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Comparison between Wait Wight & driller Well-Control Methods in Drilling an Open hole FNE-D1 (Block 6) Sudan

مقارنه لطريقتي المهندس و الحفار لاحدي أبار حقل بليله النفطي بالسودان

Graduation Project submitted in partial fulfillment of the Requirement for the Bachelor technology of Engineering (Horns) Degree in Petroleum Engineering

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November, 2020

الإستهلال

قال تعالى:

بسم الله الرحمن الرحيم

﴿ قَالَ يَا قَوْمِ أَرَأَيْتُمْ إِن كُنتُ عَلَى بَيِّنَةٍ مِّن رَّبِّي وَرَزَقَنِي مِنْهُ رِزْقاً حَسَناً وَمَا أُرِيدُ أَنْ أُخَالِفَكُمْ إِلَى مَا أَنْهَاكُمْ عَنْهُ إِنْ أُرِيدُ إِلاَّ الإِصْلاَحَ مَا اسْتَطَعْتُ وَمَا تَوْفِيقِي إِلاَّ بِاللّهِ عَلَيْهِ تَوَكَّلْتُ وَإِلَيْهِ أُنِيبُ ﴾

سورة هود الآية (88)

Dedication

Every challenging work, needs self -efforts as well as guidance of elders especially those who were very close to our heart

Our humble effort we dedicate to our sweet and loving Parents

Whose affection, love and encouragement make us able to get much success and honor Along with all hard working and respected Teachers

Acknowledgement

Everything that has a beginning must equally have an end. Thanks, of Allah for the gift of life in good health and abundant grace throughout our stay in this great citadel. It’s indeed a privilege and honor to pass through this college. We acknowledge the effort of every lecturer that has impacted knowledge into us, without your contributions we would not be who we are today

Abstract

Well control is the technique used in oil and gas operation such as drilling and work over and well completion for maintaining for the hydrostatic pressure and formation pressure to prevent the influx of formation fluid into the wellbore.

Well control problems plagued the petroleum industry since its infancy and known as losses of valuable resources, costs increasing, environmental damages, personnel casu alties using killing method.

The objective of this research is to compare wait and weight and driller methods well control case study for open hole at FNE-D1 In block 6.

Two different killing methods have been applied: Driller; W&W methods. The forma tion, borehole; wellhead; rig equipment and lay out are considered as a communicatin g system, in which the three are influenced and restrained by each other.

In this research compare the two difference methods , wait and weight and driller met hods can be used kill sheet and software excel sheet.

From the Result , After calculation by used the two methods, it’s found that different results in computing MAASP , we have different results in MAASP for driller method and weight and wait method. That difference is result of the change of the mud weight that is using in the two methods.

So that is the cause of the difference in the MASSP when using the weight & wait and driller methods.

التحكم في الابار هو تقنيه مستخدمه في عمليات الزيت والغاز مثل الحفر وصيانه الابار واكمال الابار للحصول على ضغط متوازن لسائل عمود الحفر وضغط الطبقات لحمايه موائع الطبقة من الدخول الى حفره البئر.

مشاكل التحكم في الابار من الكوارث في صناعه النفط منزو قدم الزمان المعروفة بخسائر المصدر, زياده التكلفة , تدمير البئيه, الخسائر الشخصية عند استعمال طرق القتل.

الهدف الرئيسي من هذا البحث مقارنه بين طريقه الحفار وطريقه المهندس

هناك طريقتان لطرق القتل تم تطبيقها في هذه البئر, طريقه المهندس وطريقه الحفار. الطبقات , حفره البئر , راس البئر , معدات الحفار , نظام التواصل.

في هذا البحث مقارنه بين طريقتين مختلفتين , طريقه المهندس وطريقه الحفار مستعملا ورقه القتل وبرنامج الجداول الإلكترونية.

من النتائج اعلاه وبعد الحسابات المستعملة لهذه الطريقتين , وجد الاختلاف بين MAASPS , يوجد اختلاف بين بين طريقه المهندس وطريقه الحفار , هذا الاختلاف يرجع الى التغير في كثافه سائل الحفر المستعملة في الطريقتين.

لذ في هذه الحالة الاختلاف في MAASP اثناء استخدامنا طريقه المهندس وطريقه الحفار.

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Abbreviations

P &E	Petro -Energy E & P co., ltd
GNPOC	Greater Nile Petroleum Operating Company
WNPOC	White Nile Petroleum Operating Company
CNPC	China National Petroleum Company
DQN	Dqein Company
HYD	Hydrostatic pressure
MAASP	Maximum allowable annular surface pressure
ICP	Initial circulation pressure
FCP	Final circulation pressure
BHP	Bottom Hole Pressure
SICP	Shut in casing pressure
SIDPP	Shut in drill pipe pressure
BOP	Blow out preventer
DST	Drill stem test
RFT	Repeat formation test
EOWR	End of well report
FWTR	Final well test report
EMW	Equivalent mud weight
OMW	Original mud weight
KMW	Kill mud weight
SPM	Stroke per minutes
SPR	Slow pump rate
TVD	True vertical depth
MD	Measure depth
DP	Drill pipe
HWDP	Heavy weight drill pipe
DC	Drill Collar

Chapter 1

Introduction

1.1 Introduction:

The control of formation pressure, either by ensuring that the bore hole pressure is greater than the formation pressure known as (primary control) or by closing BOP valves at surface known (secondary control) is generally referred to as keeping the pressure in the well under control.

In oil industry the first step is the drilling of the wells that will produce the oil. There is two type of drilling wells vertical wells and horizontal wells. Now a days the drilling science is develop and growth day by day and new technology has been applied to keeping up human needs for energy that we got from oil and gas industry. Drilling wells starts by spud the rig equipment at the location of the well that spouse to be drill and drill the conductor hole then surface and intermediate then production this compartment according to casing installation.

