Exploration of Deep Water Using Wellbore and Its BottomHole Pressure

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Abstract

At the formation portion, the temperature first rises and then falls, while at the saltwater part, the temperature first falls and then rises. Additionally, the rise and expansion of gas in the wellbore result in an approximately quadratic polynomial connection in the pit gain; at the bottom hole, there is a pressure decrease and an increase in the rate of gas influx. The standpipe pressure and bottom hole pressure steadily drop during kick development, which might be a key indicator for kick identification.

Keywords: Deep Water

Introduction

Deepwater drilling poses a significant risk to drilling safety and efficiency because formation gas can enter the wellbore and cause blowouts[1]. The Deepwater Horizon drilling platform blew apart in 2010, resulting in direct economic damages of about 68 billion US dollars. It also resulted in significant mortality and well-completion catastrophes. Therefore, a good control plan for the avoidance of blowouts must precisely grasp the process of gas invasion and take into account the laws of wellbore multiphase flow during the gas kick. There have been many studies of the multiphase flow model in gas kicks since the 1960s. Developed a kick model, although the model excludes the friction and pressure loss in the annulus as well as the gas-liquid slippage velocity, making it only useful for a streamlined calculation. Records developed the kick flow model, which takes into account the impact of friction and pressure loss in the annulus, although the calculation result of the model exhibits a substantial inaccuracy when compared to field measurements[2]. The fluid in a vertical pipeline momentum conservation equation was developed by Horberock and Stanberry in 1981. The characteristics of the gas-liquid flow are examined using the homogeneous flow theory. developed a deep-well kick flow model and proposed the idea of void fraction while taking into account gas-liquid slippage and pressure loss of two-phase flow. examined the mass transfer, slippage, and gas-liquid phase transition in his analysis of the wellbore multiphase flow characteristics. They investigated how wellbore pressure distribution was affected by wellbore shape, BHA, and hydraulic factors.

Based on this, Ohara created a deepwater well control model, which divides the mud flow process into many submodels for simulation at various points in the well. In particular, Nunes (2002) provided a numerical solution approach and an analytical model of wellbore multiphase flow. The model is capable of calculating the pressure and gas distributions in the choke line and wellbore at various points in time. In a gas kick, Wang and Sun (2009) developed a multiphase flow model that can be used to simulate multiphase flow in the wellbore during the gas kick and well killing during deepwater drilling. Pourafshary et al. (2009) established the unsteady wellbore two-phase flow model assuming that the gas phase and liquid phase are in phase equilibrium on any wellbore section while taking into account the coupling between wellbore fluid and reservoir fluid as well as the slippage of multicomponent gas and liquid phase. Lu and Connell (2014) took into account the wellbore multiphase flow's phase transition process and developed an unsteady model of the wellbore liquid injection process based on phase stability analysis and phase separation computation. Udegbunam et al. (2014) examined how reservoir characteristics, pipe string dimension, slippage velocity, friction coefficient, and other parameters with a high degree of uncertainty affected flow characteristics during underbalanced drilling. In the deepwater drilling wellbore, [3-6] conducted an experimental study and developed a model to simulate the development of methane hydrates under bubbly flow conditions. The production of methane hydrate in drilling mud changed its rheology, causing it to behave in a non-Newtonian manner and increasing the pressure losses of drilling mud in the wellbore. Their contributions have a substantial impact on the precision of pressure loss prediction in the wellbore and have established a strong foundation for modeling multiphase flow behavior in the deepwater wellbore. Sun et al. (2018) have created a number of models to study how phase transitions affect the migration of gas kicks in a wellbore.

Due to the alternating changes in low temperature at the saltwater portion and high temperature at the deep formation section that occur during deepwater drilling, the multiphase flow rules of gas kick are more complex than those of good onshore kick. The complicated dynamic mass and heat transfer mechanism is known as wellbore flow. In order to acquire the dynamic distribution of flow parameters, including fluid velocity, pressure, and temperature, throughout the evolution of a blowout, an accurate multiphase and multicomponent flow model must be established.

