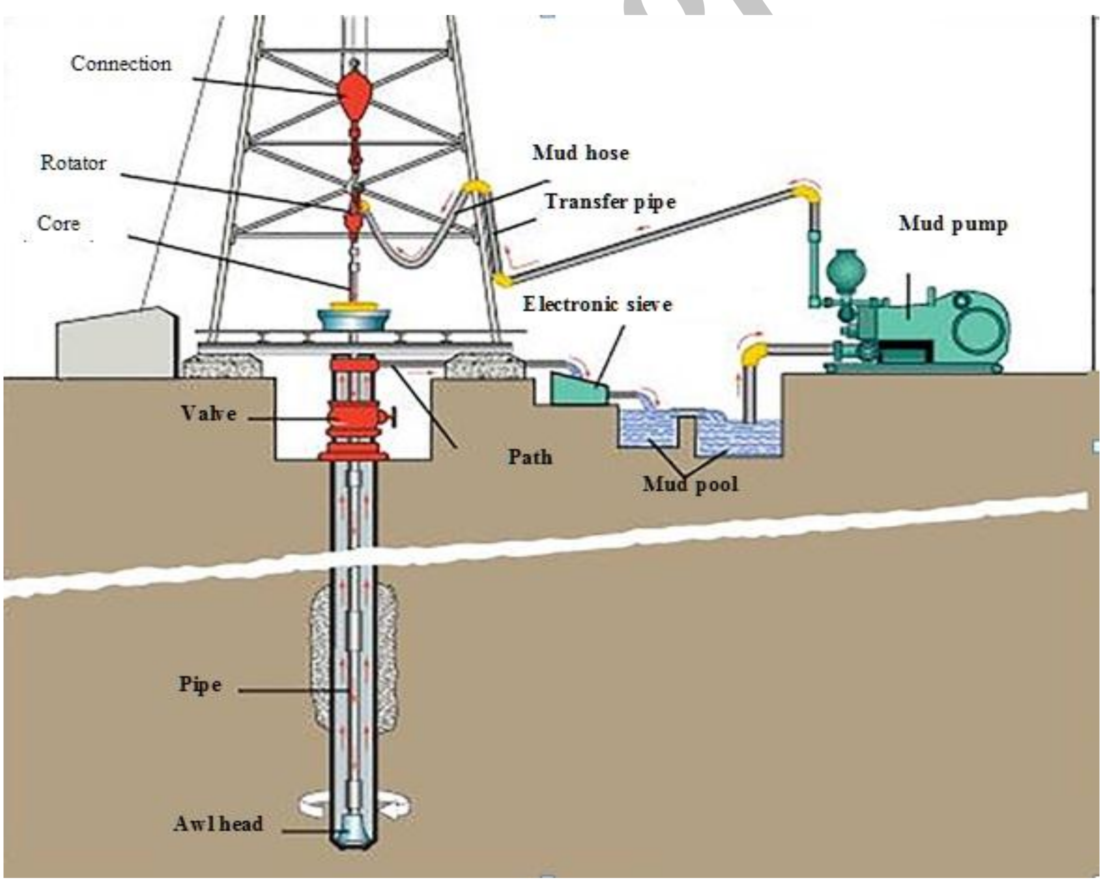

Figure 2: An example of a drilling mud pump

4. Impact of shale instability on drilling mud

Due to their specific characteristics, shales cause many problems during drilling operations. Some mechanical factors such as drilling mud pressure, thermal stresses, movement of the drilling string (hitting and suction), or the plastic movement of shale and chemical agents such as aquatic absorption or aquatic repellency can cause the shale to be shaped or destroyed leading to problems in drilling operations [13].

Instability of open pore, increase of torque and friction in drilling, loss of mud, increase of mud solids, well expansion, poor cementation, drainage of the well, or sticking of the drilling field are the results of instability of shales. The total of the above points leads to waste of time and costs in the drilling industry[14].

Methods of solving these problems include mechanical methods such as increasing the weight of the mud or chipping the well walls or using chemical methods such as the use of inhibiting drilling fluids. As clay minerals are the main components of sedimentary rocks on the surface of the earth, any drilling operations will inevitably lead to problems with them. Thus, recognizing the proper characteristics and features of clay minerals as well as shale formations that are the cause of these problems and providing the appropriate solutions to remove them from the needs of any successful drilling operations. Many studies have been conducting to identify and resolve the problems associated with shales, et a complete solution has not yet been provided. Oil-base drilling fluids have been the best choice for drilling in shale formations, but efforts are made to replace them with a hydrostatic fluid, given their high costs and environmental issues. So far, special additives have been used in aquatic-based drilling fluids to stabilize sensitive formations such as salts, polymers, asphaltenes, gilsonites, graphites, silicates and glycols [15].

