iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: III Month of publication: March 2022

DOI: https://doi.org/10.22214/ijraset.2022.41091

Surge and Swab Pressure in Oil Drilling

Rasul Valiyev Zakir
Azerbaijan State Oil and Industry University, Faculty of Oil and Gas Production, Bachelor in Oil and Gas Engineering

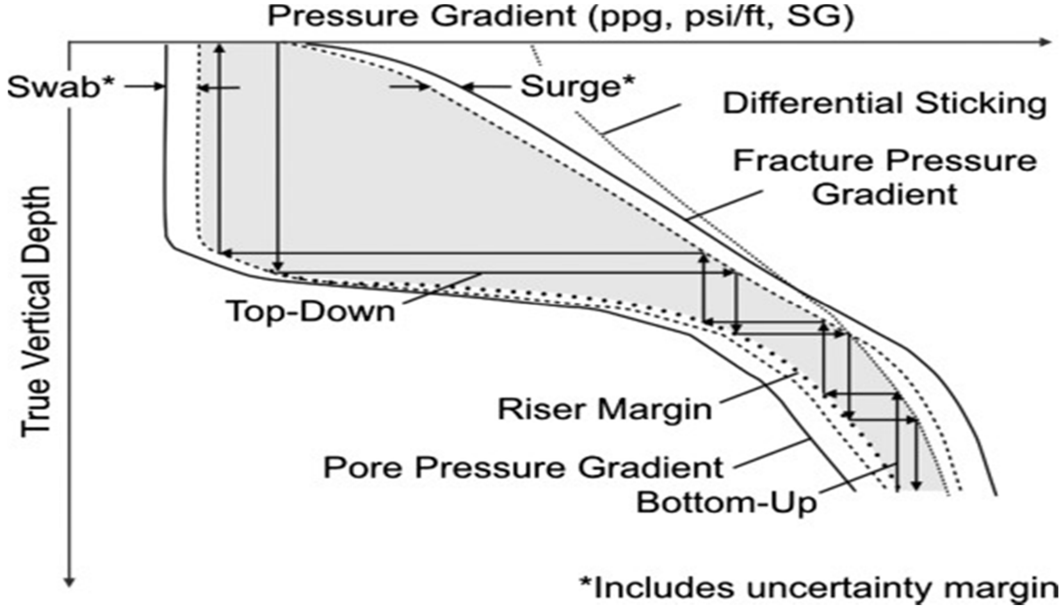
Abstract: Surge and swab pressures have been for a while an issue in the drilling of an oil well. The drill string causes a flow for displaced fluid and a pressure change in the borehole when running in or pulling out of the hole. When the string moves upward creates a swab pressure and it creates a surge pressures when moves downward. Surge and swab pressures have for a long time been a problem in the petroleum industry. These pressure changes are mainly related to tripping operations, where the drill string has to be pulled out of the well, normally due to a worn out drill bit, or a broken tool. The desire is to optimize the process and time used to trip in and out of the well, to save time and money, and at the same time not taking any risks. If the tripping speed exceeds a certain limit, the pressure changes in the well may become so severe that the consequences are fatal. The main aim of the thesis is to show the models with the affecting parameters of surge and swab pressures, to explore their effect on the fluid behavior models. The Bingham plastic model, the Power Law model, and the Herschel-Bulkley model are utilized to get the best outcomes.

Keywords: surge, swab, pressure, tripping, bottom whole assembly, drilling, oil and gas, well, drilling fluid

