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Horizontal Well Bottom-Hole Pressure Drop Steam Flooding Numerical Calculation

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Abstract

In the steam flooding process, when steam injection rate is high, wellhead and bottom hole string pressure substantially increased, oil displacement effect is affected. The numerical simulation method was used to study the process of horizontal steam flooding steam injection rate, steam hold on horizontal liquid rate and the number of holes, pore size to wellhead and bottom-hole pressure and the influence of tubing string. The calculation results show that: the steam injection amount was larger, the more pressure on the bottom of the well and string; the pipe diameter holes on the quantity increased, and the bottom of the well and the smaller string pressure. Injecting steam with more liquid rate the higher pressure were on the bottom of the well and string. Only properly reduce steam injection rate and the liquid rate, holes quantity and holes were reduced .the inner diameter tubing stress and bottom holes dramatically risen could be effectively reduced.

Key words: Horizontal well; Steam flooding; Numerical simulation; Pore size; Pressure drop

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INTRODUCTION

Since 1985, many foreign scholars got some valuable results in the study of stress analysis of horizontal wells. In 1988, F. J. Kuchuk, E. Ozkan, R. Reghavan et al. using Green source function and other methods to study the transient pressure in a horizontal well in the anisotropic media with bottom water and gas cap; R. S. Calvalho using Laplace positive and inverse transform method first calculates the dual porosity medium pressure dynamic horizontal wells; In 1991, the method of separation of variables is used by Liu Ciqun to get three-dimensional unsteady flow solution in Laplace space in extending horizontally infinite dual-porosity media type horizontal well; 1994, E. Ozkan and R. Raghavan deduce some of the more sophisticated analytical results; 1994, E. Ozkan and R. Raghavan deduce some of the more sophisticated analytical results. Liu Xiangping, Zhang Zhaoshun has done a lot of research and seepage coupling model of reservoir pressure drop in horizontal well bore for single phase flow distribution on pressure drop distribution in single-phase flow and reservoir seepage coupling model horizontal well bore; Wei Jianguang studied pressure drop of horizontal wells distributed two-phase laminar flow; On the basis of previous studies, further research of pressure drop were given in horizontal well bore gas and liquid two-phase flow. The Fluent software is applied in this paper to simulate the underground pipe column, The steam injection rate, steam injection liquid holdup, horizontal well column holes number and aperture effect on the pressure were studied ,in order to improve the effect of reservoir development objective.

1. THE ESTABLISHMENT OF MATHEMATIC-AL MODEL

Considering the complex situations of gas and liquid two-phase flow, the numerical model has been simplified assumptions based on the physical model in order to highlight the main physical phenomena.

(1) Gas, liquid two-phase flow for the three-dimensional flow in pipeline.

(2) In gas and liquid two-phase flow process, there is no heat exchange between the gas and liquid.

(3) there is no heat exchange between the inner tube and the outer tube.

(4) Ignoring the volume change of mixed liquid and the radial slip in gas and liquid two-phase.

Without considering the transformation between gas and liquid two-phase.

Equations can be given based on these assumptions.

(1) Liquid mass flow equation

$$G' = \rho'\omega'(1-\Phi)A = G(1-x)$$

(2) Vapor mass flow equation

$$G'' = \rho''\omega''\Phi''A = Gx$$

(3) Continuity equation

$$G = \rho \upsilon A$$

(4) The total mass flow equation

$$G' = G' + G''$$

(5) Liquid mixture continuity equation

$$\frac{d}{dz} = [\rho'\omega'(1-\Phi)A + \rho''\omega''\Phi A] = 0$$

Type in: G′-Liquid mass flow amount, kg/s; G″-Vapor mass flow amount, kg/s; G-Total mass flow rate, kg/s; ρ'-Liquid phase density, Kg/m^3; ω'-Liquid flow rate, m/s; Φ-Void fraction, m^2/m^2; A-Sectional area of the pipe, m^2; x-Gas mass fraction, kg/kg; ρ″-Gas phase density. Kg/m^3; ω″-Gas flow rate, m/s; θ-The angle between the pipe and horizontal line; ρ-the mixture density, Kg/m^3; z-pipe section number.

2. HORIZONTAL WELLS MODEL

2.1 Model Overview

As shown in Figure 1, there is a horizontal with 386 m length and 2,000 m from the ground. The horizontal pipe casing pressure of 15 MPa tubing to ensure that the liquid mixture injected into the well bore from tubing. The 2, 4, 6-segments of model were respectively the perforated tube 32 holes, 24 holes, 16 holes, this three-segment model diameter is 5mm and length is 2 m. The length of 1, 3, 5, 7-segments of model are 95 m. The length of 8 segment of model is 2,000 m. Analyze the impact of hole diameter、the number、injected fluids of different gas-liquid-liquid mixing ratio of flow rate to the pressure.

