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APPLICATION OF DITCH MAGNET SYSTEM TO EXTEND DOWNHOLE TOOL LIFE AND ACCURACY – REVEALING THE QUANTITY OF METAL CONTAMINATION IN DRILLING FLUID

Arild Saasen
University of Stavanger
Stavanger, Norway

Geir Olav Ånesbug
Jagtech
Orkanger, Norway

Robert Palmer
Jagtech
Houston, TX, USA

ABSTRACT

Magnetic contamination of drilling fluids is assessed. It is shown from experience how much material is typically removed from current drilling operations. Known sources for these materials are outlined, as well as the effect these materials have on down hole tools and measurements. To remove the materials a selection of strong rod magnets is positioned in a selected geometrical pattern either upstream or downstream the primary solids control equipment. Typical maximum field strength of the surface of Neodymium magnet rods is around 1.2 Tesla.

Field experience from offshore operations in the North Sea and land-based drilling operations in the Permian basin have shown how such magnets can be efficient in removal of significant amounts of sub 50 micron magnetic materials that are contaminating drilling fluids. The quantity of the removed magnetic material and the consequent effect of removal of these materials are assessed for impact on cost reductions for downhole equipment wear and improved directional drilling operations. Furthermore, to add to the technology, data from more complicated ditch magnet systems used on offshore rigs are used to help quantify the amounts of detrimental material present in the drilling fluids. In the article, it is presented how modern ditch magnet systems work

Keywords: Drilling fluid cleaning, Ditch magnet systems

1. INTRODUCTION

Construction of deviated, horizontal, and extended reach wells rely upon proper measurements of the well path direction and accurate logging of down hole properties. Wellbore direction is currently being logged by using Measurement While Drilling (MWD) magnetic compasses or gyros, as these types of instruments currently are the only applicable tools for down hole usage.

The measurement accuracy of gyro tools is reduced in areas closer to the geographic poles as the Earth's effects from rotation are less. Similarly, the accuracy of magnetic directional measurements, all else being equal, is reduced the closer to the magnetic poles a well is drilled as the horizontal magnetic field is smaller. This has become an industry issue as the number of wells drilled in Arctic regions has increased [1, 2]. The accuracy of magnetic directional measurements can also be improved by controlling error sources like shielding of the down hole compass due to contaminated drilling fluid [3]. Field experience from the North Sea area shows that directional drilling was significantly improved when the magnetic contamination of the drilling fluid was removed [3, 4].

The effect of contamination of the drilling fluid on directional drilling was brought to attention within the drilling industry by Wilson and Brooks in 2001 [5]. The magnetic contamination of drilling fluids has also other negative impacts. The BOP will slowly be filled with magnetic debris, hindering proper BOP performance in emergency situations. Magnetic material will be clogging onto ports or active surfaces in Logging While Drilling (LWD) logging tools. This will reduce the signal to noise ratio of such tools. Sometimes they may stop working completely. This was clearly shown during a drilling operation in the North Sea. Good drilling practice along with proper removal of the microscopic magnetic debris in the drilling fluid made it possible to drill 6624m with one single bit run during infill drilling at the North Sea Troll field [6, 7]. Even the solids control equipment has been reported to work better after the magnetic contamination has been removed [6].

In the following it is described how to clean the drilling fluid for magnetic contamination offshore. The efficiency of the method is compared to that of older methods in an technology assessment. Finally, some consequences for drilling and wellbore positioning are outlined.

2. DITCH MAGNET PERFORMANCE

2.1 Drilling Fluid Cleaning

The drilling fluids are cleaned by applying a flow positioned ditch magnet system. This is a set of ditch magnets placed in a geometrical suitable to handle removal of solids from the fluids given the complex rheological properties of the drilling fluids. Besides having a time dependent viscosity and a significant gel formation, most drilling fluids have yield stresses. In addition, such fluids have a significant increase in shear stresses at low shear rates. Thus, removal of particulate material from the drilling fluids is a challenging subject unless a specially designed ditch magnet system is used.