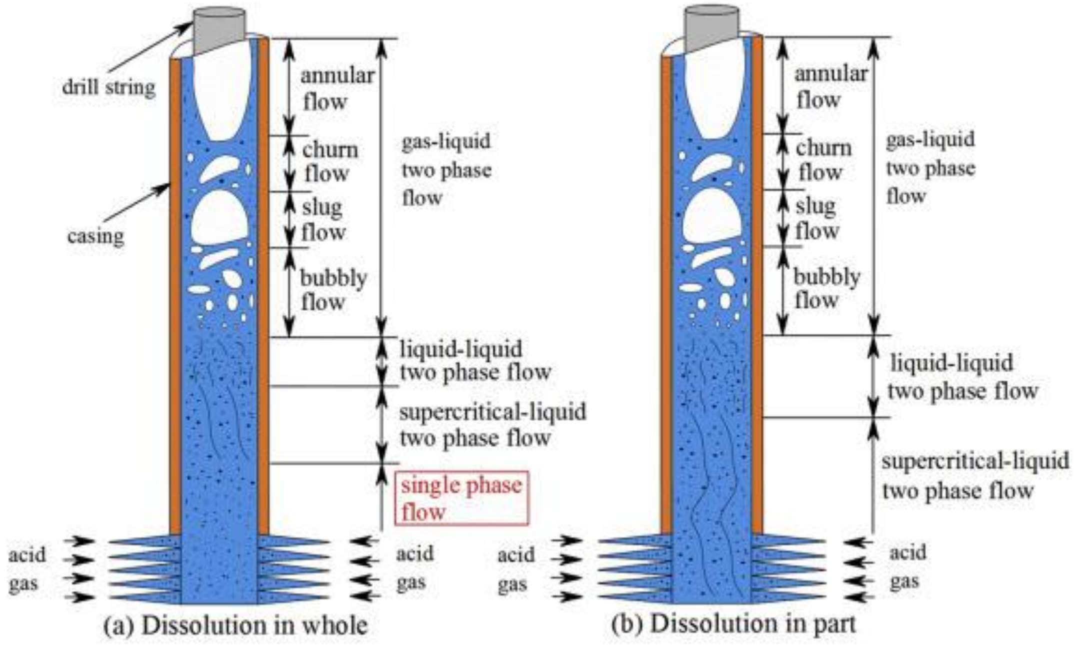

Fig.1Multiphase flow behavior for acid-gas mixture and drilling fluid flow in a vertical wellbore

The focus of global oil-gas exploration and production has been steadily moving in recent years to deepwater regions. However, drilling is extremely difficult because of the unique temperature and pressure conditions of the deepwater deposit. One of the key obstacles to be overcome is gas invasion, which is frequently caused by the restricted safe density window and complicated formation pressure system.

One approach to the aforementioned problem is the dual-gradient drilling technique. The pressure gradient above the seabed can only be changed with the traditional dual-gradient drilling technique. The limits of the traditional approach become more and more clear as deepwater drilling depths rise. Downhole dual-gradient drilling (DDGD), a technique based on the separator, has gained popularity recently. A separator is linked to the downhole drill string in this drilling technique. At the wellhead, mud and light hollow glass balls (LHGBs) are combined and pushed into the drill string. The separator in the drill string separates the LHGBs from the drill string into the annulus as the mixed fluids flow down to it. The annulus fluid density above the separator drops as LHGBs and drilling fluid move upward, resulting in the formation of two pressure gradients. The benefit of this method over the traditional dual-gradient drilling technique is obviously the ability to alter the pressure gradient throughout the wellbore as opposed to simply in the riser above the seabed.

Although the DDGD method's wellbore pressure can more closely match the small safe density window, gas invasion is still possible. The wellbore multiphase flow characteristics during gas invasion are more complex than with conventional single-gradient drilling (CSGD) due to the fluctuating temperature-mass flow generated by the dynamic transfer of LHGBs. In order to address the shortcomings of related theories and improve the detection of gas invasion and well management in DDGD, it is crucial to explore the multiphase flow characteristics in DDGD.

