DRILLING CUTTING REMOVAL IN INCLINED ANNULI - A REVIEW

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Introduction

Drilling muds were introduced with the introduction of rotary drilling in 1900. Initially, the primary purpose of the drilling fluid was to remove formation solids continuously. No time was spent on a scientific evaluation of the carrying capacity of the fluid, and very little effort was made to control the fluid properties. Even with the advancement of science in mud treating, operators ignored the lifting capacity of drilling muds.

As oil exploration and development moved into the deeper water, the cost to drill a well increases tremendously and coupled with the trend of drilling deviated hole from offshore locations, together with the increases in power requirements for circulating of the drilling fluid, has emphazised the need for critical examination of the factors affecting the removal of bit cuttings from the hole by the drilling fluid.

Failure of the mud to promptly remove bit cuttings from the wellbore causes redrilling and excessive wear on bit teeth, slows drilling rate thereby increasing well costs,

and greatly increases possibilities for stuck drill pipe when circulation is stopped for any length of time.

Extensive research and laboratory investigations has established the criteria for the selection of the proper conditions to ensure efficient hole cleaning for fast penetration rate in vertical wellbore.

This paper discusses the assessment of efficient vertical hole cleaning in relation to study deviated hole cleaning.

Problems of Hole Cleaning

In highly deviated wells, there are several problems in ensuring efficient hole cleaning. Circulation in high angle well is similar to the movement of sediments in a stream bed. The bit cutting are made up of rocks with a wide range of diameters. The heavier cuttings tend to drop down to the lower side of the hole due to gravity and hence resulting in the heavier cuttings and mud in the lower side, and clean mud in the upper side. The heavier cuttings and muds along the lower side of the hole moved at a slower rate than the clean mud on the upper side as shown in Figure 1.

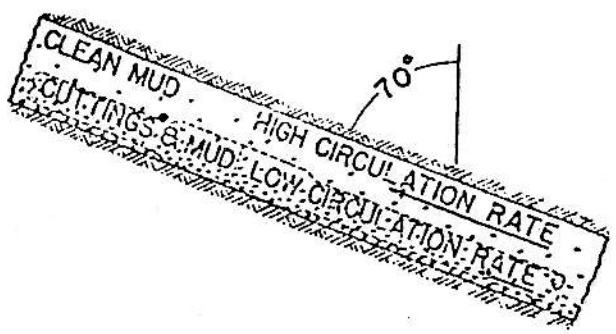

Fig. 1 Circulation problem in high-angle holes.

To overcome this problem it is necessary to establish the pump requirement to produce adequate P to circulate the cuttings to the surface. And also the criteria for the selection of the correct mud properties so that the mud can carry and keep the bit cuttings in suspension. Various techniques such as centralizing the drill pipe and rotation of the drill pipe help in ensuring efficient hole cleaning.

Factors affecting hole cleaning

The transport of cuttings through vertical pipes and vertical annuli has been investigated both in the laboratory and in the field. The variables considered in the investigations consist of the following; annular (fluid) velocity, mud properties, cutting size and concentration, rotary speed and annular size.

Since little work has been done on the study of deviated hole cleaning we should first consider the variables effecting the vertical hole cleaning and then with the aid of laboratory studies to study the effect of those variables to deviated hole.

Annular velocity [1,2,3]

The net upward velocity of a drilled particle will be the difference between the fluid (annular) velocity

and the slip velocity of the particle. So, for a drilled particle to reach the surface, the slip velocity must be less than the fluid (annular) velocity.

It has been shown that cutting transport efficiency increases rapidly with velocity until the velocity range of 100 to 200 ft/min when it begins to level out or increase more slowly. For viscous fluids like drilling muds, the breakover point occurs at lower velocities. This indicates that high velocities do not effectively increase the cutting transport efficiency but only result in greater parasitic losses and possible workouts. This does not properly utilize maximum impact or horse-power at the bit.

Hence for a vertical hole operating at a relatively low velocity (around 120 ft/min) permit the use of more hydraulic energy at the bit, this improving penetration rate.

Rheological Properties[4,5]

Viscocity is the most important property of the drilling fluids for cutting transport. And the most important component of viscosity affecting slip velocity of cuttings with the mud in laminar flow is the yield point.

It has been observed that raising the yield point will often improve the hole cleaning ability of a given mud. This improvement is perhaps caused by a change in the flow pattern in the annulus from turbulent to laminar. It is believed that cutting transport may be improved by this change because the cuttings tend to be thrown into the high velocity section of the laminar, flow pattern by the rotation of the drill pipe.

Drilling fluid density had a moderate influence on cuttings transport. The density of the mud provides lifting capacity and hole enlargement in deeper hole sections, where weighted muds are normally used, is less than in the normal pressure upper hole sections.

The optimum drilling fluid properties used are (1) the lowest practical viscosity is desirable for pumping through the bit nozzles, and a higher viscosity is required to suspend cuttings while the mud flows through the annulus, and (2) weighted muds (15 ppg or heavier) for lifting capacity and avoiding washouts

Annular Size[6]

Hole cleaning is seldom a problem in a hole that is very nearly in gauge. But oversized holes can be a serious source of error in hole cleaning calculations. For example, a pump rate that gives an annular velocity of

about 218 feet per minute in a $8\frac{3}{4}$ inch diameter hole with $4\frac{1}{2}$ inch drill pipe will give an annular velocity of only 49 feet per minute when the hole diameter is increased to $16\frac{1}{4}$ inches.

Cutting Concentration[7]

The concentration of cuttings in the annulus fluid is a function of slip velocity and penetration rate. It has been observed that a maximum of 5 per cent by volume cuttings could be transported safely, but higher concentrations might cause hole trouble.

Pipe Rotation and Eccentricity[8]

Although drill pipe rotation is normal in drilling a well it is important in the efficient removal of cuttings. The effectiveness of drill pipe rotation in increasing carrying capacity is caused by the centrifugal forces that project the particles among from the pipe into the regions of higher velocity, where they are more easily transported.

Apparently the normal rotating speeds of drilling are sufficient to take advantage of the effect.

And it has been shown that when the drill pipe was centred by using centralizers, the efficiency of cuttings transport was slightly increased.

Deviated hole cleaning research programme

Extensive investigations has established the criteria for the selection of the proper conditions for efficient vertical hole cleaning using drilling mud and little has been done on studing efficient hole cleaning from deviated wells. In field practices, a factor is added on to the conditions selected base on efficient vertical hole cleaning to allow for inefficiency due to angle of deviation. But with extremely high cost of developing offshore field, a more exact factor is needed in order to ensure optimization of drilling cost.

So an extensive program to investigate deviated hole cleaning to determine the exact solution to the problem of cleaning deviated hole efficiently is initiated in 1980.

A) Identify problems associated with hole cleaning in deviated wells [9]

B) Construct an experimental rig to study hole cleaning problems in

   a) vertical hole
   b) deviated hole
   c) highly deviated hole

C) Make a mathematical model to predict hole cleaning parameters for efficient cleaning

D) Upgrade experimental rig for precision measurement of hole cleaning parameters to be tested in the mathematical model.

Conclusion

Hole cleaning is important to ensure that the cuttings are removed from the hole so that drilling operation could progress safely and unhidered. For deviated hole cleaning, the mud must over come gravity and also the vertical hole cleaning difficulties. In the vertical hole cleaning the most significant variables in hole cleaning are the annular velocity and the flow properties of the mud. Mud weight, cutting size, annular size and rotary speed also effect hole cleaning but to a lesser degree.

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