Drilling operations is some complex procedures and full of problems like stuck pipe and low rate of penetration and hole deviation. The most dangerous problem is well control cases.

Low rate of penetration (ROP) is putting more weight on bit with low penetration occurs when drilling hard formation or bit selection is not suitable for the formation.

Well control is most danger and cost drilling operation. The purpose of well control is to ensure that fluids (oil , gas , water) doesn’t flow in an uncontrolled way from the formation being drilled into the borehole and eventually to surface, this flow will occur if the pressure in the pore space of the formation being drilled (formation pressure) is greater than the hydrostatic pressure exerted by the Colum of mud in the borehole (borehole pressure). It is essential that the bore hole pressure, due to the Colum of fluid exceed the formation pressure at all time during drilling . Most of drilling problem has direct relationship with geological description of specific area (Sudan).

1.2 Block-6 Background:

Block 6 is located in the Muglad, FNE-D1 exploration vertical well with depth 3450m drilled by PPS Rig 104, electric rig ,drilling capacity 5000,target formation Abu gabra,50% sand stone , 30% clay stone, 65% shale. Drill 215.90mm main hole from 2804.00mKB to 2826.49mKB, and generally the formation can be divided into classification from top to bottom as follows:

- Amal Formation
- Baraka Formation
- Ghazal Formation
- Zarqa Formation
- Bentiu Formation
- Abu Gabra Formation

1.3 Theoretical Background:

1.3.1 Definition:

1.3.1.1 Influx:

The flow of fluids from bottom into the well bore.

1.3.1.2 Kick:

Any influx or flow of formation fluid into the well-bore is termed as Kick. It may occur any time during drilling/ initial testing or work-over operation due to formation fluid pressure being greater than the bottom hole pressure.

With a swabbed kick there are four options:

1. Strip back in hole.

2. Perform a volumetric bleed.

3. Bullhead kickoff back into formation.

4. Perform off bottom kill then return to bottom and circulate well to desired mud weight.

1.3.1.3 Blowout Preventer Stack:

The assembly of well control equipment including preventers, spools, valves and nipples connected to the top of the casing head.

1.3.1.4 Blowout:

If the kick is uncontrolled, the formation fluid will flow to the surface is termed as Blow-out.

Type of blowouts:-

Surface blow out.

Sub surface blowout.

Underground blowout.

1.3.1.4.1 Surface blowouts:

The title shows that a surface blowout is a loss of control for the flowing fluid which is looking for the weak surface. The crew and equipment involved may face, as well as the environment.

1.3.1.4.2 Subsurface blowouts:

The blowouts that are subsurface blowouts cannot leak out through the surface easily. However, they pierce and get through a well at the bottom of the sea. Amount in case of its occurring under the rig right.

1.3.1.4.3 Underground blowouts:

The nature of blowout does not show the signs of warning straightly to be eyed easily at the surface. Underground blowouts are defined as the uncontrolled flow of the structure fluids from one a series of layers of rock to the other one.

1.3.1.5 Formation pressure:

It is the pressure hold within the structure itself. It is the pressure hold in the pore or passage spaces of the formation.

1.3.1.6 Shut-in Procedures:

When a kick is declared about its happening, soon the well must be locked at both the drill pipe and the preventers. If stopping the flowing of the well got failed, mostly a blowout would be underway. It is defined as the most common steps for shutting-in the well during the operations of drilling to avoid a kick. They are the rough shut-in and the smooth shut-in (2).

1.3.1.7 Soft shut-in procedures:

At first on observing any sign of a kick during drilling, the well is likely to flow, we must not go on rotating the drill string and lift with pumps on the drill string till we get the tool joint comes above the floor of the drill. 2.

Stop pumping then go to check the flow, if it is positive. 3.

Next open the choke line HCR valve. 4.

After that close BOP 5.

Finally close the choke. Note: While drilling, choke in an open position (21).

1.3.1.8 Hard shut-in procedures:

1. At first on observing any sign of a kick during drilling, the well is likely to flow, we must not go on rotating the drill string and lift with pumps on the drill string till we get the tool joint comes above the floor of the drill.
2. Then stop pumping then go to check the flow, if it is positive.
3. Next close the annular or pipe rams.
4. Finally open choke line of the valve of HCR (21)

1.3.1.9 Bore Pressure:

Pore Pressure is the pressure acting on the fluids in the pore spaces in the rock, is known as Formation pressure also. This is the portion of the overburden supported by the formation fluid.

1.3.1.10 Hydrostatic pressure:

Pressure exerted by the fluid column at a certain depth is termed as Hydrostatic Pressure.

1.3.1.11 Bottom hole pressure (BHP):

Sum of all pressures that are being exerted at the bottom of the hole and can be written as: BHP = Static pressure + Dynamic pressure

1.3.1.12 Fracture Pressure:

The pressure required to initiate a fracture in a sub-surface formation. Fracture pressure can be determined by Geo-physical methods; during drilling fracture pressure can be determined by conducting a leak-off test.

1.3.1.13 Kill Rate:

Kill rate is reduced circulating rate that is required when circulating out kicks, so that additional pressure to prevent formation flow can be added without exceeding pump liner rating. Kill rate is normally ½ to 1/3 of the normal circulating rate.

1.3.1.14 Accumulator (BOP Control Unit):

A pressure vessel charged with Nitrogen or other inert gas and used to store hydraulic fluid under pressure for operation of blowout preventers and/or diverter system.

1.3.1.15 Annular Preventer:

A device which can seal around different sizes and shapes object in the well bore or seal an open hole.

1.3.1.16 Choke manifold:

The assembly of valves, chokes, gauges and piping to control flow from the annulus and regulate pressure in the drill string/ annulus when the BOPs are closed.

1.4 Well control level:

1.4.1 Primary Control:

Pressure exerted by drilling fluid to hold back the formation fluid. Trip Monitoring is one of key success to avoid well control problems; which is defined as filling the hole during a trip; Driller keeps checking to see if the hole is taking the correct amount of mud; if not means two possible scenarios:

Possible lost circulation (if much volume).