Traditionally, most drilling rigs were equipped with block magnets lying in the bottom of the ditch upstream shakers. These magnets have very little efficiency in cleaning the drilling fluid. Typical magnetic field strength measured on the surface of such a block magnet is shown on a sketch presented in Fig.1. The assessed magnet is 455mm long, and the measurements were conducted around the magnet as shown on the sketch, roughly halfway along the block. With so small magnetic field strengths the only particles being removed are the larger swarf particles, for example made from occasional movement of the drill bit inside casings.

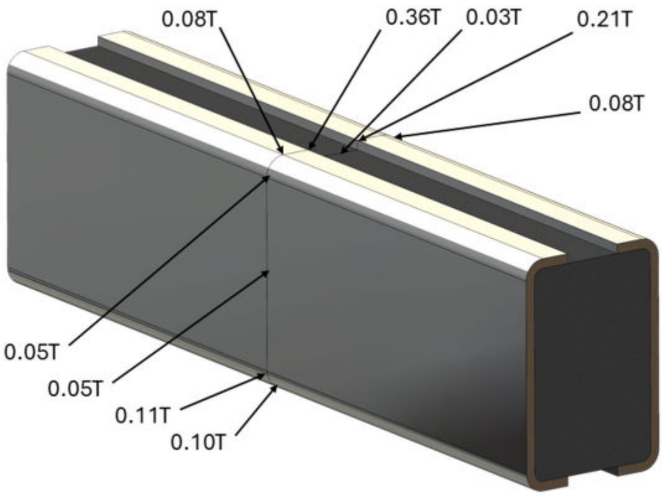

FIGURE 1: A SKETCH SHOWING THE MAGNETIC FLUX DENSITY MEASURED ON THE SURFACE OF A COMMON BLOCK MAGNET DURING A RIG SURVEY.

Modern ditch magnets typically consist of vertical rod magnets. These are typically constructed by stacking strong Neodymium magnets inside a non-magnetic support tube as shown in Fig. 2. The field strength varies along the tube passing from magnet to magnet inside the tube. The magnetic flux density as a function of the distance from the rod magnet surface at the point with maximum field strength is shown in Fig. 3. The shown data is for a case of using a support pipe outside the Neodymium magnets with only 0.5mm wall thickness. Any rod magnets with a thicker support tube wall or with additional devices outside the magnet support tube will automatically lose efficiency significantly.

