VISCOUS FINGERING IN FIVE-SPOT IMMISCIBLE DISPLACEMENT

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Abstract
The work, presented in this paper, is a numerical study that deals with the phenomenon of viscous fingering in a five-point geometry that is considered a good model of oil fields. In order to investigate the effect of the presence of the fractures and their distribution in the porous medium, three different cases are considered in this study. We considered a porous medium fully saturated with oil. Water is injected through an injection well to push this oil to a production well. The interface of the two fluids is visualized as a function of time. The flow equations are solved using the finite volume method (FVM).

Keywords: *Multiphase flow; Porous medium; Viscous fingering; Fracture.*

1. Introduction

Water flooding is widely used in the oil industry to improve the oil recovery due to its low costs and simple operations [1]. Because of the difference in viscosity of the two fluids, an instability, called viscous fingering, can occur at the interface of the two fluids [2,3]. This instability, which has been the subject of much research, occurs in a wide variety of industrial and natural processes, particularly in the enhanced oil recovery where this phenomenon is undesirable because it reduces the sweep efficiency [3, 5]. Faced with a double complexity, that of the nature of the porous medium and that of the nature of the flow, most of the researchers concentrated on simple geometries and on the qualitative aspect of the phenomenon [3]. In this work, we consider a five-point configuration with a injection well located at the center and four injection wells at the corners of a square.

2. Mathematical Model

We consider two-phase flow in a porous medium where both fluids are immiscible. The equations which govern a two non miscible phase flow in a porous medium are the mass conservation equation for each fluid phase and generalized Darcy's law:

$$\frac{\partial(\phi.\rho_i.S_i)}{\partial t} + \nabla.(\rho_i \mathrm{u_i}) = 0 \,, \qquad i = \text{oil, water} \tag{1}$$

$$\mathrm{u_i} = -\frac{\mathrm{K}.K_{ri}}{\mu_i}\nabla P_i \tag{2}$$

where ϕ and K are respectively the porosity and permeability of the porous media. K_{ri}, S_i, ρ_i and μ_i are respectively the relative permeability, the saturation, the density and the viscosity of the i phase. To simplify the problem, we consider $K_{ro} = K_{rw} = 1$. This system of equations is completed by the following relations:

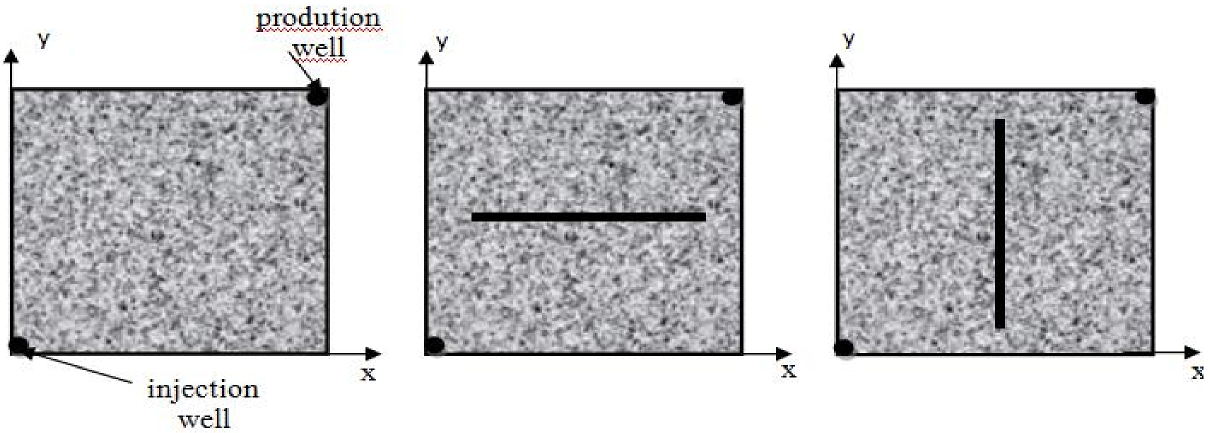
$$S_o + S_w = 1 \tag{2}$$

$$P_C(S_w) = P_o - P_w \tag{3}$$

Injection and production point pressures are 1.79MPa and 1.31MPa

3. Different cases

The field is a porous medium of dimensions $2mx2m$, porosity $\varphi = 0.2$ and permeability $\mathrm{K} = 0.4737\mathrm{x}10^{-8}\mathrm{m}^2$. Three cases were considered. In the first case, the porous medium is homogeneous while in the second and third cases the medium is considered a medium containing fractures medium (Figure1). The fracture has an opening of 1 cm, a porosity $\phi = 0.2$ and a permeability $\mathrm{K} = 10^{-3}\mathrm{m}^2$. The medium is initially saturated with oil ($\rho_w = 826\ kg.m^{-3} et\ \mu_w = 0.00762076\ \mathrm{kg.m^{-1}.s^{-1}}$).Water ($\rho_w = 998.2\ kg.m^{-3} et\ \mu_w = 0.00103\ \mathrm{kg.m^{-1}.s^{-1}}$) is injected through the injection well to push the oil to the production well.