Possible swabbing of formation fluid (if less volume).

In case of influx, the alertness in determining early warning signs in well control is of the upmost importance to wellbore safety. Careful observance and positive reaction to these signs will keep the well under control and prevent the occurrence of a well flow situation. The main warning/indicators are:

Improper fill up or displacement during trips.

Connection gas.

Change of drilling parameters.

Change of mud properties.

Increase drill string torque and drag.

Increase number and size of cutting and decrease in shale density.

The warning signs are to help engineers in taking corrective action before a kick takes place (not always there). However, kick indicators are:

Decreased pump pressure/increased SPM.

Excess flow and Return flow rate.

Pit gain and Flow from well with pumps off.

Drilling break.

An extremely important aspect of well control is the proper selection and utilization of the blowout preventers, chokes; choke manifolds, mud-gas separators, degassers, mud-monitoring equipment and all other well control related equipment. Only with properly selected equipment, which has been correctly maintained and serviced successful well control procedures initiated. It has to be realized that the BOP is only one part of the well integrity. Wellhead equipment, casing and open hole must all be considered. Wellheads and pressure control equipment should meet the minimum working pressure requirement.

1.4.2 Secondary Pressure Control:

Surface equipment that is closed to stop any further entry of formation fluid. Secondary pressure control is the system, which provides the second line of defense, in the event that primary well control cannot be properly maintained. This is generally provided by the BOP system including:

1.4.2.1 Blind/Shear Rams - Choke and Kill Outlets:

There will be at least one (1) kill and one (1) choke outlet with at least two (2) full opening valves on each choke outlet. If the BOP stack is equipped with shears rams, they shall be capable of shearing the highest grade and heaviest drill pipe used on the rig (HWDP excluded).

1.4.2.2 Relief Lines:

At least two relief lines shall be installed to permit venting of the wellbore returns at opposite ends or sides of the rig. On land rigs a single line is acceptable.

1.4.2.3 Closing Unit and Accumulator Requirement:

The closing unit will consist of an independent automatic accumulator unit rated for at least 20,700kPa (3,000psi) working pressure with a control manifold, clearly showing 'open' and 'close' positions for preventers and the pressure operated choke line valve. It is essential that BOP operating units be equipped with regulator valves, which will not fail open causing a complete loss of operating pressure. This unit will be located in a safe area. Due to the large volume required to close the annular preventer(s) and large bore diverters (such as Hydril MSP) which can result in slow closing time, the hydraulic pressure for the initial closure of the annular preventer will be set at the maximum operating pressure during normal drilling operations. However, it must be readjusted to the manufacturer's recommended pressure after closure and/or prior to running casing, routine pressure testing and stripping operations.

1.4.2.4 Mud Gas Separators:

An atmospheric or low pressure separating vessel for handling gas-cut returns must be provided where blowout preventers are used. It must be equipped with gas vent lines to discharge gas.

All equipment listed above is used to control the well using a method of killing methods. (Aberdeen Sch 2002, Neb 2009, Chevron center 1994).

1.4.3 Tertiary Control:

Techniques to control blowout and fire accidents. In the event that secondary control cannot be properly maintained due to hole conditions or equipment failure, certain emergency procedures can be implemented to prevent the loss of control. These procedures are referred to as "Tertiary Control" and usually lead to partial or complete abandonment of the well. Unlike primary and secondary control, there are no established tertiary well control procedures that will work in most situations. The procedures to be applied depends on the particular operating conditions which are encountered, and specific recommendations regarding appropriate tertiary control procedures cannot be given until the circumstances leading to the loss of secondary control are established. However, there are two procedures that are widely used:

Barite plugs.

Cement plugs.

In most cases when a well control problem occurs after cement job, cement evaluation logs give a general idea of what happened during and directly after cement job. Therefore will clear cement evaluation logs. (Robert D 1994, John R. Kozicz 1999, Erik B. Nelson 1990, Jacques Jutten1988).

1.5 Problem Statement:

FNE-D1 well in block 6 have been selected as case study; as it encounter a kick off at AG formation while drilling.

1.6 Methodology:

Preparation data.

Kill sheet Calculation.

Driller method calculation.

Comparison.

1.7 Objective:

Study and analysis well control problem and return the well to its primary control by using driller method and weight and wait method.

Find an appropriate solution through comparing between the two methods (driller and weight & wait methods).

Control the well with low cost, saving time, and less casualties and environmental damages.

Conduct a field study analysis using weight & wait method. Our case study is a kick off took place in FNE-D1 field during drilling operation (Block 6 Balila Field).

Chapter 2

Literature Review

2.1 Literature Review:

Yasser Jahanpeyma and Saeid Jamshigi (02- Des -2018), two phase simulation of well control methods for gas kick in case of water and oil based muds kick occurrence is a possible event during a drilling process.

S.Niishikawa et.al (2001) performed a series of experiment to investigate a procedure for killing sustained casing pressure (SCP) by the bleed and the lubricate methods of injecting heavy brine in to annuals. The procedure in evolves bleeding fluids from the annuals lubricating in weighted fluids in order to displace annular fluid with the heavy brine. The concept of this method of in the annulus the objective of the study was to evaluate the performance of cycler injection in view of the efficiency of displacing annular fluid with injected fluid.

Yuan Qiji Zheng Zheng et.al (2012) in the paper was aimed at finding found the non-routine well control procedure to deal with the overflow of the well in special operating conditions. Study the well killing technology in force situation. The situation include the well is full of natural gas, lower of the well is liquid column and upper of the well of natural gas, the well pore block and able establish cycling for containing liquid column, besides the well pore fish were the fish intact and does not block the wellbore, the fish block the wellbore or the fish is breakup and blocks the wellbore. Discuss the principles, steps, calculation procedures and formulas of killing well in weight and wait method.