5. Types of drilling muds

In a division, one can divide the types of drill muds into four general categories: [16]

5.1. Oily muds (base of oil compounds)

The main components of these drilling muds are hydrocarbons, especially those with a high ignition point in which solid particles are suspended. These muds are mostly used for sandstones because they cause less damage to sandstone. In drilling inside shales, due to the high hydrostatic pressure inside the pore, this type of mud is used less due to specific gravity.

5.2. Aquatic-based emulsion muds

In these drilling muds, usually hydrocarbons are dispensed into the aquatic as droplets, which normally contain 10 to 15% of the drilling volume and, if necessary, it reaches 50%. Adding hydrocarbons (especially gas oil) increases the polishing properties of drilling mud. Clay and other solid particles can be added to these muds. The base of these muds can be salt aquatic or pure aquatic. The presence of oil causes transparency and polishes the awl head, extra weights and drill pipe, thereby reducing the adhesion of drilling particles to the drill teeth and the drill string, especially in the drilling system, the drill pipe rotates faster and, in total, the drilling speed increases with this kind of drilling mud.

5.3. Oil-base compounds emulsion muds

The main components of these muds are oil hydrocarbons, which is added to a small amount of aquatic. These muds are very suitable for salt and anhydride stones. The combination of two drilling fluids is used in cases where compressed air is used to reduce the hydrostatic pressure of the fluid. In these conditions, not only the loss of drilling fluid is reduced, but also the churn speed increases

5.4. Clay muds

Colloidal particles are mainly of clay. Clays have various types. Some clay can swell and thicken drill fluids, while some others stick to drill bits and drill pipes. Both types of the clays mentioned reduce drilling speed or complicate the drilling operations in one way or another, so the determination and selection of an inflammatory clay or a concentrating or a combination of both is important.

6. Functions of drilling mud

The most important tasks of drilling fluids are as follows: [17]

1. Cleaning the bottom of the well and transferring the pieces drilled from the bottom of the well to the ground
2. Cooling drill and drill pipes to increase the quality and life of the drill
3. Flood drilling and drilling pipes and polishing the drill string, which accelerates their transfer.
4. Laying the well wall and preventing falling
5. Controlling ground pressure
6. Suspending the muds and materials of the mud when the pump is turned off
7. Discharge of drilling clogs on shaken aluminum
8. Bearing part of drill pipes and wall tubes
9. Minimizing the losses to the adjacent wells and providing maximum information about them.
10. Hydraulic transmission of pumps to drill awl head

Figure 3: Drilling mud while pulling drill out

7. Design and construction of drilling fluid

A step-by-step program for designing a suitable drilling fluid in drilling of shale formation after the complete identification of shale formation and the governing environment usually consists of the following steps: [18]

1. Determining the weight and rheology of drilling fluid.
2. How to prevent smooth penetration and flood pressure
3. Conversion of clays to less active minerals.
4. pH control of the mud.
5. Investigation of the effect of electrolytic pollutants on drilling fluid
6. Stability analysis against high temperature and time.
7. Investigating the value of damage to the utilization layers.
8. Evaluation of mud lubrication

8. Effect of polymer additive on drilling mud

Polymers have a special status given their custom design capability. Using this property of polymers, one can use a polymer that has all the properties of these additives instead of using several different additives. Nawarat et al. (2000) examined the effect of xanthan gum on reducing fluid loss concluding that xanthan gum reduces loss by increasing viscosity. They also showed that the best combination of fluid controller is a combination of calcium carbonate and a polymer such as starch and xanthan gum, which adds to the production of the product while creating a cake filter and decreasing loss. The research team focused on the formation of new polymers based on xanthan gum and obtained good results. They discovered the ditoman gum polymers. The results confirmed that the step diton increases the viscosity of the xanthan gum and is more stable against the heat and has a higher elasticity and shear dilution [20]

Salamzadeh Salmasi et al. (2006) conducted some experiments to determine rheological properties appropriate to the geometry of horizontal wells and some other items on various conventional polymers used in the drilling industrysuch as shale control experiments. Polymer xanthan has a high YP / PV ratio compared with other tested polymers. The high YP / PV ratio is used to create a tangled regime to prevent the formation of digging logs in the horizontal section of the well, while maintaining the power of carrying the mud. Thus, xanthan polymer was introduced as a suitable polymer [21]

Researchers have studied and used various additives to improve the performance of drilling mud so far. With the advent of science and technology and the advent of nanotechnology in the sciences in various applications, drilling mud has also been exploited by nanoscale additives. In 2004, Mulhouse et al. [22] studied the properties of carboxy methylcellulose and polyacrylamide graft copolymers.

