Mathematical models of DC electric field for Enhancement of Oil Recovery

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Abstract

The finite element equations of numerical models were derived. The osmotic flow mechanism in fractured-vuggy media under the influence of electric field was systematically investigated using COMSOL Multiphysics software. The distributions of velocity, pressure, and potential in the fracture and vug were studied. The results show that the electric field effectively increases osmotic flow. The distributions of isobar and equipotential line can be affected by the fracture and vug. Overall, the findings offer an important theoretical basis for the enhancement of the power of fractured-vuggy reservoir via direct current (DC) electric field methods. The 15.0 V-regulated DC power supply was initially designed according to the results of the simulation, and then MULTISIM simulation software was applied. waveform state and thereby meeting the requirements. Inductance-capacitance was then utilized to filter the DC power, resulting in a smooth simulation of capillary displacement.

Keywords

Cell's capillaries, osmotic flow, DC electric field, fractured-vuggy.

1. Introduction

Capillary electrophoresis, capillary driven power solution is the electroosmotic flow. The electroosmotic flow, capillary material transfer more quickly, the electroosmotic flow seepage smaller mass transfer more slowly. To improve the biomass of electroosmotic flow is a new technology using DC electric field, which mainly influence through physical field of fluid saturation capillary of medium, the medium electrochemical effects and electroosmosis, electrophoresis and so on many kinds of electrodynamics, thus changing the flow law of capillary. This technology at home and abroad has been more than experts, scholars have studied several studies on the technology of improving recovery by imposing electricity on oil have been reported. However, most of them mainly involved qualitative analysis. Previous research has established the osmotic flow formula of electro dynamic and hydrodynamic forces based on the model of capillary electro dynamic and hydrodynamic forces; the unsteady one-dimensional leading displacement edge was based on the Buckley –Leverett model.

2. Numerical Modeling

2.1 The Modeling

The ideas on and methods of seepage influenced by the external electric field were analysed via COMSOL Multiphysics and finite element methods consisting of three stages: (1) pre-processing and data entry; (2) finite element matrix calculation, assembling, and solving; and (3) data output and post processing phase.

The concrete procedure of modelling is as follows:

(1) In the inter phase of operating the software, the cuboid was cut to acquire a 0.5mx0.2mx0.2 m dimension.

(2) In the established place, a 0.01m radius cylinder was taken in a horizontally open fracture (0.5m in length) whose sectional view is shown in Figure 1.

(3) In the passage of the three-dimension model, a round hole with the same radius as the diameter of the spherical hole was taken. As a result, a round hole with 0.08m radius was constructed in the well-established area.

(4) The fracture and hole established in the aforementioned procedures were combined into the entity; the inside boundary was removed.

(5) The generated part and the whole area were placed into the complete part. Figure 2 shows the sectional view of the single-fracture calculating model.

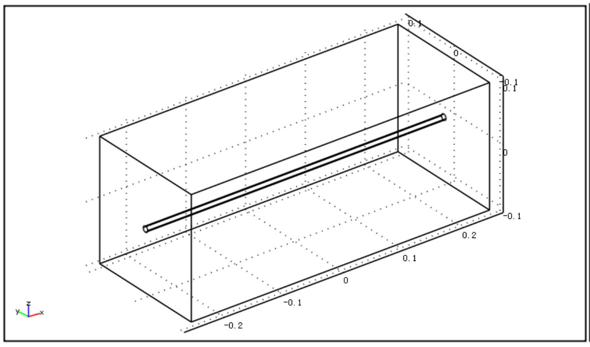

Figure 1. Structure of the single-fractured model of crack

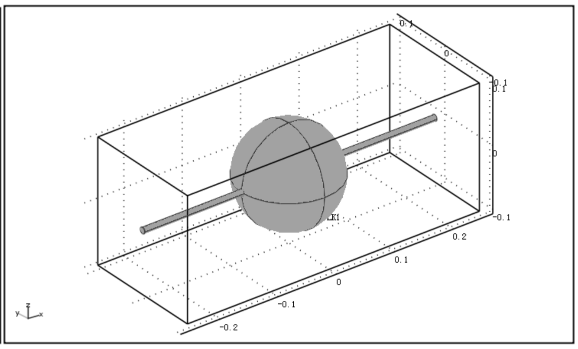

Figure 2. Structural model of the single-slit hole.

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Footnotes are permitted for notes pertaining to the text only. For biographies and funding acknowledgements, please refer to Section 2.3.1.

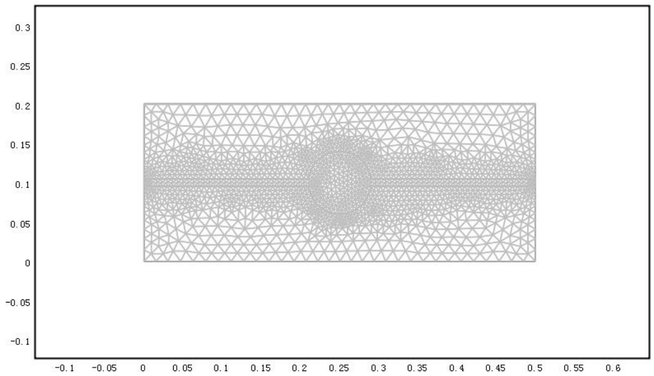

Figure 3. Fractured triangle mesh model.