I. INTRODUCTION

The petroleum industry meets higher expectations for every day, supplying the world's increasing need for energy, and at the same time trying to do so in an environmentally and economically responsible way. The wells that are being drilled gets more and more complicated, making the petroleum companies continuously facing new challenges. A semi empirical model to estimate surge and swab pressures for Bingham Plastic fluids was developed by Burkhardt. His model compares actual test results of surge pressure with a mathematical prediction, assuming ideal Bingham plastic fluids, uniform wellbore and fluid flowing at steady state. Schuh had a similar approach, when developing a power-law fluid model, also assuming steady state flow, in a concentric annulus. Fontenote and Clark presented a model to determine surge and swab pressure for both Bingham Plastic and Power Law fluids. Mitchell (1988) came up with a dynamic model, including several new factors, such as mud rheology, the elasticity of the pipe and the cement, formation, changing temperatures, and viscous forces. A new dynamic model was then again developed by Crespo et. Al., also accounting for compressibility of the fluid and formation. Two years later, a laboratory experiment was conducted by Srivastav et. al. confirming that the speed of the trip, mud properties, annular clearance and the eccentricity of the pipe affects the surge and swab pressures highly. Problems due to so-called tripping have for a long time been an issue for the drillers. It is desired to go as fast as possible, but to simply pull out the drill string in a fast manner can lead to severe damage of the well. The wellbore pressure decreases, due to what is called swabbing. Gas and oil wells produce fluid over the lifetime of a well. When a well is first drilled, it is "fracked" to help open productions zones. "Frac" fluids are recovered by swabbing to "kick" the well off. As fluids are lifted, the bottom hole pressure pushes the gas and/or oil up and out the well. About 40% of the fluids come back at kick off. The balance of frac fluids flow back with production over time. Swabbing is a process to remove fluids off the production zone from a gas or oil well. The operator must have the "feel" of the machine in sync with the well pressures, sounds and depth. This process is accomplished by machines that have a winch with cable. A foldable mast with sheave or pulley on top and a drive system. Swab machines come in various sizes that are determined by the depth of the well to be swabbed. Drilling activities are costly, consuming time, and possibly dangerous for individuals and the environment. Running in and pulling out the drill string in the hole is one of the most frequent drilling activities. Such operations are called tripping. A pressure drop is usually referred to as a swab pressure when the pipe moved upward. And for a downward pipe motion, a pressure rise, is called a surge pressure. The swab and surge pressures during tripping operations are one of the most common reasons for well-known issues such as kick, circulation loss, and fracturing. In the downward motion of a casing string, the string forces the drilling fluid and cement slurry up the annulus and out of the flow line. At the same time, the fluids immediately adjacent to the casing is dragged downhole. The resultant piston effect generates surge pressures that are added to the hydrostatic pressure. Excessive surge pressures can increase the borehole pressure to such a high level as to induce lost circulation. Conversely, in an upward motion of casing string, fluid flows down the annulus to fill the resulting void. This causes a suction effect, generating a swab pressure that can possibly bring formation fluid into the borehole.

Swab Pressure: If a drill string, casing string or logging tool is being pulled out of hole too fast, due to bigger diameter almost same hole size, BHA/ bit, casing or logging tool will possibly swab mud out of hole, like pulling small a piston of syringe. For this reason, hydrostatic pressure of bottom hole will be reduced. Pressure reduction created by this situation is called "Swab Pressure". If swab pressure is too much, kick (wellbore influx) may be into the hole and well control must be conducted in order to secure well.