Table (2. 1) Blowout Record in off shore Rigs

Year	Rig Name	Rig Owner	Type	Damage / details
1955	S-44	Chevron Corporation	Sub Recessed pontoons	Blowout and fire. Returned to service.
1959	C. T. Thornton	Reading & Bates	Jack up	Blowout and fire damage.
1964	C. P. Baker	Reading & Bates	Drill barge	Blowout in Gulf of Mexico,

				vessel capsized, 22 killed.
1965	Trion	Royal Dutch Shell	Jackup	Destroyed by blowout.
1965	Paguro	SNAM	Jackup	Destroyed by blowout and fire.
1968	Little Bob	Coral	Jackup	Blowout and fire, killed 7.
1969	Wodeco III	Floor drilling	Drilling barge	Blowout
1969	Sedco 135G	SedcoInc	Semi-submersible	Blowout damage
1969	Rimrick Tidelands	ODECO	Submersible	Blowout in Gulf of Mexico
1970	Storm drill III	Storm Drilling	Jack up	Blowout and fire damage.
1970	Discoverer III	Offshore Co.	Drillship	Blowout (S. China Seas)
1971	Big John	Atwood Oceanics	Drill barge	Blowout and fire.
1971	Unknown	Floor Drilling	Drill barge	Blowout and fire off Peru, 7 killed.
1972	J. Storm II	Marine Drilling Co.	Jackup	Blowout in Gulf of Mexico
1972	M. G. Hulme	Reading & Bates	Jack up	Blowout and capsize in Java Sea.
1972	Rig 20	Transworld Drilling	Jack up	Blowout in Gulf of Martaban.
1973	Mariner I	Sante Fe Drilling	Semi-sub	Blowout off Trinidad, 3 killed.
1975	Mariner II	Sante Fe Drilling	Semi-submersible	Lost BOP during blowout.
1975	J. Storm II	Marine Drilling Co.	Jackup	Blowout in Gulf of Mexico.

1976	Petrobras III	Petrobras	Jackup	No info.
1976	W. D. Kent	Reading & Bates	Jackup	Damage while drilling relief well.
1977	Maersk Explorer	Maersk Drilling	Jackup	Blowout and fire in North Sea
1977	Ekofisk Bravo	Phillips Petroleum	Platform	Blowout during well workover.
1978	Scan Bay	Scan Drilling	Jackup	Blowout and fire in the Persion Gulf.
1979	Salenergy II	Salen Offshore	Jackup	Blowout in Gulf of Mexico
1979	Sedco 135F	Sedco Drilling	Semi-submersible	Blowout and fire in Bay of Campeche Ixtoc I well.
1980	Sedco 135G	Sedco Drilling	Semi-submersible	Blowout and fire of Nigeria.
1980	Discoverer 534	Offshore Co.	Drillship	Gas escape caught fire.
1980	Ron Tappmeyer	Reading & Bates	Jackup	Blowout in Persian Gulf, 5 killed.
1980	Nanhai II	Peoples Republic of China	Jackup	Blowout of Hainan Island.
1980	Maersk Endurer	Maersk Drilling	Jackup	Blowout in Red Sea, 2 killed.
1980	Ocean King	ODECO	Jackup	Blowout and fire in Gulf of Mexico, 5 killed.
1980	Marlin 14	Marlin Drilling	Jackup	Blowout in Gulf of Mexico
1981	Penrod 50	Penrod Drilling	Submersible	Blowout and fire in Gulf of Mexico.
1985	West Vanguard	Smedvig	Semi-submersible	Shallow gas blowout and fire in Norwegian sea, 1 fatality.

1981	Petromar V	Petromar	Drillship	Gas blowout and capsize in S. China seas.
1988	Ocean Odyssey	Diamond Offshore Drilling	Semi-submersible	Gas blowout at BOP and fire in the UK North Sea, 1 killed.
1989	Al Baz	Sante Fe	Jackup	Shallow gas blowout and fire in Nigeria, 5 killed.
1993	Actinia	Transocean	Semi-submersible	Sub-sea blowout in Vietnam. .
2001	Ensco 51	Ensco	Jackup	Gas blowout and fire, Gulf of Mexico, no casualties
2002	Arabdrill 19	Arabian Drilling Co.	Jackup	Structural collapse, blowout, fire and sinking.
2004	Adriatic IV	Global Sante	Jackup	Blowout and fire at Temsah
2007	Usumacint a	PEMEX	Jackup	Storm force rig to move, causing well blowout on Kab 101 platform, 22 killed.
2009	West Atlas / Montara	Seadrill	Jackup / Platform	Blowout and fire on rig and platform in Australia.
2010	Deepwater Horizon	Transocean	Semi-submersible	Blowout and fire on the rig, subsea well blowout, killed 11 in explosion.
2010	Vermilion Block 380	Mariner Energy	Platform	Blowout and fire, 13 survivors, 1 injured.

2.2 Well Control Methods:

The objective of the various kill methods is to circulate out any invading fluid and circulate a satisfactory weight of kill mud into the well without allowing further fluid into the hole. Ideally this should be done with the minimum of damage to the well. If this can be done, then once the kill mud has been fully circulated around the well, it is possible to open up the well and restart normal operations. This allows approximately constant bottom hole pressure which is slightly greater than formation pressure to be maintained as the kill circulation proceeds because of the additional small circulating friction pressure loss. After circulation the well is opened up again and the mud weight may be further increased to provide a safety or trip margin. There are four constant bottom-hole pressure kill methods in common use today which are:

Driller's Method.

Wait & Weight Method (Engineer's Method).

Concurrent Method.

Volumetric method.

2.2.1 Driller's Method:

Include two Circulations: 1st Circulation to clean out influx by original mud weight considering only bottom up time and 2nd Circulation to complete cycle by kill mud weight. Practice procedure for driller method as the following:

2.2.1.1 1st Circulation:

Startups bring pumps up to kill rate holding casing pressure constant. When up to speed, look at drill pipe pressure (ICP.) Hold it constant this value for bottom up. After circulation bottom up finished, shut down the pump look for pressure.

