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NUMERICAL SIMULATION OF CASING CENTRALIZATION

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One of the main requirements to casing that provides cementing of oil and gas wells during drilling and operation is their optimum centralization, which allows achieving a better homogeneity of the slurry flow in the annulus. This is once more reminded the recent Macondo disaster. Optimum standoff between the borehole wall and the casing is ensured with special devices, centralizers put on the casing and spaced along it in a certain pattern. There are two types of centralizers: rigid and flexible (bow-spring) ones.

Methods of determining the standoff between the borehole wall and the casing body are described in Recommended Practice 10D-2 for Centralizer Placement and Stop-Collar Testing, 2004. These methods are based on the so-called “soft” pipe model, where the bending stiffness of the latter is not considered. Unfortunately, for wells with a high degree of tortuosity and substantial change in diameter along the MD this model does not always work satisfactorily. In paper [2] a serious step was made towards improvement a standard model; however, it also requires further refinement of the model of contact forces acting on the pipe in the wellbore with the varying diameter as well as improvement of the numerical methods for solution of a contact problem.

This paper offers a numerical solution to the centralization of casing that is stiff to bend. The model considers 3D dynamic equations of the lateral motion of a long pipe in the well with constrained displacements in wellbore considering all the major factors typical of casing exploration. This model represents a further development of multi-functional DYNTUB model, previously designed for the dynamic simulation of tubular in wellbore, including drilling with rotation and without rotation, buckling, whirling, tripping operations, etc. [2].

Considering the effect of elasticity centralizers does not require major changes to the model; they can be viewed as protruding elements on the pipe body like tool joints or BHA stabilizers, which are taken into account in DYNTUB model. When developing a model of flexible centralizers, four types of contact must be considered:
1) No contact with the borehole;
2) Point contact when the borehole diameter is more than the centralizer diameter;
3) Contact along the entire perimeter of the borehole when the centralizer diameter is more than borehole diameter;
4) Arc contact when the centralizer diameter is more than borehole diameter.

Depending on the contact type, an expression is proposed for the contact force normal to the borehole wall, and the friction force.

Static stress-strain state of casing with centralizers is determined by means of establishing a dynamic process, the initial condition for which is determined in a rather arbitrary way. Partial differential equations describing the dynamics of pipes are approximated by finite differences over length. Iintegration in time is performed by an explicit scheme. The artificial inertia and damping are inserted in system for improving of algorithm convergence. It allowed achieving good numerical stability while maintaining high accuracy of approximation.

The main parameter characterizing the centralizer performance is the standoff ratio (SR) defined as a percentage of the minimum annular gap between the borehole wall and the casing OD to the nominal annular gap. Figure shows an example of SR distribution along the 7-in 38.7 kg/m casing equipped by 10 ¼-in bow-spring stabilizers an inclined 60-deg well with a substantial change of borehole diameter.

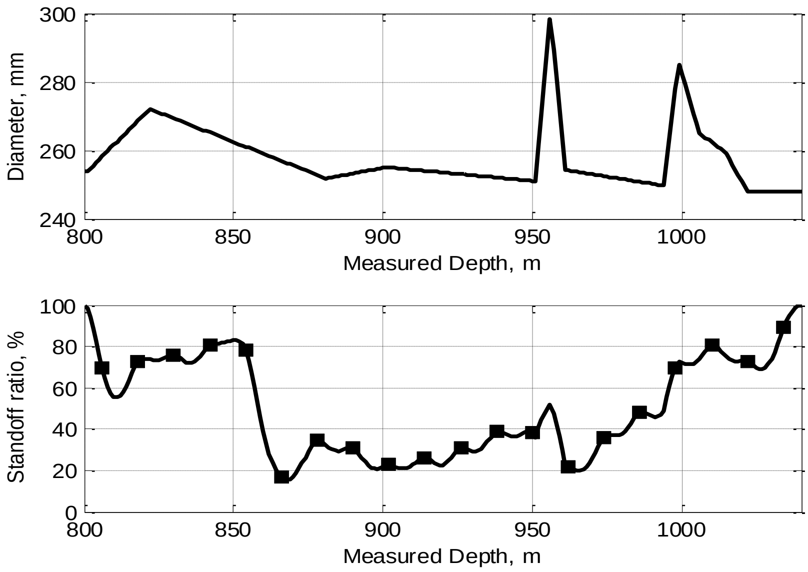

Figure. Hole diameter and standoff ratio versus depth
(points indicate position of centralizer)

The report gives other examples of SR calculation for a tortuous wellbore and studies the centralizer size effect, the casing rotation while running, and other factors. SR calculation results will be used to determine the optimum placement of the centralizers along the casing.

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