The production of carboxymethyl cellulose and polyacrylamide coupling polymerization was carried out by Krik ion using an oxidation polymerization method. Elemental, infrared, scanning electron microscopy and analytical thermal analysis were used to determine the properties of the coupler produced. Mirzaie et al. (2008) [23] studied the performance of nanoscale particles with a size of about 30 nm on drilling mud. The results of the addition of soot nanoparticles to drilling mud showed that these nanoparticles reduce or prevent the absorption of drill pipes, reduce the thickness of sludging, and reduce the viscosity and the point of submission.

Sensoy et al. (2009) examined the performance of silica nanoparticles on a aquatic-based drilling mud. The nanoparticle was studied on the drilling mud of four oil fields with shale Atoka in the Gulf of Mexico. The results showed that the presence of nanoparticles significantly reduced the aquatic absorption by shale, which reduced the amount of 16 to 42% in the fields and decreased by 22% compared with sea aquatic. [24]

Yung et al. (2009) studied the production, properties and application of nanoparticles of copolymer of carboxymethylcellulose with polyacrylamide. They initially examined the carboxy methylcellulose coupling with polyacrylamide in an aqueous medium using ridox as a primer, monomer concentration, reaction temperature and pH value on the average molecular weight of the coupling copolymer. Infrared ray imaging analyses, thermal analyzes, and X-ray diffraction were used to prove the transplanted copolymer. They also studied the intrinsic viscosity of the system both with and without salt [25]

Fereiduni et al. (2012) examined the effect of poly (ionic) cellulose on the rheological properties of drilling mud. For this purpose, they investigated the effect of full ionic cellulose in the form of both mass and nanoparticles on the fluid permeation, as well as the thickness of the plated mud. The poly-ionic cellulose nanoparticles produced a poly-ionic cellulose pulp from a high-energy pellet mill. The nanoparticles produced a size of about 100 nanometers, which had a significant effect on the reduction of fluid loss and the thickness of the lime mud compared to the poly Cellulose ionic cell masses [26].

9. Effect of granular materials on loss control

Messenger et al. (1974) used an aquatic solution, including coal and a gypsum. The main technique used to carry out these experiments to reduce the loss of gravity was to adhere the asphaltic material to the wall and to block the pores and gaps in the temperature and pressure of the formation [27]

Cookel et al. (1984) studied the use of industrial pumice to control the cracks in sandstone formations. Their results showed the proper performance and proper operation of pumice in porous granular sandstone formations (low porosity). [28]

Ali Pilehvary et al. analyzed the effect of 24 samples of different materials in 2002, and examined the effect of the type and distribution of aggregates on the fluidity of reducing agents on their performance and efficiency. The important results of this research are the indirect ratio of the reduction of the concentration and the concentration of materials [29]

Kengson Lee et al. (2008) investigated the interaction of three factors of fluid loss, permeability, and granular materials using an equal ratio of graphite and walnut peeled skin to block the formation of gaps. The results of this study showed that the gap closure mechanism provides the most effective control over the barrier. This process needs that the composition of the drilling fluid contains particles larger than the span [30]

Pomerillo (2008) has discussed contaminants for reducing fluid loss (aquatic and oil base) and the stability of well walls. Substances such as pumice, barium, dolomite, whose particle size is between 80 and 4,000 microns [31]

Generally granular materials can block up to three different mechanisms of pores and early cracks. These mechanisms include blocking, bridging, filling, and the conditions for the formation of each of these mechanisms are shown in the figure below. [30]

Due to the better distribution of materials in the blocking mechanism, this mechanism is known as the most suitable mechanism for blocking gaps and pores.

