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REMOVING CUTTINGS FROM DEVIATED AND HORIZONTAL WELLS

Effective cuttings transport is critical in drilling production horizontal and extended reach wells. In these cases, failure to remove drill cuttings from the hole would lead to deposition and accumulation of cuttings in the annulus, resulting in stuck pipe, eccentric annulus and/or reduced penetration rate.

Эффективная транспортировка обломков выбуренной породы является ключевым фактором при бурении горизонтальных эксплуатационных скважин и скважин с большим отходом. В этих случаях невозможность извлечения обломков выбуренной породы из скважины может способствовать осаждению и накоплению обломков в затрубном пространстве, что приводит к прихвату трубы в скважине и снижению скорости проходки скважины.

Introduction.

Deviated angles and horizontal sections typically lead to some of the most troublesome hole cleaning problems. Particles can typically remain suspended in high angle wells if the provided drill pipe rotation is sufficiently high to agitate the cuttings and the annular flow rate is sufficient to provide lift. Problems can rapidly develop under static conditions or in case of inadequate flow rate or pipe rotation, allowing cuttings to accumulate in beds. Inadequate hole cleaning can lead to costly drilling problems such as: stuck pipe, premature bit wear, slow drilling rate, formation fracturing and high torque and drag. As a result, cuttings transport has continued to be a subject of interest to engineers and researchers. There have been a number of experimental investigations on different aspects of cuttings transport; recently, several studies have also been performed on numerical modeling of cuttings transport.

Experimental Investigation. Various methods have been tried to remove cuttings which usually settle on the low side of a deviated borehole. Some of the earliest experimental studies of cuttings transport in directional drilling were carried out by University of Tulsa (Oklahoma, USA) researchers, Tomren, Iyoho, Okrajni, Becker and Azar. Sanchez investigated effect of drill pipe rotation on hole cleaning in directional well drilling. Experiments were also carried out by some companies like Petrobras, Mobile and M.I. Drilling Fluids-Houston (Texas, USA), by Heriot Watt University (Edinburgh, Scotland) and French Oil Institute. Experiments intend to determine the influence of all the factors on cuttings transport performance: pipe rotation and eccentricity, hole inclination angle, type of drilling mud, mud flow rate, mud weight, flow regimes, field-measured mud rheological properties, cuttings size and shape, cuttings slip velocity and other drilling parameters. Empirical correlations were also developed for critical flow rate for different flow conditions.

Factors Influencing the Cuttings Transport Performance. *Drill pipe rotation* has a significant effect on hole cleaning, and the dynamic behavior of the drill pipe (vibration, whirling, etc.) play a major role on improvement of hole cleaning. In coiled tubing drilling, the pipe does not rotate above the motor. The influence of drill pipe rotation is more pronounced in viscous muds and in smaller holes. *Drill pipe eccentricity* was found to have a significant impact on cuttings removal in case of hole inclination angle of 40°-50°. *Inclinations angles* between 55 and 70 degrees have been

reported in the literature as the most difficult for cuttings transport. In drilling deviated and horizontal wells, the velocity vector deviates from vertical and is sometimes horizontal, while the gravity vector remains vertical. In this situation, the cuttings tend to settle to the bottom of the hole away from the fluid flow. If the *fluid velocity* falls below the critical rate, it will be a risk of particles settling, forming beds or bridges that may obstruct the well bore As an alternative to running with higher annular velocities, the drill operator may increase the viscosity of the circulating fluid for effective hole cleaning. A number of studies have been conducted to investigate the effect of *drilling fluid rheology* on cuttings transport. These studies and others debated high viscosity versus low viscosity fluids and which rheological parameters are most useful for characterizing hole cleaning efficiency. Thus higher mud yield value reduced annular cuttings concentration, particularly in laminar flow regime. Effect of mud yield was insignificant in high-angle wells (> 55°). Becker, Azar and Okrajni correlated rheological properties, including mud yield point, plastic viscosity, power-law exponent, consistency index, etc., with cuttings transport performance from 180 tests. They indicated that data with low-shear-rate parameters correlated better with annular cuttings concentration in steady-state flow. Increased *mud weight* provides buoyancy, reduces the effective weight of cuttings with effective transport occurring at lower annular velocities. The relevant literature shows that *cuttings size and density* have an effect on the carrying capacity of conventional drilling fluids.

Critical Transport Velocity. The experiments conducted to evaluate cuttings removing capacity in deviated and horizontal wells dignified the existence of a minimum fluid velocity in the annulus from which all cuttings particles are evacuated from the well bore. If the fluid velocity falls below this critical transport velocity, it will be a risk of particles settling, forming beds. Both experimental investigation and numerical simulation were performed to determine the critical cuttings transport velocity in inclined annulus, for different flow conditions, in a study carried out by University of Tokyo. The critical cuttings transport velocity depends on inclination angle of the well, eccentricity, mud weight, rheologycal mud properties, flow regimes and more.

Conclusions and Recommendations.

1. Flow rate in the annulus has to be up to 50 % higher than in a vertical well; flow should be turbulent in the annuli.

2. In order to obtain high flow rates and turbulence in the annulus, big diameter drill pipes are recommended.

3. Pipe rotation and fluid rheology are key factors affecting cuttings transport. Improvement by pipe rotation in the transport efficiency of small cuttings is up to twice as large as the improvement in large cuttings transport.

4. Drill pipe rotation combined with polymeric drilling fluids is highly recommended to efficiently transport cuttings during extended reach or horizontal drilling.

5. Top Drive System permits circulation while manipulating the drill string, that's why it is used in directional drilling, especially offshore.

REFERENCES

1. *Neculai Macovei*. Directional Drilling. Ploiesti, 2003.

2. *Masuda Y.*, University of Tokyo; *Q. Doan*, Vincano Inc.; *M. Oguztoreli, Mustafa Oguztoreli* Inc.; *S. Naganawa,* University of Tokyo; *T. Yonezawa, A. Kbayashi*, TRC/JNOC; *A. Kamp*, INTEVEP/PDVSA: Critical Cuttings Transport Velocity in Inclined Annulus: Experimental Studies and Numerical Simulation, SPE 65502-MS, 2000.

3. *James B. Terry, Carey J. Naquin, Patrick Laursen, James Estep, Martin Paulk, E. Alan Coats, Ron Crook, Rickey L. Morgan*: Method and apparatus for removing cuttings, Halliburton Energy Services, 2005.

4. *Valluri S.G., Miska S.Z., Ahmed R., Yu M. and Takach N.E.*, U. of Tulsa: Experimental Study of Effective Hole Cleaning Using «Sweeps» in Horizontal Wellbores, SPE 101220-MS, 24-27 September, 2006.

5. *Leising L.J., Walton I.C.*, Schlumberger: Cuttings-Transport Problems and Solutions in Coiled-Tubing Drilling, March, 2002, SPE.

6. University of Tulsa: Advanced Cuttings Transport Study, January 30, 2000.