Research on Mechanism & Applicability of Vortex Tool Process in Gas Well

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Abstract: At present, drainage gas recovery technology is usually used to solve gas well drainage problems in the development of lard gas fields at home and abroad. A large amount of the produced water discharged from the bottom hole effusion is discharged to the ground. In the process of lifting, processing and injection consumes a lot of energy and greatly increased the capital investment and gas production costs, more serious is greatly shortened the economic life of gas wells, while the water produced by the environment also caused serious pollution. In order to achieve high efficiency of gas well production, it is necessary to further study and develop new technology suitable for gas field development, which can improve water drive energy and lifting rate, reduce energy consumption and reduce pollution. For better application of eddy current drainage gas recovery tools, better play to its performance, it is necessary to determine the eddy current drainage gas recovery tools use after the change of the flow pattern, the research on the mechanism both liquid eddy current drainage gas recovery tool, to analyze its influence factors, and carry on the optimization of structure, thus improve the efficiency of gas drainage and production efficiency.

Keywords: Eddy Current Extraction, Pulse, Gas-liquid Two-phase Flow, Liquid Carrying Capacity, Applicability

1. Introduction

As the production of most gas fields enters the stage of medium and high water cut, the rise of water production in the process of natural gas production is gradually accelerating, and the phenomenon of water and gas production often occurs in the gas production process of most low-producing gas wells. When the water production of the gas well reaches a certain level, it will seriously affect the normal production of the gas well, which is the main reason for the decline of gas production and even the occurrence of flooding and shutdown [1-3]. Therefore, in order to ensure the normal production of gas wells, it is first necessary to improve the liquid-carrying capacity of low-production gas wells. In order to solve this kind of problem, the research of drainage and gas recovery technology has been proposed, and has been widely developed and applied. The vortex drainage gas recovery tool can change the flow regime of the fluid from turbulent flow to spiral vortex laminar flow, reduce energy loss, and have the characteristics of improving liquid discharge capacity, reducing pressure loss, reducing production decline rate, and reducing Xiaoice plugging. After the use of vortex drainage gas production tools, the movement of gas-liquid two-phase flow in the wellbore will become extremely complex, and it is very difficult to study the simulated flow field. At present, there is a lack of relevant theoretical research on its structural design and performance prediction at home and abroad, and the drainage mechanism and influencing factors, the working conditions of the vortex drainage gas recovery tool immersed in the liquid accumulation are still unclear, and the flow pattern of the fluid changes after passing through the vortex drainage gas production tool, so it is necessary to establish a flow model to accurately describe the flow of miscible fluid. In order to better apply the vortex drainage gas recovery tool and maximize its drainage performance, it is necessary to determine the change law of the flow pattern after the use of the vortex drainage gas recovery tool, and then study the liquid-carrying mechanism of the vortex drainage gas recovery tool [4-7], and realize the optimization of the tool structure through the analysis of its influencing factors, so as to achieve the purpose of improving the drainage efficiency and production benefit of the gas well.

2. CFD Modeling of Vortex Tool Process

The movement state of the gas-liquid phase in the flow field of vortex tool is relatively complex, and there are great difficulties in the study of its moving flow field, and there is no quantitative calculation expression for the separation efficiency of downhole vortex tool. Therefore, in order to further understand the influence of spiral structure parameters of vortex tool on the liquid-carrying effect, CFD software was used to numerically simulate the influence of bottomhole working conditions, production parameters and spiral section structural parameters of vortex tool on the liquid-carrying effect, The model is constructed as shown in Figure 1 and Figure 2. The basic assumptions are as follows: (1) fluid motion is continuous; (2) When the fluid is at rest, the total pressure is equal to the hydrostatic pressure; (3) the fluid is homogeneous; (4) The inlet fluid is infinitely uniformly flowing, that is, the inlet velocity end face is evenly distributed.