II. PROBLEMS OF SURGE AND SWAB PRESSURE

Numerous studies were carried out to examine the impacts of surge and swab pressure. Early research recorded that due to high tripping speeds, wellbore issues such as lost circulation, formation fracturing, kick, wellbore damage, etc. were associated with a swab and surge pressures. When the string is run in a hole, it pushes the drilling mud out of the well. Meanwhile, the mud, which is immediately adjacent to the drill string, is dragged down. Surge and swab pressure can lead to unsafe conditions. When swab pressure is too large, then the pressure of formation may exceed the pressure of the wellbore and cause a flow into the borehole. This occurs because the formation pressure can no longer be controlled by the swabbed hydrostatic mud column. This is a serious concern, understanding that some gain of fluid in the borehole leading to blowing out. On the other hand, additional hydrostatic pressure is exerted to the surge pressure. If the margin of pore formation and fracture pressure is narrow, and therefore any additional pressure, like surging pressure, is added to the hydrostatic mud pressure allowing the fracturing of the formation. Getting a formation fracturing allows the mud column within the formation to get lost. Surging happens as the pressure of the bottom hole is raised due to the impact of moving the drill string too quickly through the hole. If caution is not taken and fracture pressure is exceeded while run in the hole, the drilling mud losses may occur. Proper monitoring with the trip tank of the displacement volume is always needed. This in turn can result in another zone flowing into the wellbore, while the loss zone is taking mud, or even a catastrophic loss of well control. Even in the two less severe forms, the loss of fluid to the formation represents a financial loss that must be dealt with, and the impact of which is directly tied to the per barrel cost of the drilling fluid and the loss rate over time. The purpose of this study is to investigate the dynamic motion of the drill string when there is an influx of formation fluid, with particular interest focused on the effect of bottom hole pressure. Increased underbalanced and managed-pressure drilling operations have necessitated predicting wellbore pressures more accurately, as they allow for reduced fluid loss and reservoir influx. While drilling through or reciprocating in a potential reservoir zone where the borehole and formation fluid pressures are in a narrow margin under a managed-pressure condition, the swab pressures may cause the wellbore to be underbalanced for a small period of time. At certain times, an incremental influx for a short duration may be potentially detrimental. Neither the steady-state model nor the transient model is comprehensive enough to predict the wellbore pressures correctly, as both models neglect the reservoir fluid influx or fluid loss under this condition. This paper presents a coupled swab/surge model, whereby the wellbore bottom hole pressure can be predicted more accurately with a reservoir fluid influx. A full balance of mass and momentum for pipe and annulus flow is solved. The model also includes the effects of fluid inertia and compressibility, wellbore elasticity, axial elasticity of the pipe, and temperature-dependent fluid properties.

III. PARAMETERS AFFECTING SURGE AND SWAB PRESSURE

There are several methods that affecting surge and swab pressure. These are:

A. Tripping speed
B. Bottom Hole Assembly
C. Types of drilling fluid
D. Drilling fluid properties

1) This physical movement of the drill string in or out of the well is called tripping. It is a time consuming process that the drillers want to minimize due to higher costs and nonproductive time. Thus, severe problems may occur if the tripping speed is too high. When tripping out, the upward movement of the drill pipe causes friction between the pipe and the drilling mud. The pressure decreases in the well due to the surge effect. The opposite happens when the pipe is tripping in, when the downward movement causes a pressure increase. This is the swab effect. Several field experts and researchers have confirmed which simple wells are already drilled, and we only have difficult wells left. Such problems contain the narrow gap among fracture and pore pressure, wellbore stability, and depleted formations. The quick and unexpected motion of the "drill string" when tripping out of the hole reduces the pressure of the wellbore. Also because of the force of friction between the upward moving of pipe and the stationary drilling mud, defined as the "swab" pressure. The reverse case is also true, it will lead to an increase the pressure by moving rapidly within the wellbore, and this is considered as the "surge" pressure. Both the "swab & surge" pressures can contribute to several drilling troubles like drilling fluid losses and influx of wellbore. The formation pressure can no longer be resolved by the swabbed hydrostatic mud column. any fluid that gets in the borehole generates a kick contributing to a blowout is a critical threat.
2) The bottom hole assembly (hereinafter referred to as BHA) is the part at the end of the drill string. At the bottom of the BHA is the drill bit. It may also consist of a drill collar, stabilizer, reamer, heavy weight drill pipe, jarring device, mud motor, directional drilling equipment, MWD, and logging tools. The BHA components functions is to penetrate the formation, stabilization of the drilling, enhancement of the directional control, and the maximization of the drilling performance per se. The various parts of the BHA are explained below. It is proven that most of the pressure loss in the well happens around the BHA, especially where the annular space is small. Prior to running a BHA most oilfield service providers have software to model the BHA behavior such as the maximum WOB achievable, the directional tendencies & capabilities, and even the natural harmonics of the assembly as to avoid vibration brought about by exciting natural frequencies.
3) In drilling engineering, the mud system has many important functions. It is pumped through the drill string, then out from the bit nozzles, and brings the formation cuttings through the annulus from the bottom hole to the surface. It goes to a shaker, where the cuttings are washed 17 out, and the mud goes back to the mud tank. Thus, the removal of cuttings and the cleaning of the hole is not the mud's only feature. The drilling mud is usually made of water, clay, and additives. The mud system has several important functions in a drilling operation. It is pumped from the mud pit through the drill string, going out through the bit nozzles, and carry cuttings from the well back up to the surface through the annular space. From here it goes to a shaker where the cuttings are filtrated out, and the mud returns to the mud pit.
4) The different properties of drilling fluid play all an important role for a successful drilling operation, and are the easiest changeable variables of the process. Each mud program used to drill a well is designed for the specific individual conditions of the well. The American Petroleum Institute (API) described the drilling fluid measurements that are necessary to describe the main characteristics: density, viscosity and gel strength, filtration, concentration of sand, Methylene Blue Capacity, pH, chemical analysis.

