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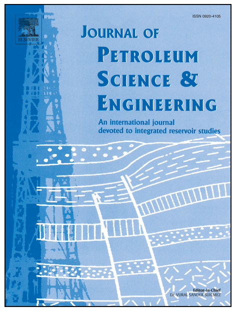

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Comprehensive Modeling for Temperature Distributions of Production and Geothermal Wells☆

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Abstract

When producing hot fluids from a reservoir, production wells experience temperature changes with depth for different tubing, casings, cements and wellbore interfaces. The changes of the fluids' temperature depend on many factors. Production flow rate, specific heat capacity (SHC) of produced fluids, thermal conductivity (TC) and viscosity of annular fluids, Joule-Thomson effect on produced fluids, radius of wellbores, annular clearance, inclinations and production time are some of the parameters playing an important role in the heat transfer across the wellbore between produced fluids and formations. Modern downhole production tools are equipped with a temperature sensor to monitor the temperature variation with production time. It is important, however, to be able to predict how the temperature will be changing during the various production phases depending on the production rate and other operational parameters. This information is also valuable in downhole pressure estimation, as the viscosity of the produced fluid varies with temperature. A robust temperature estimation technique is therefore required to be able to estimate the temperature distribution along the well.

A comprehensive wellbore heat transfer model for oil production wells has been developed in this study. The model considers a fairly complex wellbore configuration consisting of five wellbore sections with multiple annulus (annulus A, B and C), with the possibility of natural/free heat convection taking place in three brine filled annulus. Correlations taking temperature and pressure into consideration have been implemented for all thermophysical properties, such as TC of tubing, casings, and cements, SHC, viscosity and TC of annular/produced fluids, and densities of produced and annular fluids to mention some. The program allows for custom well configuration and is able to calculate the temperature at the interfaces between the wellbore, casings and tubing. It also allows to use properties of the fluids, casing/tubing, cement and formation other than those used in the simulations presented in this paper.

Extensive knowledge of the effect of the essential parameters on the heat transfer is of great importance for the performance of production wells. Sensitivity analysis has been performed to demonstrate the importance of properties of produced/annulus fluids, wellbore architecture and operational parameters in oil production. Our work is a good tool to analyze the thermal performance of wellbores, fluids and so on with a lot of potentials for different applications, like annulus pressure build up, well plan and casing/fluid design for production/geothermal wells.

Keywords: Temperature model, production wells, heat transfer.

1. Introduction

Knowing correct casing and tubing temperatures in completed wells is of great importance for multiple applications. Tubing/casing stress analysis, selection of appropriate materials for the well constriction - are some of the examples of the application areas where the accurate temperature information is required. It is increasingly important as we drill deeper, with pressure margins becoming smaller. Precise temperature estimates are also important for geothermal wells, due to many of the same reasons as for oil wells, but also to maximize the energy extracted from wells.

The motivation of this study is to develop a comprehensive and accurate temperature model for oil production/geothermal wells, and to perform a sensitivity analysis to get a better understanding of the mechanisms controlling the heat transfer in a well with a complex configuration consisting of multiple casings, multiple fluid filled annulus, and depth/temperature-dependent

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