COMPARING DRILLER'S AND ENGINEER'S METHODS TO CONTROL KICK FOR BASEMENT RESERVOIRS

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I would like to dedicate this research work to my darling wife Amerh and my lovely kids Hamza and Elyas

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ABSTRACT

There are various difficulties involved in drilling operations in the oil and gas industry. Well control is considered the most vital one. Well control systems are applied when a kick is detected entering the wellbore from the formation. Kicks occur when formation pressure is greater than wellbore pressure causing an influx of gas into the wellbore. Uncontrolled gas kicks have the potential to cause a blowout, resulting in financial loss, possibility of injury, loss of live, and pollution. Once a gas kick is detected, it has to be circulated out safely and efficiently to surface. While the influx of gas migrates in the wellbore toward the surface, it affects different parameters such drill pipe pressure, annulus pressure, fracture pressure, bottomhole pressure, and casing shoe pressure. This work investigates and analyses these pressure changes that act on these parameters during well control. A Drillbench simulator was used to conduct a comprehensive comparison between the Driller’s and Engineer’s method to determine the most effective method to kill the well in basement reservoirs. A case study was conducted on a Masila basement reservoir, since fractured basement is becoming an important oil and gas contributor to the petroleum industry. Engineer’s method showed better results and more advantages over Driller’s method since it would require only one circulation to kill the well and no potential for further kicks. The sensitivity analysis proved that kick size and kick intensity have significant effect while circulating the kick. The bigger the size of kick the higher pressure profile was noticed. Similarly, an increase in kick intensity would result in increasing choke pressure, casing shoe pressure and pump pressure.

ABSTRAK

Terdapat pelbagai kesukaran yang terlibat dalam operasi penggerudian dalam industri minyak dan gas. Kawalan telaga merupakan faktor yang paling penting. Sistem kawalan telaga digunakan apabila terjahan dikesan memasuki telaga dari formasi. Terjahan selalu berlaku apabila tekanan formasi lebih besar daripada tekanan telaga yang menyebabkan kemasukan gas ke dalam lubang telaga. Tendangan gas yang tidak terkawal berpotensi menyebabkan ledakan, menyebabkan kehilangan kewangan kemungkinan kecederaan, kehilangan nyawa dan pencemaran. Apabila tendangan gas dikesan, ia harus dialirkan keluar secara selamat dan secara cekap ke permukaan. Apabila gas di telaga berhijrah ke arah permukaan, ia mempengaruhi beberapa parameter yang berkaitan dengan kaedah penghapusan yang digunakan seperti tekanan annulus, tekanan pecahan, dan tekanan kasut casing. Penyelidikan ini menyelidik dan menganalisa perubahan tekanan ini yang bertindak ke atas parameter semasa kawalan telaga. Simulator gerudi digunakan untuk membandingkan antara kaedah gerudi dan kaedah jurutera untuk menentukan kaedah yang paling berkesan untuk mematikan telaga di takungan bawah tanah. Satu kajian kes dijalankan di sebuah takungan Masila, memandangkan ruang bawah tanah retak menjadi penyumbang yang penting kepada minyak dan gas dalam industri petroleum. Kaedah jurutera menunjukkan hasil yang lebih baik dan lebih banyak kebaikan berbanding kaedah gerudi kerana ia hanya memerlukan satu peredaran untuk mematikan telaga dan tidak berpotensi untuk tendangan selanjutnya. Analisa kepekaan membuktikan bahawa saiz tendangan dan keamatan tendangan mempunyai kesan yang signifikan semasa peredaran tendangan. Semakin besar saiz tendangan, lebih tinggi profil tekanan diperhatikan. Begitu juga, kenaikan intensiti tendangan akan menyebabkan peningkatan tekanan choke, tekanan kasut casing dan tekanan pam.