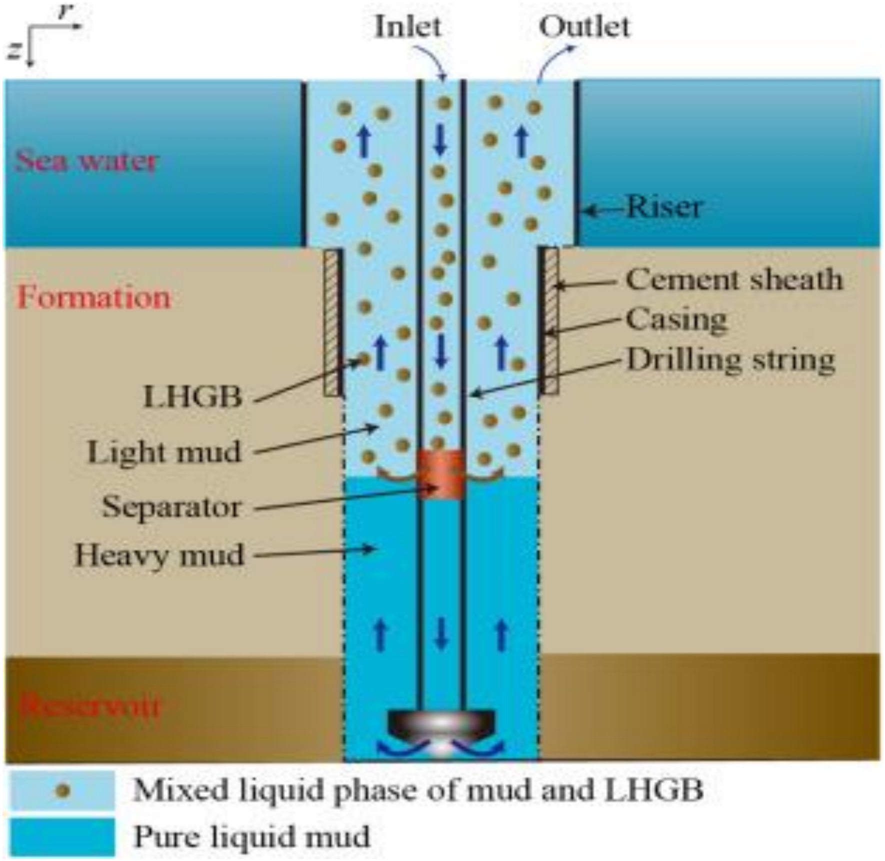

Fig. 2 Schematic of the deepwater DDGD method.

Oil-based drilling fluid is frequently used in deepwater drilling to increase wellbore stability and lessen friction and torque. However, it is more challenging to find the gas invasion because of the high solubility of the gas in the oil-based drilling fluid. Additionally, a significant amount of dissolved gas is separated out when the oil-based drilling fluid with dissolved gas runs close to the wellhead, which makes well control treatment more challenging. The differences in the annulus flow rates and pit gains during gas invasion are based on oil-based drilling fluid and water-based drilling fluid. Using drift flow theory, a gas invasion model in oil-based drilling fluid was created. The model was used to investigate the effects of reservoir parameters, such as formation pore-pressure and permeability, engineering parameters, such as pump rate, rate of penetration, wellbore configuration, and well depth, and control methods, such as the engineering method and waiting cycle weighting method, on multiphase flow behavior. For the modeling of gas invasion in an oil-based drilling fluid under non-isothermal conditions, White and Walton (1990) developed a multiphase flow model. Since wellbore temperature was taken into account for the first time in multiphase flow modeling, the computed accuracy was much increased. A transient multiphase flow model that takes into account wellbore temperature and gas dissolution in deepwater drilling is based on the flash theory that was previously reported. Under the related flow pattern circumstances, the heat transfer parameters could be obtained from the wellbore temperature field model and the hydraulic flow parameters from the hydrodynamic model.

Researched the impact of wellbore temperature on the coupling relationship between wellbore multiphase behaviors and formation gas invasion behaviors in ultra-high temperature, ultra-high pressure, and ultra-deep formation drilling using the gas solubility model derived from the experimental data. Researchers examined the impact of transient interphase mass transfer and system heat transfer on wellbore multiphase behaviors in deepwater drilling by combining the theories of gas bubble mass transfer, energy conservation theory, and multiphase flow.