If annulus is clean, SICP. Will now read same value as SIDPP, If annulus is not clean then SICP will be greater than SIDPP.

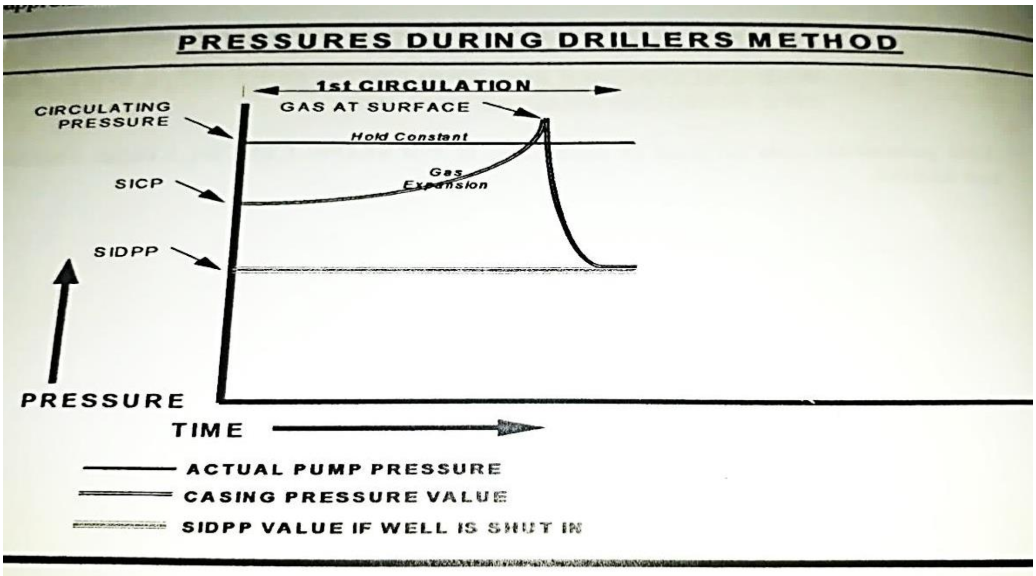


Fig. (2. 1) Driller Method Carve First Circulation

2.2.1.2 2nd Circulation:

Startup Bring pumps up to kill rate holding casing pressure constant.

When kill mud reaches at rotary table, re-zero stroke.

When up to speed maintain casing pressure constant until kill mud is at the bit.

With kill mud at bit switch to drill pipe pressure (FCP) and hold constant until kill mud returns at surface.

It may be preferred to use the Wait and Weight procedure for the 2nd circulation. This is in case of any influx that was not cleaned out in the 1st Circulation.

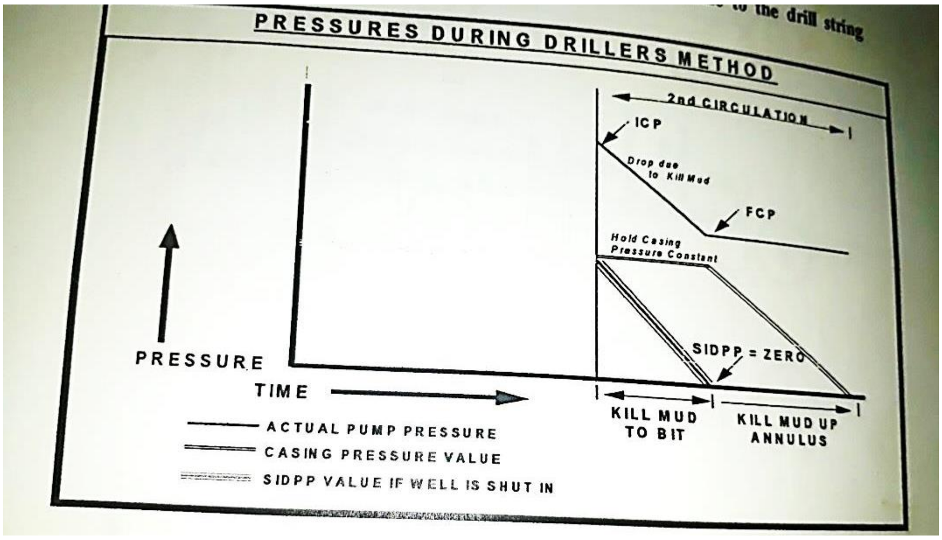


Fig. (2. 2) Driller Method Carve Second Circculation

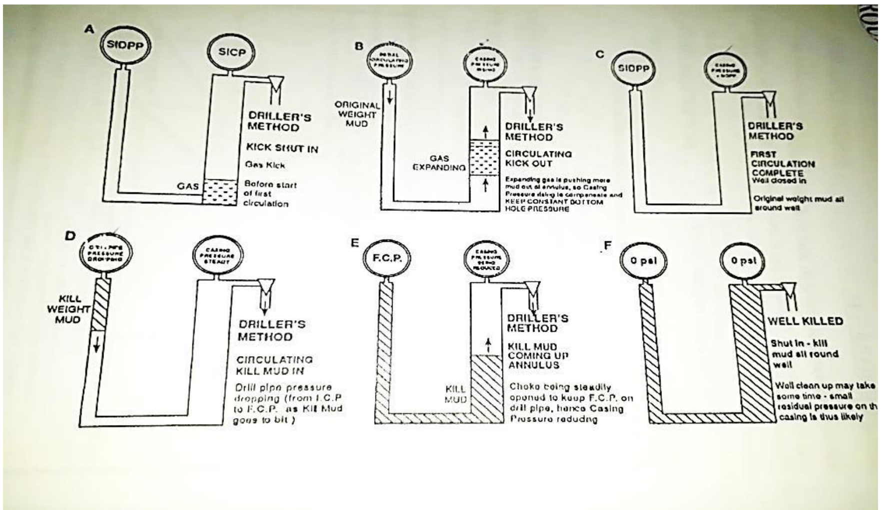


Fig. (2. 3) Driller Method Procedure

2.2.2 Wait and Weight Method:

One Complete circulation with kill mud weight.