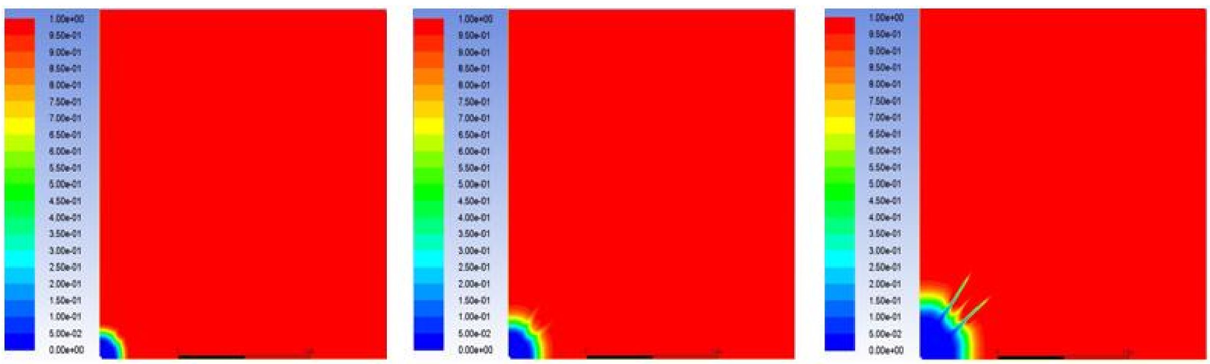


Case1. homogeneous medium **Case2.** medium with an horizontal fracture **Case3.** medium with vertical fracture

Figure. 1 : Physical domain

4. Results :

Some results corresponding to the first case are presented as saturation fields :



t=0.6s t=1.2s t=1.7s

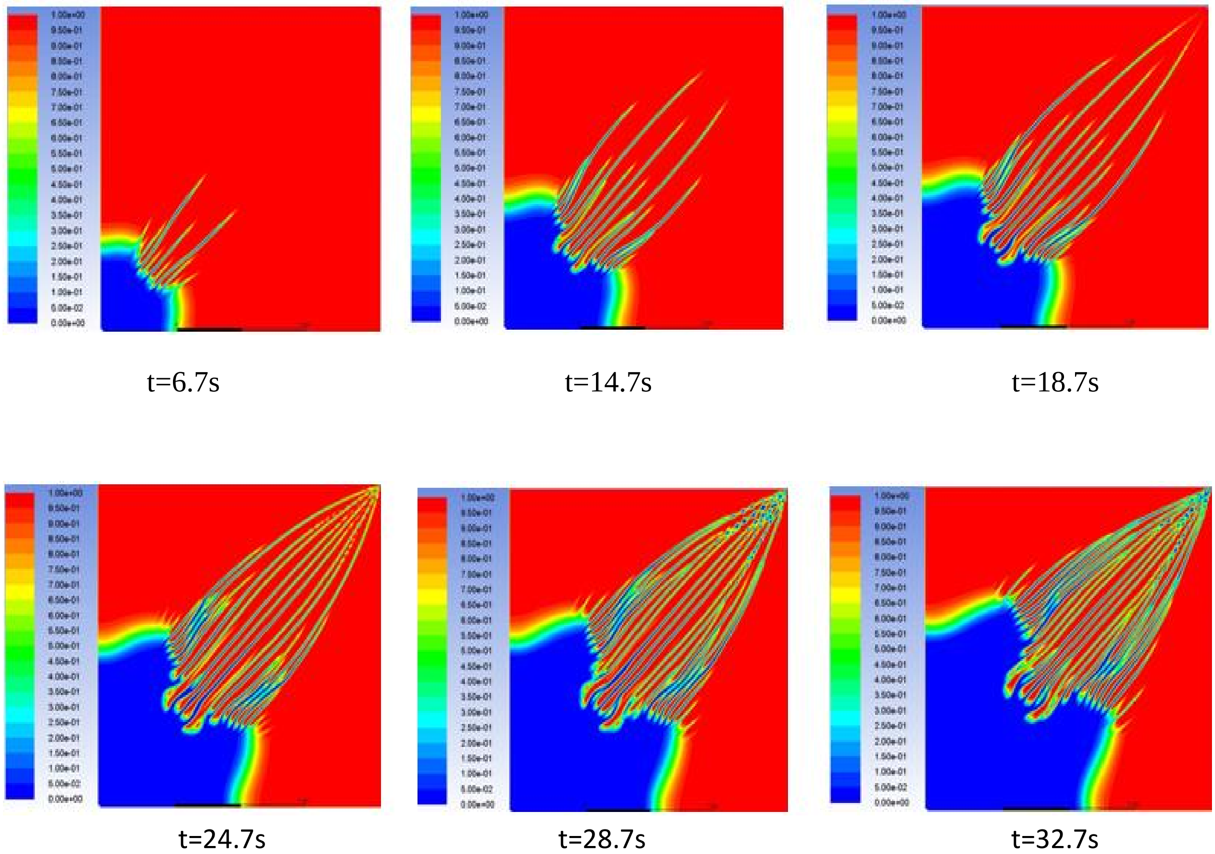


Figure. 2 : oil saturation field

5. Conclusion :

The numerical study of a multiphase water-oil flow has been presented in this work. We successfully simulated immiscible viscous fingering during water flooding in five-spot system. The influence of the fractures of the porous medium on this flow and on the formation and the propagation of viscous fingers was examined.

- The characteristics of the porous medium modify the behavior of the water-oil interface and the breakthrough time. This result is in agreement with previous studies.

- The number and disposition of fractures affect significantly the number of the fingers

- The number and disposition of fractures affect also the velocity of propagation and the direction of the fingers through the porous medium.

6. References

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