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Numerical Study of Swab and Surge Pressures in Wellbores

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An accurate calculation of surge and swab pressures is of utmost importance as pressure changes during tripping are one of the leading causes of well control incidents. The paper presents numerical investigations of swab and surge pressures in concentric and eccentric annuli.

A series of concentric and eccentric simulation cases, mimicking a straight section of the wellbore, is defined. As a non-Newtonian incompressible drilling fluid, 1% polyanionic cellulose is selected. Tripping speeds range from 0.1 to 0.8 ft./s. Hexahedral and, in the case of complex geometries, polyhedral computational meshes are used. The numerical investigations are conducted with the solver pimpleFoam from the computational fluid dynamics (CFD) toolbox OpenFOAM® and post-processed with the software ParaView.

The simulation results of different concentric cases are successfully validated with existing laboratory experiments. The paper presents additional eccentric cases with pressure-reducing effects of up to 38% and the associated annular flow profiles. The effect of a linear drill string acceleration on the surge and swab pressure is shown. The impact of drill string rotation and a bottom-hole-assembly on the pressure behavior in the annulus as well as the occurrence of turbulence are discussed. Results of the numerical investigations are compared with an analytical swab and surge pressure model by Srivastav et al. and the model is extended for eccentric annuli by a correcting term based on the simulation results.

The paper presents an application of CFD to swab and surge pressure modeling. It states a novel analytical pressure model that allows the direct calculation of pressure changes in an eccentric annulus.