Practice procedure for driller method as the following:

Startup brings pumps up to kill rate, holding casing pressure constant.

When kill mud reach at rotary table, re-zero stroke.

Once up to speed the drill pipe pressure should equal ICP.

Allow drill pipe pressure to fall from ICP to FCP as kill mud is pumped to the bit, by using drill pipe step down Pressure schedule.

With kill mud at the bit hold drill pipe pressure constant at FCP til kill mud returns to surface.

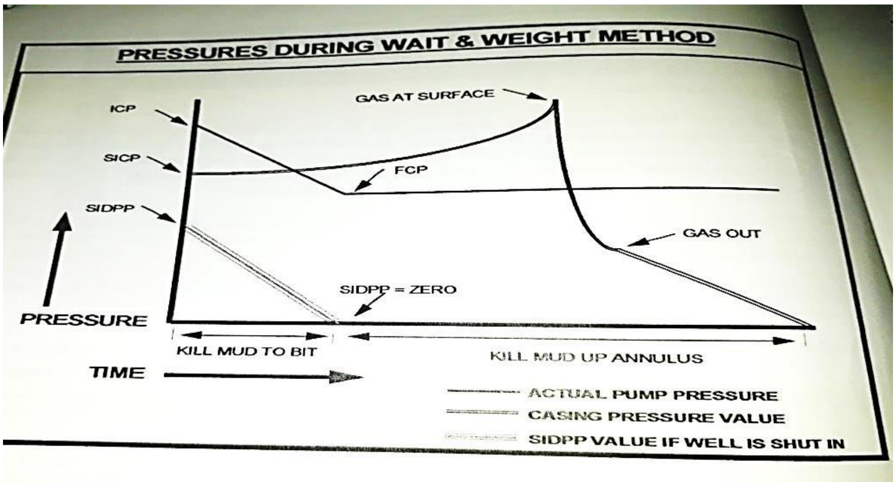


Fig. (2. 4) Weight and Wait Carve

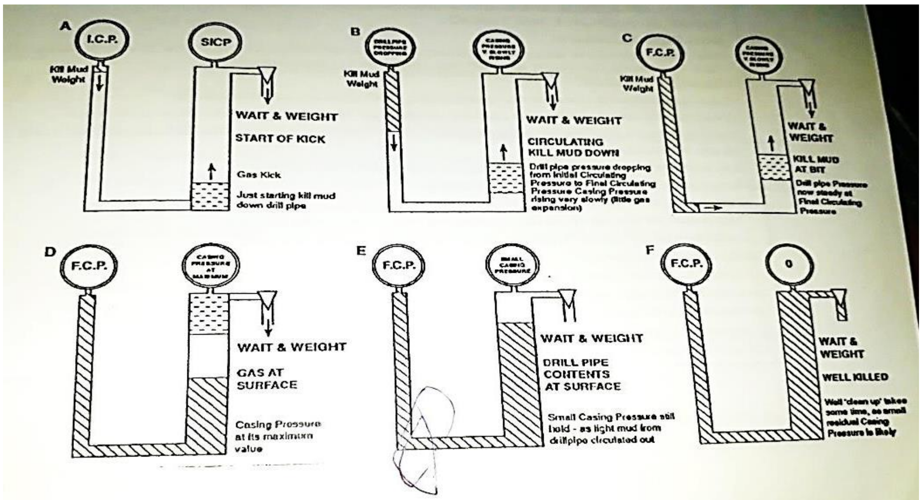


Fig. (2. 5) Weight and Wait Procedure

Table (2. 2) advantage and disadvantage two methods

Advantages	Disadvantages
Lower annulus pressure	High non circulating time
Lower casing shoe pressure when open hole volume is more than string volume	In case of salt water kick, sand setting around BHA is maximum
Well can be killed in one circulation	Calculation are more
Less time on choke operation	More chances of gas migration

2.2.3 Volumetric Method:

It depends on Boyle's law; it does not kill the kicking well, but it can be used to bring the migration gas in side casing and exclude it. Situations can the volumetric method of well control is applied are:

Bit is on bottom and drill string is plugged. (bit is fully choked)

Bit is off Bottom and not possible to strip or pipe stuck.

Drill string out of hole.

Mud pump down and not available or failure in surface line was shut in the drill string.

2.2.4 Concurrent method:

It depends on gradual increase in mud weight from the original mud kill mud weight.

Sometime referred to as the circulate and weight method or slow weight up method.

It involves gradually weighting up fluid while circulating out the kick.

Additional calculations are required when tracking different fluid weights in the string at irregular intervals.

Sometimes crew members are required to record concurrent method data even if this is not the method intended to be used.

Circulate out kick while gradually increasing mud weight (same as wait & weight method except you will follow DP pressure vs. mud weight schedule as you weight – up your mud) only used insufficient weighting material is at rig site till kill mud weight.

2.3 kick Case History:

0:00	**3:00**	**3.00**	**Drill 215.90mm main hole from 2804.00m KB to 2826.49mKB.**
3:00	10:30	7.50	**Due to gas increase while drilling to 580512ppm & mud flow mix with oil & gas, close the BOP's pipe ram and waiting for pressure to stabilize (SIDPP 3MPa,SICP 6MPa). while prepare kill mud**
10:30	13:30	3.00	**Kill the well with 1.45 g/cm3**
13:30	14:15	0.75	**Closed BOP's (SIDPP=zero, SICP=zero).**
14:15	15:15	1.00	**Circulate & condition mud, but return mud weight drop to 1.32g/cm3.**
15:15	22:15	7.00	**Closed BOP's, Circulation with chock manifold & keep SICP 2Mpa.**
22:15	0:00	1.75	**Prepare kill mud.**

Chapter 3

Methodology

In this chapter present the methodology of the study, include data preparation and calculation.

