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Modeling and Analysis of Drilling Operation in Shale Reservoirs with Introduction of an Optimization Approach

Authors : Sina Kazemi, Farshid Torabi, Todd Peterson

Abstract : Drilling in shale formations is frequently time-consuming, challenging, and fraught with mechanical failures such as stuck pipes or hole packing off when the cutting removal rate is not sufficient to clean the bottom hole. Crossing the heavy oil shale and sand reservoirs with active shale and microfractures is generally associated with severe fluid losses causing a reduction in the rate of the cuttings removal. These circumstances compromise a well's integrity and result in a lower rate of penetration (ROP). This study presents collective results of field studies and theoretical analysis conducted on data from South Pars and North Dome in an Iran-Qatar offshore field. Solutions to complications related to drilling in shale formations are proposed through systemically analyzing and applying modeling techniques to select field mud logging data. Field data measurements during actual drilling operations indicate that in a shale formation where the return flow of polymer mud was almost lost in the upper dolomite layer, the performance of hole cleaning and ROP progressively change when higher string rotations are initiated. Likewise, it was observed that this effect minimized the force of rotational torque and improved well integrity in the subsequent casing running. Given similar geologic conditions and drilling operations in reservoirs targeting shale as the producing zone like the Bakken formation within the Williston Basin and Lloydminster, Saskatchewan, a drill bench dynamic modeling simulation was used to simulate borehole cleaning efficiency and mud optimization. The results obtained by altering RPM (string revolution per minute) at the same pump rate and optimized mud properties exhibit a positive correlation with field measurements. The field investigation and developed model in this report show that increasing the speed of string revolution as far as geomechanics and drilling bit conditions permit can minimize the risk of mechanically stuck pipes while reaching a higher than expected ROP in shale formations. Data obtained from modeling and field data analysis, optimized drilling parameters, and hole cleaning procedures are suggested for minimizing the risk of a hole packing off and enhancing well integrity in shale reservoirs. Whereas optimization of ROP at a lower pump rate maintains the wellbore stability, it saves time for the operator while reducing carbon emissions and fatigue of mud motors and power supply engines.

Keywords : ROP, circulating density, drilling parameters, return flow, shale reservoir, well integrity
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