IV. CALCULATION OF SURGE AND SWAB PRESSURE

Calculating surge and swab pressures can be a complex undertaking depending upon the casing string configuration and hole geometry. Burkhardt developed a relationship between hole geometry and the effect of the fluid being dragged by a pipe. Based on Burkhardt's work, the effective annular velocity is equal to $v_e = v_f - k v_p$

where

v_e = the effective annular velocity, ft/s or m/s
v_f = fluid velocity, ft/s or m/s
v_p = pipe upward velocity, ft/s or m/s

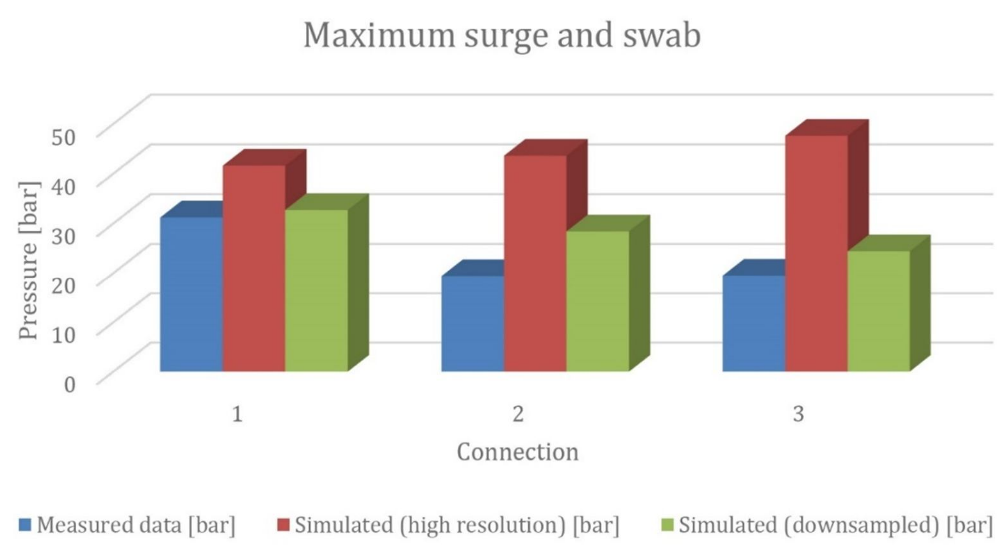
and k is referred to as the clinging constant, which is a function of annular geometry. Burkhardt presented a chart for determination of the value of k in both laminar flow and turbulent flow. Guo and Liu found that the chart can be replaced by the following correlations with minimal error. For laminar flow, the correlation is k = 0.275(dp/dh) + 0.25

These calculations outline the procedure and calculations necessary to determine the increase or decrease in equivalent mud weight (bottom hole pressure) due to pressure surges caused by pulling or running pipe. These calculations assume that the end of the pipe is plugged (as in running casing with a float shoe or drill pipe with bit and jet nozzles in place), not open ended.

1) Surge pressure around drill pipe:
2) Estimated annular fluid velocity (v) around drill pipe: v = [0.45 + Dp2] Vp

Total surge (or swab) pressures: psi = Ps (drill pipe) + Ps (drill collar)

a) If surge pressure is desired: SP, ppg = Ps - 0.052 - TVD, ft "+" MW, ppg
b) If swab pressure is desired: SP, ppg = Ps - 0.052 - TVD, ft "—" MW, ppg