3.1 data Preparation:

Collected data from DDR of FNED-01 well , located in block -06 , it have been a kick in AG formation at depth 2826m.

3.2 kill sheet:

3.2.1 Data required:

Data Hole size

Hole depth TVD

Drilling Fluid density

Heavy Wall pipe capacity

Drill collars capacity

Capacity open hole x drill collars

Capacity open hole x drill pipe / HWDP

Capacity casing x drill pipe

Fracture fluid density at the casing shoe

Slow Circulating Rate Pressure at

Mud pumps displacement

Pit gain

SIDPP

SICP

LOT DATA :SHOE LEAKED

3.2.2 Excel form:

Created an excel sheet form to calculate kill sheet by used the following equation:

Equivalent Mud Wt (ppg) = (APL + Pmuda) ÷ 0.052 ÷TV……………(3.1)

$$\text{Kill Weight Mud (ppg)} = \text{Original Mud Weight} + \left(\frac{\text{SIDPP}}{\text{T.V.D.} \times 0.052} \right) \quad \text{……………………(3.2)}$$

Maximum Allowable Mud Weight (ppg) = Formation Breakdown Gradient (psi/ft) | 0.052 ……………………(3.3)

or

$$\text{Maximum Allowable Mud Weight (ppg)} = \frac{\text{Formation Breakdown Pressure (psi)}}{\text{Vert Shoe Depth (ft)}} \mid 0.052 \quad \text{…………………………(3.4)}$$

ICP = PSCR + SIDPP ……………………………………………….(3.5)

$$\text{FCP} = \frac{\text{kill mud weight}}{\text{current mud weight}} * \text{dynamic pressure loss} \quad \text{……………………… (3.6)}$$

3.2.3 Calculation problem:

By used kill sheet calculate the flowing

Determine MAASP

Calculate drill string Volumes

Calculate annular Volumes

Calculate total annular Volumes

Calculate total system Volumes

Calculate Kill Mud Weight

Calculate Pressure chart

Calculate ICP & FCP

3.3 Driller calculation:

3.3.1 Data required:

Data Hole size

Hole depth TVD

Drilling Fluid density

Fracture fluid density at the casing shoe

Slow Circulating Rate Pressure at

Mud pumps displacement

Pit gain

SIDPP

SICP

Lot data :shoe leaked

3.3.2 Calculation:

By used driller excel sheet form calculate the following

Determine MAASP

Calculate Kill Mud Weight

Calculate Pressure chart

Calculate ICP & FCP

3.3.3 Comparing:

Comparing between weight and wait and driller methods in MAASP and ICP.

Chapter 4

Results and discussion

In this chapter we will apply wait and weight methodology to compute the required bottom hole pressure to control the kickoff. Discuss and analyze the differences between weight and wait and driller method using FNED-01 Well as a field case study.

4.1 Computation of kick using wait and weight method:

4.1.1 Input data:

Well & kick data:

Table (4. 1) Well and Kick Data

Hole size	8 1/2	in
Hole depth TVD	9271	ft
Drilling Fluid density	12.8	ppg
Casing (9 5/8 in)	6730.5	ft
Drill pipe 5 in capacity	0.01741	bbl/ft
Heavy Wall pipe 5 in	367	ft
Heavy Wall pipe capacity	0.00874	bbl/ft
Drill collars 6 $^1/_2$ in	371.5	ft
Drill collars capacity	0.0076	bbl/ft
Capacity open hole x drill collars	0.0291	bbl/ft
Capacity open hole x drill pipe / HWDP	0.0469	bbl/ft
Capacity casing x drill pipe	0.0489	bbl/ft
Fracture fluid density at the casing shoe	16.4	ppg
Slow Circulating Rate Pressure at 40 SPM	500	psi
Mud pumps displacement	0.13	bbl/strk
Pit gain	12	bbl
SIDPP	435	psi
SICP	870	psi
LOT DATA :SHOE LEAKED	1600 psi	11.9 ppg

4.1.2 kill sheet calculation:

By using excel kill sheet calculation; we have got the following result:

MAASP =1250 psi

Drill string Volumes = 154.58 bbl.

Total annular Volumes = 441.66 bbl.

Total system Volumes = 596.24 bbl.

Kill Mud Weight = 13.8 ppg.

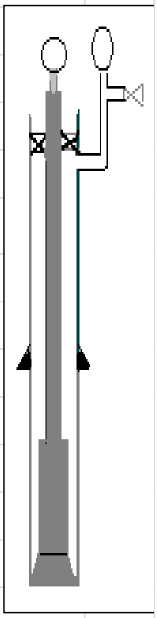
ICP = 970 psi

FCP = 589 psi

International Well Control Forum Surface BOP (Vertical Well) Kill Sheet - API Units	Name :	SHEET NO :3
	Date :	MARCH 24

Formation Strength Data :-				Current Well Data:		
Surface Leak-off Presure:-	(A)	1600	psi	Mud Data:		
Mud Weight:-	(B)	11.9	ppg	Weight	12.8	ppg
Maximum Allowable Mud Weight:-				Gradient		psi/ft
(B) + (A) / shoe True Vertical Depth *0.052 =	(C)	16.4	ppg	Casing Shoe Data:		
Initial MAASP =				Size	9 5/8	inch
[(C) - Current Mud Weight] x Shoe TVD x 0.052 =		1250	psi	M.D	0	ft
Pump No. 1 Displacement	Pump No. 2 Displacement			T.V.D	6730.5	ft
0.13 bbls/stroke	bbls/stroke					

