Determination of the hydraulic fracturing initiation pressure for different types of the well completion

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In the present talk, we consider a problem of determining the minimal pressure required for the initiation of a hydraulic fracture. Three cases of well completion are observed: open borehole, open borehole containing a packer, and cased wellbore with perforations. For each type of the well completion, the problem is solved numerically in a rectangular 3D-domain with the well located inside. Orientation of the wellbore to the eigen vectors of the geological stress tensor can be arbitrary. For the first two cases, the well is modelled as a cylindrical hole inside a rock formation. For the cased wellbore, the geometry involves a steel pipe, a coaxial cement sheath and a surrounding rock. The perforations are situated perpendicular to the well and have a cylindrical body with a spherical ending.

The problem is a set for equations of the linear elastic solid equilibrium subject to the prescribed stresses over boundaries. Normal fluid pressure is defined over the inner surfaces of the well and the perforations. The stress state over the outer boundary is taken from the analytical Kirsch solution for the wellbore without perforations [1, 2].

The problem is solved numerically by the finite element method using the open-source software package FreeFem++ [3]. Construction of the geometry and the numerical mesh is implemented in the open 3D mesh generator Gmsh [4]. The created numerical module calculates the stress-strain state near the wellbore and determines the initiation pressure according to several failure criteria.

As a result, the potential zones of a rock failure during the hydraulic fracturing initiation are presented. The module takes into account the complex geometry of the wellbore's competition, differences in physical properties of the materials, as well as the arbitrary in-situ geological stress. All calculations are performed automatically for given geometrical and physical characteristics of the well.

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