V. CONCLUSION

The BHA diameter appears to be more relevant to swab and surge than the BHA length. The most important variable for surge and swab pressures is annular clearance. Around the drill bit, most of the pressure changes occur, and the surge and swab pressures are heavily dependent on the BHA and bit diameter. The only manipulative parameter concerning control surge and swab pressure is the tripping speed. For certain critical situations, this has been built into a graphical view. The properties of fluid, speeds of tripping, and annular clearance have important effects on the pressures of the surge and swab. The concentric annulus-based models over-predict the surge and swab pressure and require pipe eccentricity correction. The prediction of surge pressure for an eccentric and concentric model can be noted as the boundary limits for the anticipated surge pressures the pipe does not retain the concentric or fully eccentric geometry throughout in real field condition due to pipe lateral motion, resulting in surge pressure variations to limits between these. To estimate the impact each parameter has on surge and swab, a factor of impact is calculated using the following formula for the 0.4 m/s tripping speed results: Factor of impact on ECD = (dECD/ECD)/d of parameter analyzed/original value of parameter analyzed. The Herschel-Bulkley fluid behavior model provides the most accurate estimations of drilling fluid behavior out of the existing models. The density of the drilling mud will not affect the ECD in a greater amount than the density added to the mud or the density reduction of the mud, independent of the tripping speed. Both the yield point and the plastic viscosity of the fluid has small effects on ECD, and needs to be considered in the estimations. The detailed components and dimensions of the BHA cannot be neglected or simplified to obtain accurate values for ECD. The BHA diameter seems to be more important than the BHA length for surge and swab. The annular clearance is the most important factor for surge and swab pressures of the parameters analyzed in this sensitivity study. The size of the open hole and bit is more important for annular clearance than the drill pipe size. The majority of the pressure changes occurs around the drill bit, and the surge and swab pressures depend heavily on the diameter of the bit and BHA.

REFERENCES

[1] Bourgoyne, A. T., Millheim, K. K., Chenevert, M. E., & Young, F. S. 1991. Applied drilling engineering (SPE textbook series, vol. 2). Society of Petroleum Engineers.

[2] Srivastav, R., Enfis, M., Crespo, F., Ahmed, R. 2012. Surge and Swab Pressures in Horizontal and Inclined Wells. Society of Petroleum Engineers.

[3] Adewale, F. J., Lucky, A. P. A., Fadairo, A., & Adedeji, A. A. (2018). Modification of Bingham plastic rheological model for better rheological characterization of synthetic based drilling mud. Journal of Engineering and Applied Sciences, 13(10), 3573–3581. https://doi.org/10.3923/jeasci.2018.3573.3581

[4] Al-Awad, M. N. J. (1999). Prediction of Critical Pipe Running Speed During Tripping in Drilling Operations. Journal of King Saud University - Engineering Sciences, 11(1), 131– 148. https://doi.org/10.1016/S1018-3639(18)30994-2

[5] Coussot, P., Bertrand, F., & Herzhaft, B. (2004). Rheological Behavior of Drilling Muds, Characterization Using Mri Visualization. Oil & Gas Science and Technology, 63(1), 9– 19. https://doi.org/10.2516/ogst

[6] Baker Hughes, 2006. Drilling Fluids Reference Manual.

[7] Mitchell, R. F. 1988. Dynamic Surge/Swab Pressure Predictions. Society of Petroleum Engineers.

[8] Fontenot, J. E., Clark, R. K. 1974. An Improved Methods for Calculating Swab and Surge Pressures and Circulating Pressures in a Drilling Well. Society of Petroleum Engineers.

[9] Alkinani, H. H., Al-hameedi, A. T. T., Flori, R. E., Dunn-norman, S., & Hilgedick, S. A. (2018). Drilling Strategies to Control Lost Circulation in Basra Oil Fields, Iraq. April.

[10] Hansen, E. 2012. Automatic Evaluation of Drilling Fluid Properties. Master's Thesis, University of Stavanger, Faculty of Science and Technology.

[11] Schlumberger's Oilfield Glossary, https://www.glossary.oilfield.slb.com

[12] https://glossary.oilfield.slb.com/en/terms/l/lost_circulation

[13] https://www.petrolink.com/drillact-swab-surge/

[14] https://www.sciencedirect.com/topics/engineering/swab-pressure

[15] https://www.tigergeneral.com/swabbing-oil-gas-industry/