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BOP	Blow out preventer
BHP	Bottom hole Pressure
CB	Compressibility of bulk volume (psi-1)
dp	Difference in pressure (psi)
dv	Difference in volume
ECD	Equivalent circulating density
EMW	Equivalent mud weight
FCP	Final circulation pressure
ICP	Initial circulation pressure
KMW	Kill mud weight
LOT	Leak off test
MASP	Maximum allowable surface pressure
MD	Measured depth
MISICP	Maximum initial shut-in casing pressure
MPD	Managed pressure drilling
MW	Mud weight
OBM	Oil based mud
PPG	Pound per gallon
PSI	Pound squire inch
SCR	Slow circulating rate
SIDDP	Shut in drill pipe pressure
SITHP	Shut in tubing head pressure
TVD	True vertical depth
VB	Bulk volume

CHAPTER 1

INTRODUCTION

1.1 Background

Well control is an expression for all measures that can be applied to prevent uncontrolled release of wellbore effluent to the external environment or uncontrolled underground flow. A blowout is defined as uncontrolled of formation fluid that passes all well barriers and flow to the surface. The consequences are:

(1) Potential loss of lives or severe injury.
(2) Stop operation and nonproductive time.
(3) Pollution of the environmental.
(4) Reservoir depletion and loss off hydrocarbon.
(5) Water coning.
(6) The cost to control the blowout.
(7) Destruction of equipment and material assets.
(8) Damaging of company reputation.

There are many classifications of blowout:

(1) Surface wellhead blowout: when the uncontrolled flow of formation is flowing through the wellhead or wellbore annulus.

(2) Underground blowout when the uncontrolled flow of formations is flowing into unconsolidated formation to the surface. They are more disastrous and hard to control. As the fluid moves from high pressure zones to shallower low pressure zones, underground blowouts can either occur during drilling or in rare cases in completed wells. The first case is normally related to improper handling of a kick while the second case may occur due to improper cementing of casing, causing fluid flow; failure in casing due to tectonic movements or bad choice of casing steel quality (Rich, 1987).

(3) Under water blowout can happen on the seabed. The formation fluids will pass through the reservoir rock and mixed with sea water, because of the breakage of trap and seal caused by drilling.

A kick is defined as a sudden flow of formation fluids into a wellbore. Several types of fluid can enter a wellbore as a kick such as gas, hydrocarbons, formation water, or combinations of all these. Among these fluids, a gas kick is considered the most difficult to be handled due to its high compressibility and low density.

Kick may occur when the formation pressure is more than the wellbore pressure causing influx of gas from the formation into the wellbore. The main reason for gas kicks is insufficient mud weight that results in formation pressure exceeding the wellbore pressure. On the other hand too much over pressuring the wellbore using heavy mud-weight is not a viable solution as it can cause fractures into the formation which would lead to loss of circulation and formation damage.

Many blowouts happened in the early 20th century. There were no proper methods in the early days to prevent blowouts. The average blowouts were 10 cases per year in 1950's and it gradually reduced to four per year in 1991. Some of the famous blowouts that occurred are:

(1) Sedco 135F and the IXTOC-1 Well, Gulf of Mexico in 1979 caused by blowout preventer failure. If the blowout preventer was designed with the consideration of subsurface pressure, this disaster would have been avoided.

(2) Ekofisk Bravo Platform, Norway in 1977 when performing workover operation blow out caused because of incorrectly installed down hole safety valve by inexperienced drilling personal. This blowout might have been avoided if an experienced drilling engineer was operating the system carefully.

(3) West Vanguard, Norway in 1985 by the failure of circulation methods which failed to kill the well because of insufficient time. This blowout might have been avoided if the drilling personals reacted early.

(4) Al Baz blowout, Nigeria in 1989 which was a shallow water blowout which the drilling system could not handle. It caused the collapse of drill string along with string, drill bit and blowout preventers. If proper modeling techniques were present at that time, they could identify the loose consolidated formation which collapsed during drilling (Khan, 2010).

(5) Adriatic IV, Egypt in 2004 caused because of less density drilling fluids. If the drilling fluid density would have been maintained properly this disaster would not occur (Khan, 2010).

1.2 Problem Statement

There are many problems that may occur during drilling, workover, snubbing, and coil tubing. To this extent, occurrence off a kick is considered a serious problem because making a mistake in well control may lead to a catastrophe. Particularly when gas kicks are not properly controlled which eventually can escalate into blowout. Thus, a quick, appropriate, and an effective response to well control is vital.

