SWEEPING MADE SIMPLE

Keith Davis and Daniel Biddle, FORTA Corp., USA, *explain the merits of using innovative fibre technology in wellbore sweeping.*

The art and science of cleaning, or sweeping, cuttings from a wellbore while drilling can be a complicated study, with a long and varied history of methods and materials to accomplish the task. Removing the cuttings while drilling is an important and sometimes costly part of the drilling programme, and one that is extremely critical to the entire process. If the hole cleaning operation is not successful, drilling costs, both in materials and time, become unmanageable and profits and production suffer accordingly. This important function can be made as complicated – or as simple – as desired, based on the cleaning theory and method of practice chosen by the operator.

Traditional theory

Hole cleaning is a universal dilemma and constant challenge for drilling operators throughout the world, regardless of conditions and territory. Furthermore, a lack of effective cleaning adds a host of costly time and material expenses, such as slow penetration, excessive equipment wear, and high torque and drag. Traditional methods for removing excess cuttings include either increasing the fluid flow rate, or increasing the fluid viscosity – both of which are designed to improve the fluid's ability to carry the cuttings to the surface. Yet both methods can also create side-effects that are not always desirable, and present operators with the challenge of solving one drilling issue while creating yet another dilemma to deal with. For instance, increasing the flow rate can certainly help cuttings transport, but may also create unwanted turbulence that negatively impacts other hole conditions. Increasing the fluid viscosity also clearly helps raise cuttings, but the resulting high-viscosity fluid remains to be dealt with once the sweep has been completed. In either case, the art involved is to find a way to transport the solids when circulating, with the capacity to suspend them even when circulation is interrupted, all without unwanted viscosity.

Figure 1. *½ in. long treated polypropylene fibre.*

Figure 2. *Fibre suspends without changing fluid viscosity.*

Developing a fibre alternative

Aside from flow rate change methods, conventional practice has typically involved raising the fluid viscosity by either reverting to a higher viscosity drilling fluid or mud, or adding a wide variety of gels or polymers to the existing fluid to accomplish this same goal. Both methods will help suspend cuttings, but will need to be dealt with once the sweeping process is completed by exchanging the high-viscosity fluid with a lower-viscosity one or removing the polymers back out of the fluid. A focus on alternative ways to simply suspend cuttings led to a unique and relatively inexpensive material and process, that has few, if any, negative ramifications after sweeping. This simple but effective material was based on two-fold fibre-suspension dynamics:

- The ability of certain fibres to suspend themselves in a wide variety of fluids without floating or sinking.
- The ability of those suspended fibres to then also suspend cutting particles within the fluid.

During development, it was assumed that a fibre that could accomplish both of these suspension-related goals would also be able to finish the easier portion of the sweep process by transporting the cuttings to the well surface. The subsequent study of fibre characteristics involved relatively few variables that would impact this suspension goal – fibre shape, chemistry, length, and dosage. For instance, the fibre shape could be varied from thick to fine, smooth or deformed – whichever configuration would improve suspension characteristics. In this case, best results were obtained with a very fine diameter, single filament fibre configuration – a shape that caused no downhole issues with Measurement While Drilling (MWD) tools or bit-jet openings. An additional benefit of this fine filament shape was to facilitate a high fibre piece count per pound, thereby increasing capacity for suspension without requiring ultra-high concentrations. Given this fibre shape and fine diameter, each pound contains approximately 850 miles of fibre, which allows for considerable opportunity for improved suspension and carrying capacity. Fibre chemistry was also a key consideration; to determine a fibre make-up that would properly suspend in fluids of any viscosity, yet not cause any negative chemical-related issues with disposal or potential offshore use. This chemistry selection resulted in the use of a specially treated polypropylene material that maintained tremendous suspension characteristics in any fluid, while still being inert and non-hazardous, and did not compromise any reactivity or eco-friendly issues. Having arrived at the important fibre shape and chemistry solutions, fibre length could be adjusted to accomplish optimum results with regards to suspension and solids retention. Arriving at a length of ½ in. (13 mm) provided an optimum result between suspension and flow, and preserved the performance vs. blockage balance. Shorter lengths, such as ¼ in. (6.5 mm) could also be used for Horizontal Directional Drilling (HDD) applications for additional comfort level, though the longer length has not offered field difficulties to date.