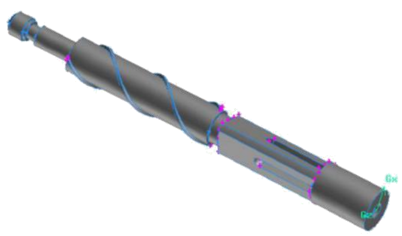

Figure 1. The Numerical Model of Vertax Tools

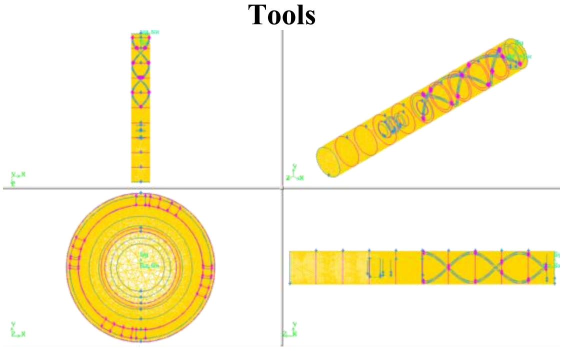

Figure 2. The Mesh Model of Vertax Tools

3. Analysis of Flow Field Characteristics

The figure shows the volume ratio distribution of the liquid phase imported to the end of the model during the vortex tool process, and the liquid phase is uniformly distributed on the flow field section when the gas-liquid phase initially enters the flow field. When the gas-liquid two-phase flow passes through the vortex drainage tool, the liquid phase distribution on the flow field section changes. In the initial stage, the liquid phase converges at the blades of the vortex drainage tool, because the gas-liquid two-phase flow has slipped, and the gas phase passes through the flow field at high speed, and the liquid droplets are blocked by the blades of the vortex drainage tool [8, 9]. As the gas-liquid two-phase flow continues to flow through the vortex tool, the liquid phase gradually converges to the outer wall of the wellbore. (In Figure 3)

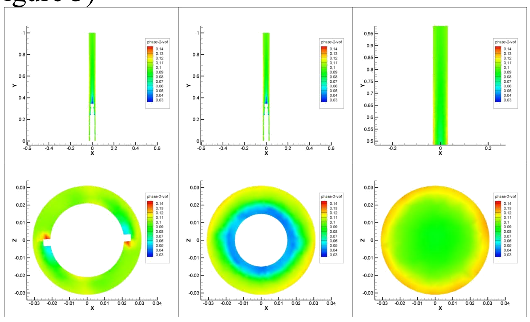

Figure 3. Liquid Phase Distribution

This stage is the front section of the flow field of eddy current drainage technology, this stage from the inlet end to the spiral section of the vortex drainage tool, by observing the internal changes of the flow field, it can be seen that the gas-liquid two-phase flow is evenly distributed in the inlet section, with the increase of the longitudinal distance, the gas-liquid two-phase flow flows to the spiral section of the vortex drainage tool, and the distribution of gas-liquid two-phase flow changes significantly. In the rear section of the vortex drainage tool, the liquid film is gradually evenly distributed along the periphery, and the inlet mist flow is transformed into a ring flow. After flowing out of the vortex drainage tool section of the spiral blades, the secondary vortex will gradually decay to the final disappearance, the fluid will do a spiral movement in the direction of the pipeline, the liquid film will be distributed along the circumferential direction of the circular pipe gradually and evenly, and the turbulence intensity of the fluid will be improved. Due to the decrease of swirl intensity, the deposition of droplets gradually weakens, and the thickness of the liquid film gradually decreases. Under the action of the main centrifugal force, the droplets are evenly distributed due to the influence of wall deposition and the pulling force of the existing liquid film.

4. The Distribution Law of Pressure Field

The figure shows the axial pressure distribution movement of the flow field of eddy current drainage technology, and it can be seen from the figure that the pressure of the gas at the inlet increases rapidly due to the resistance of the spiral blades, and reaches the highest point in the whole flow field. After passing through the spiral blades, the space gradually increases, the liquid gradually diffuses, and the pressure field decreases rapidly, because the gas-liquid two-phase flow increases after passing through the spiral section of the vortex drainage tool, and in the flow field at the rear end of the tool, the main item in the centre of the tangential cross-section of the flow field is the gas phase, and the flow field is a annular flow, which leads to the pressure of the outlet section is lower in the flow field, and the inner wall of the wellbore is slightly higher.(In Figure 4)

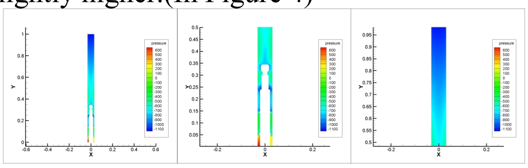

Figure 4. Pressure Profile in Flow Field

It can be seen from the pressure field distribution diagram of the vortex drainage tool that the vicinity of the vortex centre in the flow field of the vortex drainage technology belongs to the low pressure, and the fluid density on the cross-section remains basically unchanged when the gas-liquid two-phase flow, and the centrifugal force is related to the velocity and coordinate value, but not the density distribution, and the static pressure is mainly used to balance the centrifugal force. In this case, the distribution of static pressure is low in the region where the centrifugal force is low and the absolute value of the tangential velocity is close to zero. (In Figure 5)

