McLellan, P.J., Hawkes, C.D., Smith, S., Coupled Modeling of Borehole Instability and Multiphase Flow for Underbalanced Drilling, SPE 74447 presented at the IADC Underbalanced Technology Conference, Aberdeen, Scotland, Nov. 27-28, 2001 and at the SPE/IADC Drilling Conference, Dallas, Texas, Feb 26-28, 2002.

Abstract

Underbalanced drilling techniques have been applied to avoid or mitigate formation damage, reduce lost circulation risks, and increase the rate of penetration. However, drilling with a bottomhole pressure less than the formation pore pressure will usually increase the risk of borehole instability due to shear or tensile failure of the rock adjacent to the borehole. The extent of rock failure is very sensitive to the pressure in the annulus between the drill pipe, collars or BHA and the formation. The capacity of the drilling fluids to effectively circulate cuttings and cavings to surface is also strongly sensitive to the annular flow velocity. This paper describes the coupling of two popular software packages STABView™ and WELLFLO7™ to solve the complex interaction of borehole instability, rock yielding, collapse, detachment, and wellbore hydraulics during underbalanced drilling operations. In particular, a profile of the average borehole diameter can be predicted that accounts for hole enlargement in weak rock formations, and its consequences for annular pressures and flow velocities. The use of these two models running in a coupled mode is illustrated with two examples. The first one is a case study of a sidetracked well that was drilled underbalanced using coiled tubing technology in western Canada. Severe tight hole problems and poor hole cleaning had been experienced during drilling operations, and ultimately the bottomhole assembly became stuck. Subsequent borehole stability analyses indicated that significant hole enlargement was occurring in two weak shaley intervals. Wellbore hydraulics analyses showed that the liquid velocities achieved in the enlarged intervals of this well were low, which led to an accumulation of cuttings and cavings, thus resulting in the stuck pipe. A second, hypothetical horizontal well case is also described in order to illustrate the procedures for characterizing the operating envelope (i.e., optimal annular pressures and flow rates) prior to drilling an underbalanced well. This example demonstrates additional features of the two software programs for simulating the complexities of hole failure, erosion and enlargement in an annulus with a two-phase fluid for both strong and weak rock cases.