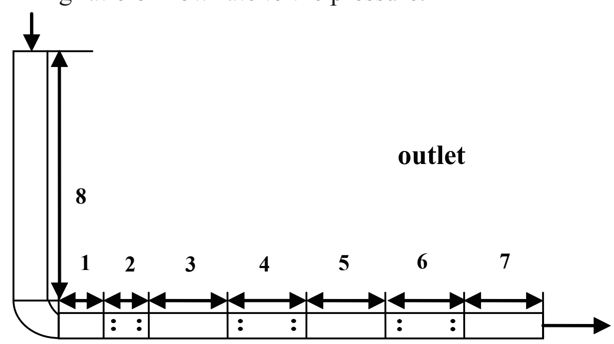

Figure 1
Model of Horizontal Well

2.2 The Main Physical Parameters

The flowing of gas and liquid two-phase flowing in a horizontal tube with a certainly speed. The main relevant physical parameters are shown in Table 1.

Table 1
The Main Physical Parameters

Length of pipeline (m)	Tube diameter (m)	Outlet pressure (MPa)	Liquid density ($kg \cdot m^{-1}$)	Vapor density ($kg \cdot m^{-1}$)	Aperture (m)
386	0.057	15	1000	1.29	0.01/0.02

3. CALCULATION AND ANALYSIS

3.1 Different Inlet Speeds the Pressure Drop

The pressure of two-phase flow is focus on the orifice number of horizontal pipe. Figure 2 shows the inlet velocity 7 m/s horizontal tube gas-liquid two-phase flow pressure trends. Figure 2 shows the number of holes, the more the walls of the pipe, the pressure drop trends more obvious.

In the same situation of the horizontal tube structure parameters and the basic operating parameters，the curve of the tubes length and the pressure change when changing the gas liquid two-phase flow rate to 5, 7, 11 m/s are shown in Figure 3. The results showed that the higher the speed of horizontal tube gas-liquid two-phase flow, the more obvious the pressure drop trend.

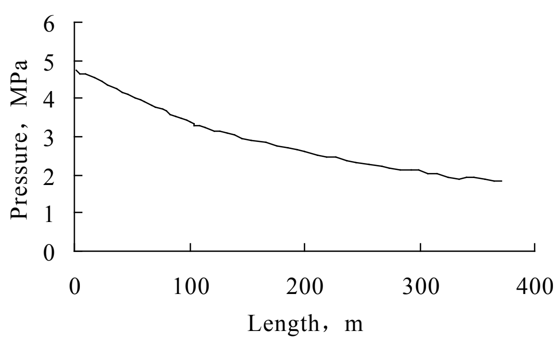

Figure 2
The Relationship Between Horizontal Tube Length and the Pressure When Inlet Velocity of Gas-Liquid Two Phase Flow Is 7 m/s

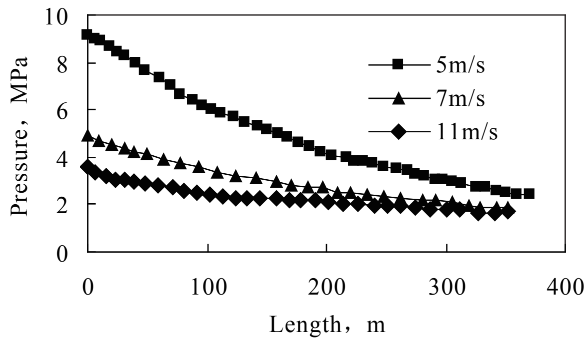

Figure 3
The Relationship Between Horizontal Tube Length and the Pressure of Gas-Liquid Two Phase Flow in Different Inlet Velocity

Gas, liquid two-phase flow has a great impact on the pressure drop of the tube. In the same situation of the horizontal tube structure parameters and the basic operating parameters, setting the inlet velocity of 7 m/s, the pressure curve when changing the gas-liquid two-phase flow rate of the liquid for 0.05, 0.25, 0.45 are shown in Figure 4. As can be seen, the gas liquid two phase flow at the same inlet velocity, with the gas and liquid two phase flow of liquid holdup increases, the pressure drop has a more obvious tendency.

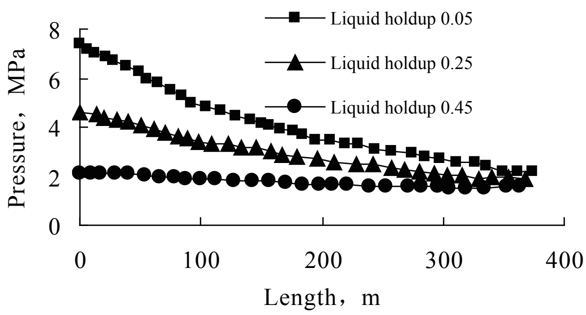

Figure 4
The Relationship Between Horizontal Tube Length and the Pressure of Gas-Liquid Two Phase Flow in Different Rate of the Liquid