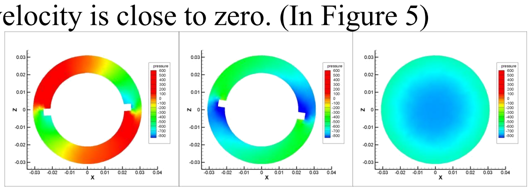

Figure 5. Pressure Profile in Flow Field

In the two-phase flow field dominated by the gas phase, the volume ratio of the liquid phase is low, the density on the cross-section varies greatly, and the centrifugal force distribution on the cross-section is affected not only by velocity and coordinates, but also by the density distribution. Compared with the liquid phase distribution map of the previous vortex drainage technology, a layer of liquid film is formed on the outer wall of the center of the vortex drainage tool, and a central gas layer with less pressure is formed in the upper part of the annular air, and the pressure field distribution map also verifies the swirling fluency and flow law of the liquid phase distribution map.

5. Velocity Field Distribution Law

By analyzing the velocity field, the flow law of eddy currents can be further explained. The contour diagram shows the swirl flow in the measured straight pipe section more clearly. It reflects the comparison of the velocity curve of the wellbore with a spiral deflector plate in the outlet section and the wellbore outlet gas along the pipe diameter direction under general conditions. The above different comparison diagrams illustrate from different angles how the gas develops from the annular high-speed region to the central gas core after passing through the spiral blades. It also illustrates the advantages of the application of deflector plate in gas well drainage and gas recovery from another angle. (In Figure 6)

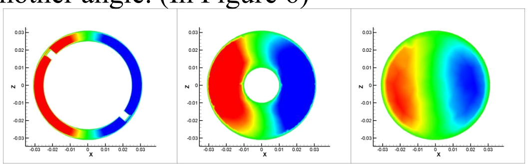

Figure 6. Velocity Profile in Flow Field

The contour diagram shows the swirl flow in the measured straight pipe section more clearly. It reflects the comparison of the velocity curve of the wellbore outlet gas along the pipe diameter direction under normal conditions in the wellbore with a spiral deflector plate in the outlet section and the wellbore. The above different comparison charts illustrate how the gas develops from the annular high-speed zone to the central gas core after passing through the spiral deflector. Comparing the magnitude of the axial velocity at different axial positions, it is found that the axial velocity attenuation is not large. When the flow velocity of the gas phase reaches the critical liquid-carrying flow rate, the gas phase can carry the liquid phase to move upward along the pipe wall, and the obvious wetting phenomenon can be seen after the vortex drainage tool. Therefore, the key to the effect of the vortex drainage tool lies in whether the gas phase can reach the critical liquid-carrying flow rate after passing through the vortex drainage gas recovery tool.

6. Conclusions

In this chapter, starting from the aspect of gas-liquid two-phase flow in the pipe, a mathematical model is established, and the critical velocity formula of the liquid film and droplets carried by the gas is deduced, so as to study the advantages of the boiler flow liquid drainage gas recovery device, and the swirl field caused by the vortex drainage gas recovery tool is simulated by numerical simulation, and the application effect of the vortex drainage gas recovery technology under different process parameters is analyzed, and the following conclusions are drawn:

(1) The mechanism of vortex drainage gas recovery technology is to form gas-liquid separation through the increase of centrifugal force, and reduce the pressure drop of the wellbore by changing the gas-liquid two-phase flow pattern in the wellbore, so as to improve the liquid-carrying capacity of the gas well

(2) By studying the changes of water volume rate, pressure distribution, two-phase flow law, pressure drop and rotation distribution, it is found that the gas-liquid two-phase fluid produces a strong swirl motion through the vortex drainage gas production tool, and the flow pattern changes from the fog flow pattern dominated by liquid droplets to the annular flow pattern dominated by liquid film in a short distance. The change of flow pattern reduces the pressure drop of the tubing, reduces the critical liquid-carrying flow rate, and improves the liquid-carrying capacity. The vortex drainage gas recovery tool divides the flow in the pipe into two areas: the central gas core with weak swirl but fast upward flow and the wall liquid film area with strong swirl but upward spiral flow.

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