2.2 Imposing of the boundary condition and division of the grid

The boundary condition was imposed after the establishment of the model. The boundary was created to set the WASD boundary of the model in COMSOL Multiphysics.

The boundary of the different materials was divided equally. In the single-fracture model, the holes make the model irregular in some way. Therefore, division through the triangle grid can be directly done, or a four-node quadrilateral can be used by adding lines. The division of the grid is shown in Figure 3. The figures followed the x- and y-axis graph model to facilitate observation.

3. Results and discussion

3.1 Speed distribution in the cell's capillaries fracture and hole under the influence of a DC electric field

The electric energies were 0, 3, and 5V at 1000Pa entrance pressure. The speed distribution (in meters) is shown in Figures 4, 5, and 6.

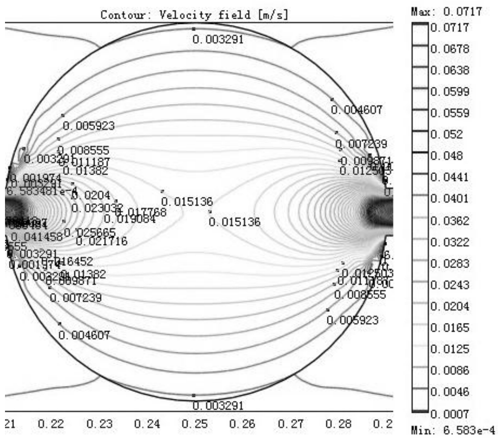

Figure 4. Equipotential line chart of velocity field at 0V potential energy.

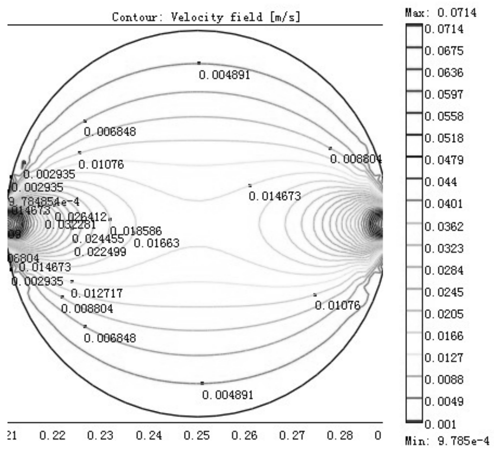

Figure 5. Equipotential line chart of the velocity field at 3Vpotential energy.

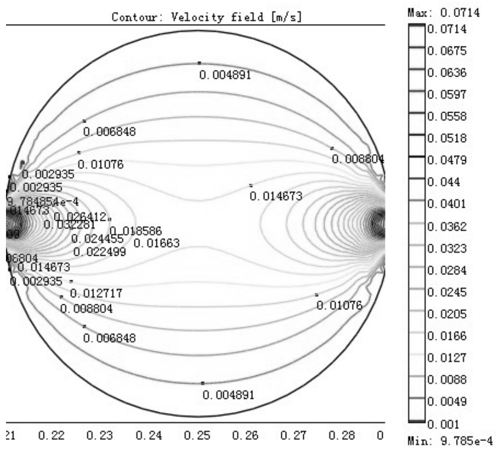

Figure 6. Equipotential line chart of the velocity field at 5Vpotential energy.

The speed near the wall of the round cave is 0.003291 and 0.004891ms-1 under the absence and presence of an electric field, respectively (Figures 4 and 5). The presence of an electric field results in a much faster speed compared with that without electric field.

Thus, electric field decreases the wallop of fluid to the wall, saves energy, and increases speed. Fluid speed increases with an increasing DC electric field energy (Figure 6), indicating that the electric field can significantly increase fluid speed.

Table 1: Different seepage velocities under different electric potentials of the point (0.276 622 and 0.129 849).

Electric potential(V)	Seepage velocity of the point (0.276 622 and 0.129 849; e-3 ms-1)
0	2.962 859
1	3.439 585
3	4.158 801
5	5.017 988

4. Application and simulation

Figure 7 shows the whole power circuit. Figure 7 shows the simulation circuit. They show the results of this simulation.

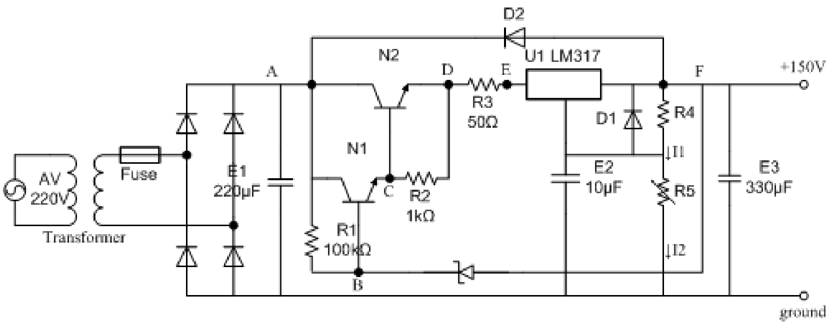

Figure 7. Power circuit.

5. Conclusion

(1) Fracture-hole speed and pressure distributions were examined under the influence of an electric field. The DC electric field significantly increases fluid speed, and the effects are very obvious at 150V electrical potential.

(2) The whole circuit of the DC electric field was designed for practicability reasons. In addition, the requirements of the DC electric field were met using MULTISIM emulation software.

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