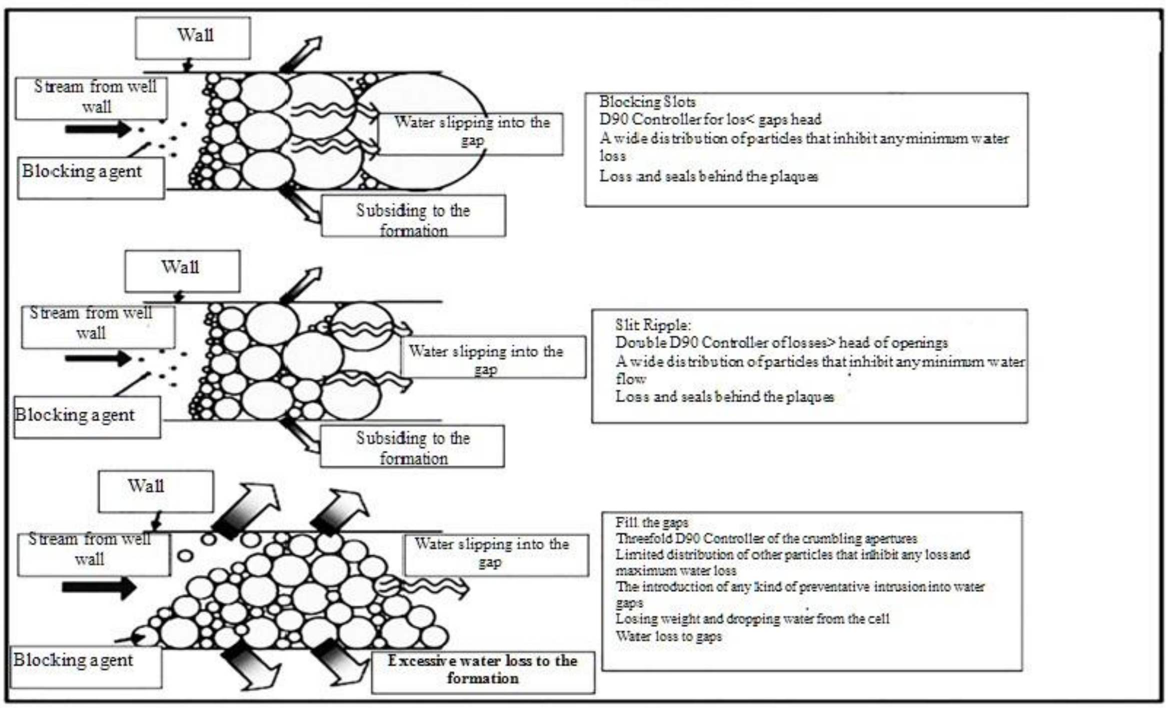

Figure 4: Granulated material mechanisms for blocking gaps

Alireza Nasiri et al. (2013) compared and analyzed the experiments conducted on the use of industrial pouches in control of freeze, concluded that [32]

Increasing the concentrations of the concentrate controller to a certain concentration has been able to improve the control efficiency of losses, and after that, the concentration of blockage efficiency reduces or remains constant. This optimal concentration for small industrial pumice is about 6%, and for the industrial pans it will be about 2%. More concentrations cannot be used due to changes in mud characteristics and operational problems.

The performance of the industrial pumice scale with a moderate size is weaker due to the lack of proper distribution of fine particles in the control of freeze, which is intensified by increasing the concentration of this process.

The use of percentages of average industrial pans as a solid framework on the dam and a percentage of smaller shells is needed to fill the gap between the framework and increase the efficiency of the barrier damper from the outflow of drilling fluid.

10. Effect of drilling mud pressure on well wall stability

Excessive pressure drilling may result in damage to the well wall. In a study, different dimensions of drilling mud pressure using simulation software are simulated and ultimately the optimal operating pressure with the least amount of damage to the reservoir is shown. [33]

The instability of the well wall is one of the most important forms of destruction of the formation. This problem is strongly a function of the flow and compression behavior of the drilling mud under the injection. Thus, the design of a suitable fluid that is compatible with the characteristics of rock and reservoir fluid is one of the priorities of the choice of an injecting fluid that, in addition to increasing the power of the well, results in high added value and high cost and time savings. [34]

11. Conclusion

As drilling mud affects the drilled well quality and the efficiency of drilling operation, so it plays a significant role in drilling operations. Thus, knowing the type of drilling fluid and choosing its type will reduce the cost of drilling and increase productivity.

Overall, the results show that the addition of nanocomposites reduces the thickness of the mud sludging and reduces the fluidity and also increases the viscosity of the drilling mud.

The results of indicated that the clogging blocking mechanism creates the most suitable control barrier. This process requires that the drilling fluid composition contains particles larger than the span.

The performance of the industrial scale with a moderate size is weaker due to the lack of proper distribution of fine particles in the control of loss, intensified by increasing the concentration of this process.

The use of percentages of average industrial pumice as a solid framework on the dam and a percentage of smaller pumice is needed to fill the gap between the framework and increase the efficiency of the barrier damper from the outflow of drilling fluid.

Polymers have a special place in the control of misalignment due to their custom design capabilities. Formulation of new polymers based on xanthan gum can be very useful in controlling the loss in drilling fluid.

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