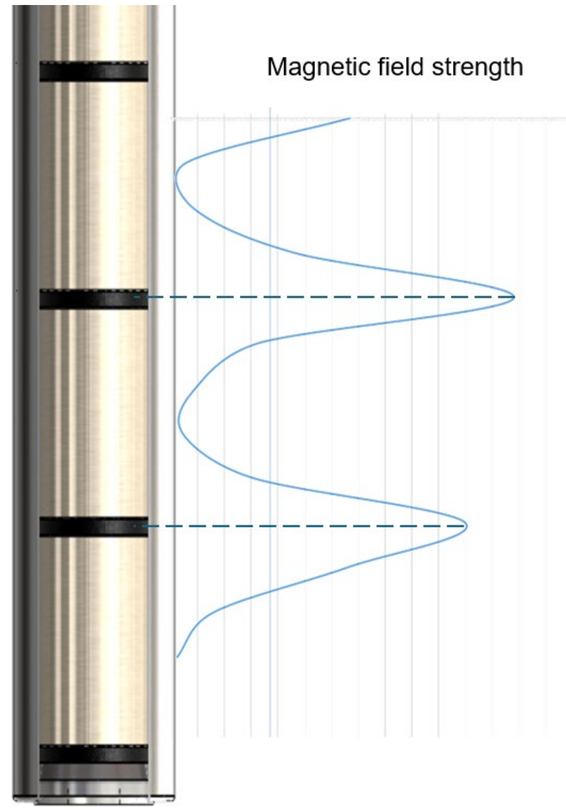

FIGURE 2: THE MAGNETIC FLUX DENSITY MEASURED AS A FUNCTION OF THE DISTANCE FROM THE MAGNETIC ROD

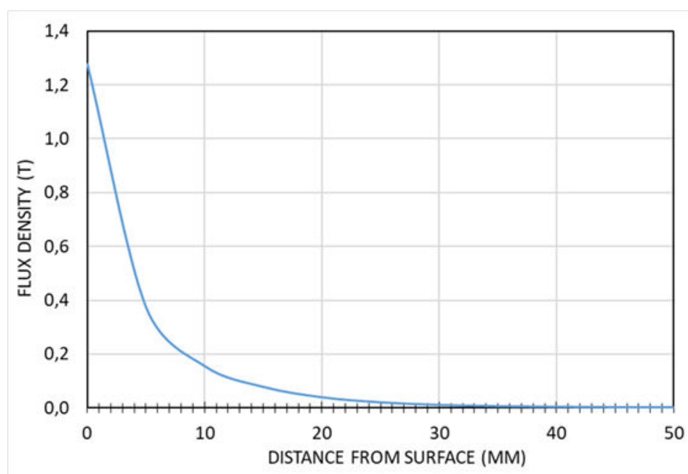

FIGURE 3: THE MAGNETIC FLUX DENSITY MEASURED AS A FUNCTION OF THE DISTANCE FROM THE MAGNETIC ROD

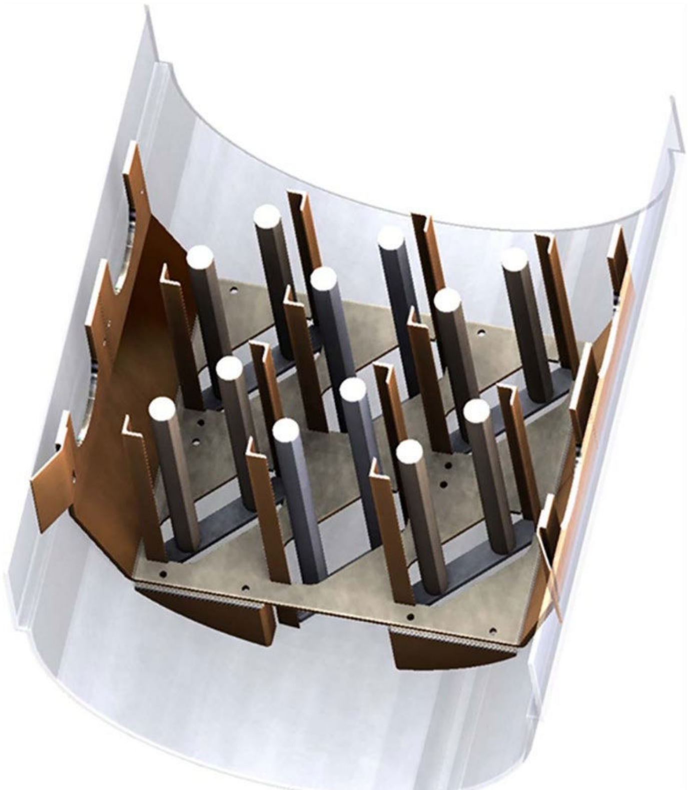

FIGURE 4: ILLUSTRATION OF MAGNETIC RODS MOUNTED ON A GUIDING SHOE THAT WILL FOLLOW THE RIGHT-ANGLE GUIDING SUPPORT FRAME. FIGURE FROM SAASEN ET AL. [3].

As described previously, the presence of yield stresses and other shear thinning items at low shear rates prevent removal of particulate material. This is a necessary property of the drilling fluid to prevent weighting agents from sagging out of the fluid. At the same time these properties significantly reduce the efficiency of a single magnet to remove magnetic contamination from the drilling fluid. Hence, a system based solely on single magnet rods may be insufficient to remove magnetic contamination. It is important to ensure that the highest possible portion of the drilling fluid approaches the magnetic rod surfaces. At the same time, it is necessary that the viscosity of the fluids is at minimum when passing the magnets. The flow positioned ditch magnet system, presented by Pallin and Ånesbug [8], is constructed to ensure these properties. Both supporting frames and magnet positions are placed in a way, shown in Fig. 4, generating flow vortices. These vortices bring larger volumes of the return fluid into the near vicinity of the magnets ensuring exposure to a strong magnetic field. Furthermore, the shear field created by the vortices reduces formation of yield stress generating flow structures that in turn reduce the viscosity of the fluids in the rod magnet area.

