



A borehole temperature during drilling in a fractured rock formation

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Abstract

Drilling in brittle crystalline rocks is often accompanied by a fluid loss through the finite number of the major fractures intercepting the borehole. These fractures affect the flow regime and temperature distributions in the borehole and rock formation. In this study, the problem of borehole temperature variation during drilling of the fractured rock is analyzed analytically by applying the approximate generalized integral-balance method. The model accounts for different flow regimes in the borehole, for different drilling velocities, for different locations of the major fractures intersecting the borehole, and for the thermal history of the borehole exploitation, which may include a finite number of circulation and shut-in periods. Normally the temperature fields in the well and surrounding rocks are calculated numerically by the finite difference and finite element methods or analytically, utilizing the Laplace-transform method. The formulae obtained by the Laplace-transform method are usually complex and require tedious numerical evaluations. Moreover, in the previous research the heat interactions of circulating fluid with the rock formation were treated assuming constant bore-face temperatures. In the present study the temperature field in the formation disturbed by the heat flow from the borehole is modeled by the heat conduction equation. The thermal interaction of the circulating fluid with the formation is approximated by utilizing the Newton law of cooling at the bore-face. The discrete sinks of fluid on the bore-face model the fluid loss in the borehole through the fractures. The heat conduction problem in the rock is solved analytically by the heat balance integral method. It can be proved theoretically that the approximate solution found by this method is accurate enough to model thermal interactions between the borehole fluid and the surrounding rocks. Due to its simplicity and accuracy, the derived solution is convenient for the geophysical practitioners and can be readily used, for instance, for predicting the equilibrium formation temperatures.

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1. Introduction

A reliable assessment of thermal interaction between the borehole and the surrounding rock formation is of considerable interest in a number of geophysical

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