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Numerical Simulation of a One-Phase Steady Flow Towards a Multistage Fractured Horizontal Well

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Abstract—This paper presents a 3D mathematical model and its numerical implementation for a one-phase flow around a multistage fractured horizontal well with transverse fractures. The flows in the reservoir and in the fractures are governed by the Darcy's law and were simulated separately. The problem was approximated by the finite volume method. The obtained systems of linear equations for the reservoir and the fractures were solved simultaneously, which allowed us to avoid the use of iterative process for solution adjustment both in the fractures and the reservoir. We investigated various techniques and proposed an optimal variant for solving ill-conditioned systems of linear equations appearing due to the grid approximation of the continuous mathematical flow model. We also studied how the fractures and well parameters affect the well productivity.

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1. INTRODUCTION

Vertical injection and production wells are traditionally used for developing oil reservoirs. Horizontal well (HW) drilling makes it possible to increase the oil recovery especially at the last stage of development. Another way to increase the oil recovery is hydraulic fracturing (HF), which is the most effective for high viscosity tight oil formations. Usually HF is performed on vertical wells. Nowadays, however, a new type of fracturing—multistage HF (MSHF)—is widely accepted. For this type, certain fractures (transverse fractures) are located on the orthogonal planes relative to the horizontal well axis.

Alongside with the development of horizontal well drilling techniques with MSHF and expansion of their usage in practice, theoretical investigations of complicated processes in the "reservoir-hydraulic fractures-well" system are being evolved. Mathematical descriptions of the fluid inflow towards HW with MSHF can be different and depend on the purpose of the model.

Numerical calculations of the fluid inflow towards horizontal wells with MSHF have recently become widespread. The advantage of numerical schemes is that they make it possible to get the desired result taking into account the flow in all subareas with complicated geometry and inhomogeneity. However, they require much more computation compared with analytical and semi-analytical methods.

The universal packages for HF modeling apply some simplifications. In commercial programs such as Schlumberger Eclipse and ROXAR Tempest More, wells with HF are modeled by using equivalent skin-factor. To define this factor, a correlation between the productivity of a multistage hydraulically fractured HW and the fracturing parameters is used. This kind of results for infinite permeability fractures was obtained by the electro-hydrodynamic analogy method [1, 2]. McGuire [1] solved a three-dimensional problem in a parallelepiped reservoir containing one well and two fractures. The reservoir

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