The flow positioned ditch magnet system is significantly more efficient than a series of magnet rods placed across the ditch. In one well, 1.7 tons of contaminants were removed from a well at the Troll Field in the North Sea. This enabled drilling the to date world record length of 6 624m in one bit run [6, 7]. On the Troll field the drilling fluid was a low viscosity water-based drilling fluid. For oil-based drilling fluids the situation is similar. The cleaning performance at the Ivar Aasen field, where a flow positioned ditch magnet system was used, was significantly better than that of a different North Sea field with ditch magnets placed across the return ditch, even if the rheological properties of the drilling fluids were reasonably similar [4,3].

The magnetic debris particle size is reasonable small. Scott et al. [9] showed that the flow positioned ditch magnet system were able to remove particles with a D_{50} between 10 and 15 microns. Even with the flow positioned ditch magnet system placed downstream the original ditch magnets of the rig, three times as much debris was removed by these ditch magnets compared to the original ones. In addition, much finer debris was removed.

2.2 Measurement of Magnetic Debris Content

Based on the findings of Khalili et al. [10], a measurement system has been developed to measure the content of magnetic contamination in drilling fluids. A tool kit has been developed. This consists of a one litre bottle filled with the drilling fluid to be tested. A magnetic rod fit to this bottle is immersed into the bottle and the bottle is gently shaken. Thereafter, as illustrated in Fig. 5, the magnetic rod is moved over to a similar bottle with base fluid to wash off as much drilling fluid residual as possible from the rod. Then the wet contamination is scraped off and measured.

FIGURE 5: WASHING OFF DRILLING FLUID RESIDUE FOR DETERMINATION OF MAGNETIC CONTENT IN DRILLING FLUIDS.

An example is presented from an offshore field in the North Sea. No information exists about the drilling fluid volume history. Thus, no information can be given about the values being higher or lower than normal. The drilling fluid was a 1.53 s.g. oil-based drilling fluid circulated at a rate of 1400 litres per minute. The weight of the removed material was measured to be 3g as shown in Fig. 6. As can be seen in Fig. 6, some residual fluid still exists in the sample. However, the mass of this residual material is anticipated to be insignificant compared to that of the metallic debris.

FIGURE 6: WEIGHING THE MAGNETIC CONTAMINATION

The amount of magnetic material found in the offshore test of the measurements system indicates that the potential for debris removal from the flow should be around 4.2 kg/hour when the flow rate is 1400 litres per minute. No information was given about the well construction and rig in this case. But the data seems valid for an 8 ½" section. Assuming that the active system is 400m^3, which seems to be a realistic lower limit of an active drilling fluid volume for an offshore well, this well would have as a lower limit more than 1.2 tons of magnetic debris in their circulation system.

As mentioned earlier, Scott et al. [9] found the D_{50} to be somewhere between 10 and 15 microns. Thus, the surface area of the magnetic debris can be very large. A consequence is that the amount of residual drilling fluid on the removed material can also be significant. The smaller the debris, the larger the amount of residual material. Still, the measured amount of magnetic contamination is expected to give realistic numbers.

A laboratory test was conducted on an oil-based drilling fluid sample collected from a Permian basin well to evaluate the amount of magnetic contamination. The laboratory analysis revealed a content of 2.8g steel contamination per litre of drilling fluid; not very different from the values of the North Sea well. The total volume of drilling fluid in the active system, being the active pit and the well circulation volume, was 460m^3. If the laboratory sample is representative of the rest of the drilling fluid, this measurement indicates that there is 1.37 tons of magnetic contamination in the total active system. Furthermore, it was commented from the laboratory that the contamination particles were fine grained.

3. CONCLUSION

An assessment has been conducted on the removal of magnetic contaminants from drilling fluids. This removal has been recognised to be important to improve directional drilling and obtaining good signal to noise ratios in down hole logging tools. A method to measure the amount of magnetic contamination has been presented, including the description of a toolkit for this purpose. Measurements both from a North Sea well and from a Permian basin well show that the volume of contaminants in the drilling fluid is very large.

4. ACKNOWLEDGEMENTS

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