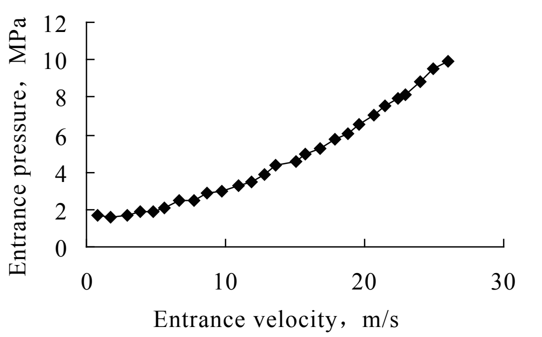

Figure 5
The Relationship Between Different Inlet Velocity of Gas-Liquid Two Phase Flow and Pressure

When gas, liquid two-phase flow rate was held unchanged at 0.05, changing the velocity level of two-phase flow enters the inlet pipe to 1 - 25 m/s, the trend of the inlet pressure are shown in Figure 5. As can be seen, the higher the liquid two-phase flow inlet velocity, the faster the inlet pressure rises.

When analyzing the relationship between the gas and liquid two-phase flow velocity and inlet pressure inlet, gives when a gas, liquid two-phase flow in the liquid holdup were 0.05, 0.25, 0.45, the inlet pressure under different inlet velocity trend are shown in Figure 6. As can be seen, the higher the gas liquid two phase flow rate, the higher inlet pressure in the same speed.

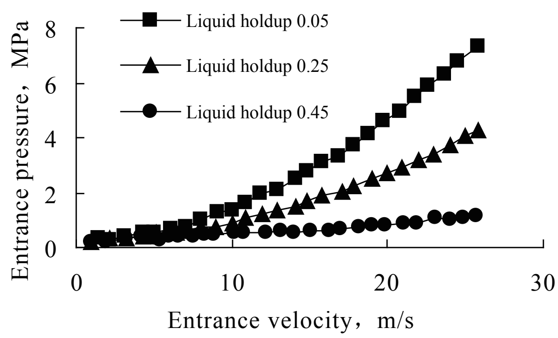

Figure 6
The Relationship Between Different Rate of the Liquid of Gas-Liquid Two Phase Flow and Pressure

3.2 Different Pore Pressure Drop

The Bore holes on the wall has a certain level of influence on the horizontal pipe pressure drop, In the same situation of the horizontal tube structure parameters and the basic operating parameters, when the inlet velocity is constant 7 m/s , Changing the hole diameter was ø10, ø20 mm, the pressure drop curve are shown in Figure 7. As can be seen, the trend of pressure drop is inversely to the pore size, and inversely to the pore number.

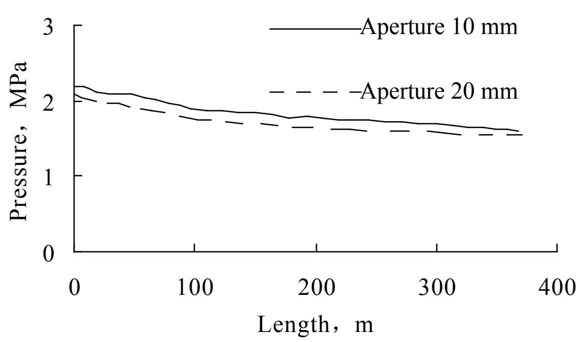

Figure 7
The Relationship Between the Length of Different Horizontal Tube Aperture and Pressure

Figure 8 is trend of the entrance pressure change different entrance speed aperture 10, 20 mm, liquid holdup is 0.05. As can be seen, the change rate of entrance pressure is inversely proportional to the size of the aperture of the tube wall.

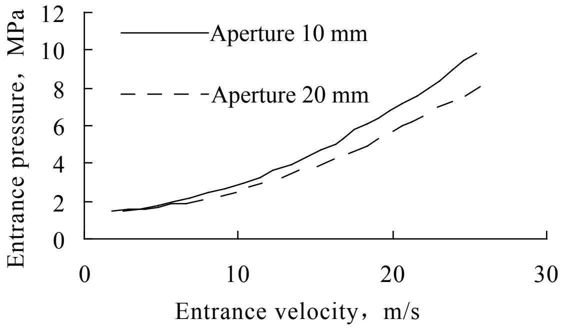

Figure 8
The Relationship Between Inlet Pressure of the Different Aperture and Pressure

CONCLUSIONS

(a) The establishment of three dimensional calculation model about gas-liquid two-phase flowing differential pressure in the horizontal tube, using the hybrid model and CFD analogy method evaluate the key influence factors of flow system.

(b) Gas-liquid two-phase flowing differential pressure increases as small pore quantity increases on the body wall; The higher entrance velocity of two-phase flow, the more apparent the loss of differential pressure. Adequately increasing the number of small pore quantity is recommended when pressure of well head and column is too high.

(c) The higher ratio of liquid phase in the gas-liquid two-phase flow, the more apparent pressure changes in the horizontal tube.The effect of the size ratio of liquid phase on differential pressure increases with the increasing velocity of flow. Adequately reducing liquid holdup is essential when pressure of well head and column is too high.

(d) The size of small hole diameter in the horizontal tube is always proportionate to pressure changes. It is essential to increase small hole diameter to prevent pressure of well head and column increased.

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