The dosage or fibre concentration element is somewhat more subjective than the other fibre characteristics, in that the correct dosage is just enough to accomplish the desired goal; in other words, enough to unload the cuttings from a particular wellbore. In general, concentration ranges of 0.1 lbs of fibre per bbl. of fluid in large volume sweeps where

MWD tools are being used, to 0.5 lbs of fibre per bbl. for heavy lifting for milling or sluffing shale, have proven effective. The fibre dosage and sweep volume can be adjusted up or down to achieve desired results.

The end result of the fibre characteristic analysis resulted in a material description that accommodated each of the four fibre variables, while acknowledging that each parameter was interactive and impacted the other characteristics. Optimising these material characteristics resulted in a sweep product that was quick and easy to apply, simple in technology and use, cost-effective in practice compared to alternative products and methods, and was easily removed from the fluid system after use. The eventual product introduced to the drilling arena became FORTA® Super-Sweep® fibre, and has been tested in both field and laboratory environments, and used successfully in scores of application sites all over the world.

Gel strength vs. viscosity

One of the most surprising performance aspects of this fibre material is its high capacity to suspend and carry solids without changing the viscosity of the fluid; a very desirable trait during the drilling process. The material proved very successful in hole cleaning capacity in the field, however, the effects on actual rheology were more challenging to measure. The distribution of millions of micro-fine fibre filaments creates a startling amount of carrying capacity, and in essence, allows for a purely mechanical gel strength without affecting fluid flow, acting like a mechanical filter of sorts. Researchers at the University of Oklahoma[1] tested various fibre concentrations in a variety of conventional fluids with regards to viscosity changes, and concluded that adding fibre had minimal, if any, effect on the flow rates of the fluid. While adding higher concentrations of the sweep fibre has shown to dramatically improve hole cleaning performance, no significant change to the fluid rheology has been noted. Further, the fibres' effect, or lack thereof, on viscosity is not dependent on the fluid type, exhibiting similar results in fresh water, salt water, and oil-based or synthetic-based fluids. Previous research, also at the University of Oklahoma[2], had confirmed the sweep fibre's capacity to suspend and lift cuttings, but also provided evidence that the fibre was just as effective on fine cuttings particles as coarse cuttings, and had the ability to improve the re-suspension capacity of the fluid.

Figure 3. *Fibre easily added at mud hopper.*

Figure 4. *Fibre-impregnated solids screened and removed by solids control equipment.*

Fibre sweep use

This laboratory research was valuable in adding reason and verification to real world sweep experiences that had been recorded over the past 10 years. Scores of successful examples and trials have been reported in many parts of the world under a wide variety of drilling scenarios, many of which have pleasantly surprised the specifiers and users. In practice, the sweep fibre has developed a reputation for ease-of-use, which has resulted in a dramatic increase in worldwide volume and applications. In general, the recommended application is to add the fibre at the mud hopper at the desired weight-per-barrel concentration, and then proceed by suctioning the pill into the system.

The return of fibre with impregnated solids will be quite evident, once the fibre-fluid has had time to circulate through the system. The fibre-cuttings are easily removed from the system by the shale shaker screens at the surface, and the original fluid then re-circulated as normal. The fibre-cuttings are typically disposed of in the cuttings pit, and being inert and non-hazardous, offer no detrimental impact to conventional disposal practice. Static sheen and definitive toxicity testing has confirmed that the fibre sweep fluid offers no related issues, and easily passes the LC50 survival requirements.

For almost 15 years, this patented fibre suspension material has been used effectively to improve hole cleaning capacity of vertical wells. Since introduction, the use of this unique sweep fibre has expanded to many related applications, such as horizontal bores as well as removing metal fragments during milling operations. The improved performance offered by this fibre sweep technology has certainly improved the art of hole cleaning in the drilling industry, and reduced the cost of the process while maintaining a very simple and extremely efficient solution to an age old drilling dilemma. OT

References

1. M. George, R. Ahmed, University of Oklahoma, 'Rheological Properties of Fibre-Containing Drilling Sweeps at Ambient and High Temperature Conditions', April 2011.
2. R. Ahmed, N. Takach, University of Oklahoma, 'Fibre Sweeps for Hole Cleaning', April 2008.

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