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Thermal Analysis of a Perforated Vertical Wellbore

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Abstract

A numerical simulation of the effect evaluation of heat loss and temperature distribution along the wellbore is performed, for two models, the first is an open hole (without perforation) and the other is a perforated vertical wellbore. In this study, the Computational Fluid Dynamics (CFD) software code ANSYS FLUENT 15.0 has been used, for simulate a model of 3-D turbulent flow with stander k-ϵ model. The results of this show that, increasing the heat losses leads to an increase in the temperature gradient, while the temperature gradient decreases with increasing inlet main velocity. Also, the temperature of the produced crude oil decreases with increasing the length of the wellbore.

Keywords: Vertical wellbore, Perforation, Heat loss, CFD, Numerical.

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1. Introduction

The fluid temperature enters into a variety of petroleum production operations calculations, including well drilling and completions, production facility design, controlling solid deposition, and analyzing pressure transient test data. Until the 1950, there were no substantial developments in this field except some unreliable laboratory-based correlations. In 1962, Ramey [1] presented the first transient heat transfer model of the vertical wellbore. He developed an approximate solution to the wellbore heat-transmission problem involved in injection of hot or cold fluids. The solution permits estimation of the temperature of fluids, tubing and casing as a function of depth and time. The result is expressed in simple algebraic form suitable for slide-rule calculation. The solution assumes that heat transfer in the wellbore is steady-state, while heat transfer to the earth will be unsteady radial conduction. The method used may be applied to derivation of other heat problems such as flow through multiple strings in a wellbore. Charles and Igbokoyi [2] developed the prediction model for flowing temperature distribution for a single-phase, two-phase, three-phase and identifying fluid type and properly analyzing its effect on temperature profile in the wellbore. The model can also be used to identify the parameters that affect the temperature profiles. The results showed that, there is a change in the temperature of the oil along the well, where the percentage of the decrease in the temperature from 152 °C to 138 °C, for a length of 4500 ft, and a flow rate of 4000 bbl/day. Xingkai et al. [3] studied the temperature distribution in the wellbore under different conditions using a designed horizontal well simulation experimental device. The experimental results were compared with the theoretical values. It was found that the error of the model was within 4%, which showed the reliability of predictions of the model. The experimental results showed that the Joule Thomson effect was significant in perforated wellbore. When the opening mode was the same, the larger the gas flow rate, the lower the temperature in the wellbore. Also, with the increase of liquid volume, the temperature drop effect decreased gradually. The more uniform the perforation distribution, the smaller the temperature change in the wellbore. With the increase of liquid volume, the influence of gas flow rate on temperature distribution decreased. The temperature gradient caused by Joule-Thomson effect decreased with the increase of wellbore holdup. Recently, Yang et al. [4] developed a transient heat transfer model for controlled gradient drilling. The model can be used to predict wellbore temperature distribution and to analyze the wellbore heat transfer efficiency for controlled gradient drilling. Tang et al. [5] developed three representative solutions for heat transfer in wellbore and formation: a fully numerical solution, a semi-numerical solution, and a fully analytical solution. These solutions play an important role in solving complex heat transfer models.

The aim of this research paper is to study the influence of heat loss and temperature distribution along the wellbore. Also, the effect of inflow velocity on the temperature distribution using the simulation program ANSYS FLUENT.

2. Numerical simulations

The rapid advancement of computer technologies and software enables the solution of theoretical simulations for complex applications. This paper investigates a thermal analysis of a single-phase flow through a vertical wellbore. The mathematical simulation with 3D model with turbulent flow in the vertical wellbore is performed. Using CFD ANSYS FLUENT. The vertical wellbore simulation is carried out using the conservation law (mass, momentum, and energy) in conjunction with the perturbation (k-ε) model [6].

The Finite Volume Method (FVM) solution of the continuity, momentum, energy, and turbulence model equations is used to explain the calculation process of the