Mechanism model

An integrated, synergistic feedback connection between multiphase flow, interphase mass transfer, and wellbore temperature drives the development of the multiphase flow in the oil-based drilling fluid.

The interphase mass transfer rate and the fluid thermophysical characteristics are influenced by the wellbore temperature, which is established by the heat transfer between the wellbore fluid and the formation. The wellbore's free gas percentage is impacted by the interphase mass transfer, which in turn impacts how multiphase flow develops. The distribution of wellbore temperature and pressure is determined by the multiphase flow, which also influences the rate of mass and heat transfer. As a result, the development of multiphase flow in oil-based drilling fluid is a complex and dynamic process that depends on a number of factors, including temperature, pressure, the pace of heat and mass transfer, the rate of gas invasion, flow rate, etc.

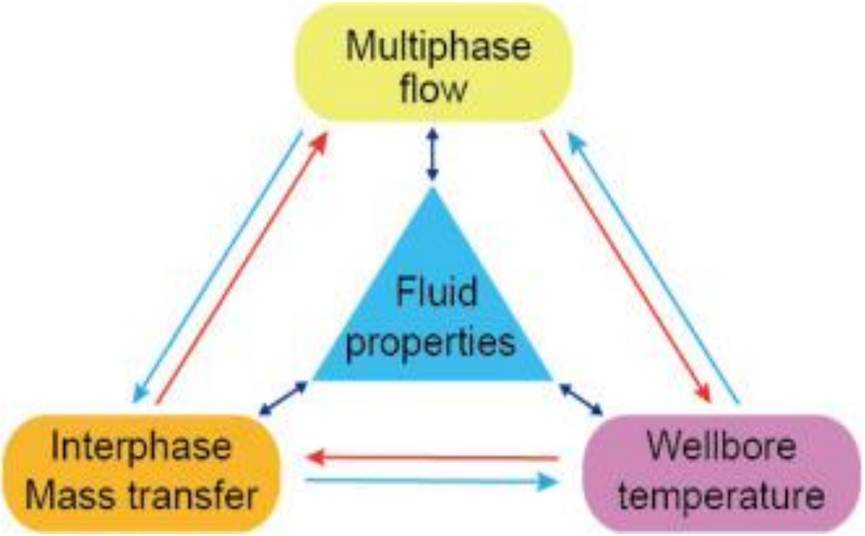

Fig. 3 Schematic of the synergistic feedback relationship of multiphase flow, interphase mass transfer, and wellbore temperature.

A completely transient multiphase flow model in oil-based drilling fluid was constructed, taking into account the wellbore flow characteristics in deepwater DDGD. The wellbore temperature, interphase mass transfer, and changing temperature-mass flow were all connected in the model. During the gas invasion in deepwater DDGD, the distribution of wellbore temperature and pressure, as well as multiphase flow characteristics, were examined.

Conclusion

For the early detection and treatment of gas invasion, understanding wellbore multiphase flow characteristics is crucial, especially when using oil-based drilling fluid. In contrast to traditional single-gradient drilling, downhole dual-gradient drilling (DDGD) uses a wellbore multiphase flow law that is more complicated. At this time, there was no report on any pertinent literature. In this study, a completely transient wellbore multiphase flow model based on oil-based drilling fluid in deepwater DDGD was constructed. This model took into account the synergistic feedback connection of multiphase flow, interphase mass transfer, and wellbore temperature. The dynamic transfer of hollow glass balls and formation gas also created changing temperature-mass fluxes, which were likewise linked in the model. The interphase mass transfer rate was explained using the bubble interface mass transfer hypothesis. The wellbore temperature and transient interphase mass transfer have significant effects on the wellbore multiphase flow characteristics. Additionally, the model based on the bubble interface mass transfer theory could more precisely describe how the wellbore multiphase flow evolved. This study may offer some theoretical support for the identification and management of gas invasion in deepwater DDGD.

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