In order not to end up with a surface or underground blowout it is crucial to circulate and remove gas kicks safely by choosing the optimum operating method to bring the well under control. Hence there are many methods available such as Driller's method, Engineer's method, bull heading method, reverse method, lubricate and bleed method. More over shut-in technique has to be implemented without any surface or subsurface complications.

This work covered unconventional reservoirs such as basement. A Drillbench simulator was used to conduct a comprehensive comparison between the Driller's and Engineer's method to determine the most effective method to kill the well in basement reservoirs. A case study was conducted on a Masila basement reservoir since fractured basement is becoming an important contributor to the petroleum industry. However, drilling into the granitic basement reservoir is challenging because of the severe shocks, vibrations, heterogeneity, extensive fracture network, high flow rate and unexpected over-pressurized network. Consequently this shall require proper reaction to kill flowing well meanwhile avoid impacting other wells within same network which might lead to different challenges in many wells at the same time.

The following parameters are studied for analysis and to examine their complication while applying well control:

(1) Formation fracture pressure.
(2) Bottom hole pressure.
(3) Drill pipe pressure.
(4) Casing shoe pressure.
(5) Choke pressure.
(6) Pit gain.

1.3 Objectives

The objectives of this project were:

(1) To choose the most appropriate operating technique to control a gas kick in basement reservoirs and circulate it out safely.
(2) To investigate the effects of circulating a kick on different parameters such as pit gain, casing shoe pressure, choke pressure, and drill pipe pressure while killing the well, and also develop an understanding of the behaviour of gas kicks from the time the kick influx flows to the wellbore till the well is killed properly.

1.4 Hypothesis

(1) Choosing the appropriate well control system to contain the kick and manage not to get other influx is essential in order to minimize the size of the kick. The smaller the size of the kick the safer and easier to be circulated out to the surface by using conventional method.

(2) Determining the kick tolerance is the key that will be used either to kill the well by conventional methods or need to go with unconventional complicated methods. Hypothetically, using Engineer's method to circulate the influx in basement reservoirs proven to be the right decision to be taken since it requires less time, and no further influx will flow to the wellbore.

1.5 Scope

To accomplish the objectives of this study, a scope of this work is divided into three sections as follows:

(1) A comprehensive review was done in the kill methods mentioned above to obtain a broader understanding in removing the influx from the horizontal, deviated and vertical wellbore. The study drew conclusions about the conceptual validity, applications, advantages, substantial shortcomings, and design problems for each method.

(2) Drillbench simulator was used to compare between the Driller's method and Engineer's method to make the right and critical well control decisions. A thorough investigation was accomplished with clear vision in the subsequent affect on the related parameters in order to choose one of the methods to circulate the kick. And identify the technique to shut-in the well.

(3) A sensitivity study was done for both, kick size and kick intensity since they are considered the main contributors that affect well control while killing a well.

1.6 Significance of Study

Well control simulation makes it possible to examine otherwise unexpected kick behaviour. It fully simulates transient two-phase flow, and outputs are communicated in simple graphics for easy application in the field. It is a practical tool for well planning and drilling operations. From the study and results obtained; recommendations, guidelines and mitigations could be put in place to determine optimum well control, procedures and improve field practices that can be validated by Drillbench simulator, especially for Masila Basin since most of the producers are basement reservoirs.

1.7 Chapter Summary

This chapter summarizes the well control issue and explained how important is to control the well. If we lost control of the well it would be a catastrophe. Detect the kick is a very important factor since if the kick was not detected early more influx will continue to flow to the wellbore as a result of that a blowout will occur. After that the conventional methods to kill the well will not be viable to kill it. Accordingly an early detection of a kick will allow to minimize the size of the kick. There are various methods available in order to circulate the kick out to the surface in an efficient and safe manner. This research focused on these methods and tried to choose the optimum operating method to be used in basement reservoirs. Drillbench simulator was used to simulate both the Driller’s and the Engineer’s methods. More over a sensitivity study was also conducted.

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