Slow Pump Rate Data :	Dynamic Pressure Loss (PL)		Hole Data :-		
	Pump NO.1		Size	8 1/2	inch
40 spm	500 psi	psi	M.D	0	ft
spm	psi	psi	T.V.D	9271	ft



Pre-Volume Data:	Length ft.		Capacity bbls/ft		Volume bbls		Pump strokes		Time minutes	
Drill pipe	8532.5	x	0.01741	=	148.55					
Heavy Wall Drill pipe	367	x	0.00874	=	3.21		Volume / Pump Displacement		Pump Strokes / Slow Pump Rate	
Drill Collars	371.5	x	0.0076	=	2.82					
Drill String Volume				(D)	154.58	bbl	(E) 1189	stks	30	min
DC x Open Hole	371.5	x	0.0291	=	10.81					
DP / HWDP x Open Hole	2169	x	0.0469	=	101.73					
Open Hole Volume				(F)	112.54	bbi	866	stks	21.6	min
DP x Casing	6730.5	x	0.0489	=(G)	329.12	bbi	2532	stks	63.3	min
Total Annuulus Volume			(F+G) = (H)		441.66	bbi	3397	stks	85	min
Total Well System Volume			(D+H) = (I)		596.24	bbi	4586	stks	115	min
Active Surface Volume			(J)			bbi		stks		
Total Active Fluid System			(I+J)			bbi		stks		

Kick Data								
SIDPP	435	psi	SICP	870	psi	Pit Gain	12	bbls

Kill Mud Weight KMW	Current Mud Weight	SIDPP / TVD x 0.052	12.8+ (435\.052 *9271)	13.80 ppg
Kill Mud Gradient KMG	Current Mud Gradient +	SIDPP / TVD		0.72 psi/ft
Initial Circulating pressure ICP	Dynamic Pressure Loss + SIDPP		500+435	935 psi
Final Circulating pressure FCP	Kill Mud Weight / Current Mud Weight x	Dynamic Pressure Loss	(13.80\12.8)*500	539 psi

(K) = ICP - FCP	935-539	395.94 psi	(K) x 100 / (F) =	(396\1189)* 100	33.3	psi/100 strokes

Strokes	Pressure
0	935
100	902
200	868
300	835
400	802
500	769
600	735
700	702
800	669
900	635
1000	602
1100	569
1189	539
1300	539
1400	539
1500	539
1600	539
1700	539
1800	539

Fig. (4. 1) Weight And Wait Kill Sheet

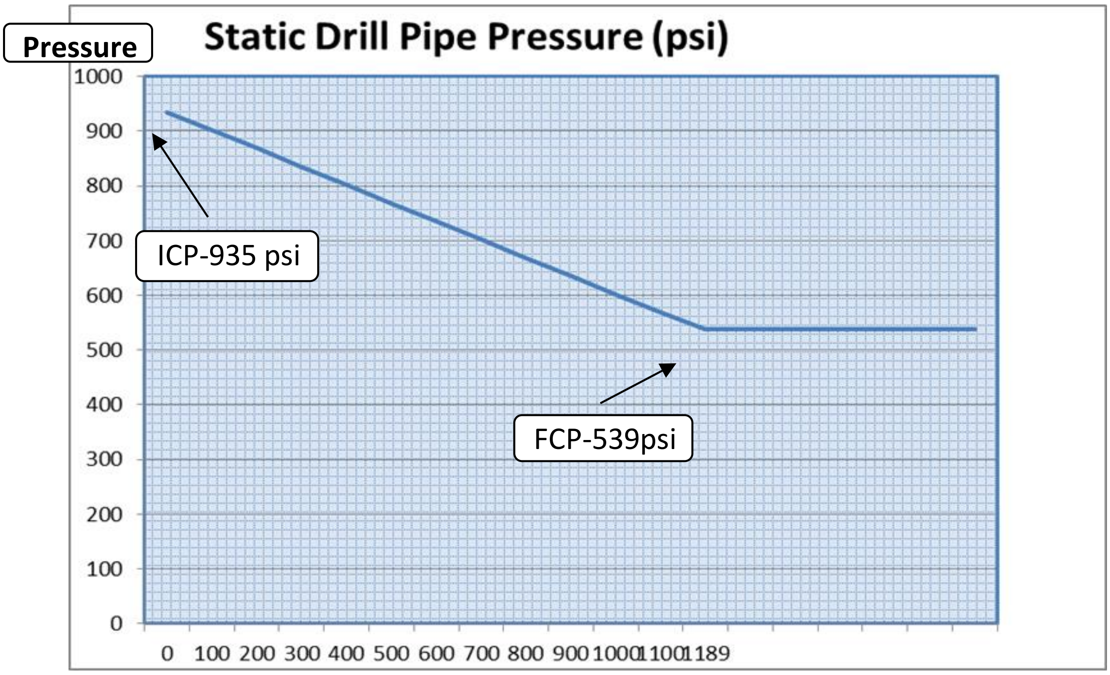


Fig. (4. 2) Pressure vs Stroke

4.2 Driller Method Calculation:

4.2.1 Input data:

Well & kick data:

Table (4. 2) Well &Kick Data

Hole size	8 1/2	in
Hole depth TVD	9271	ft
Drilling Fluid density	12.8	ppg
Casing (9 5/8 in)	6730.5	ft
Drill pipe 5 in capacity	0.01741	bbl/ft
Drill collars 6 $^1/_2$ in	371.5	ft
Drill collars capacity	0.0076	bbl/ft
Slow Circulating Rate Pressure at 40 SPM	500	psi
Mud pumps displacement	0.13	bbl/strk
Pit gain	12	bbl
SIDPP	435	psi
SICP	870	psi
LOT DATA :SHOE LEAKED	1600 psi	11.9 ppg

4.2.2 Excel sheet calculation:

By using excel kill sheet calculation, we have got the following result:

MAASP = 1285psi

Kill Mud Weight = 13.7 ppg.

ICP = 935 psi.

FCP= 535 psi.

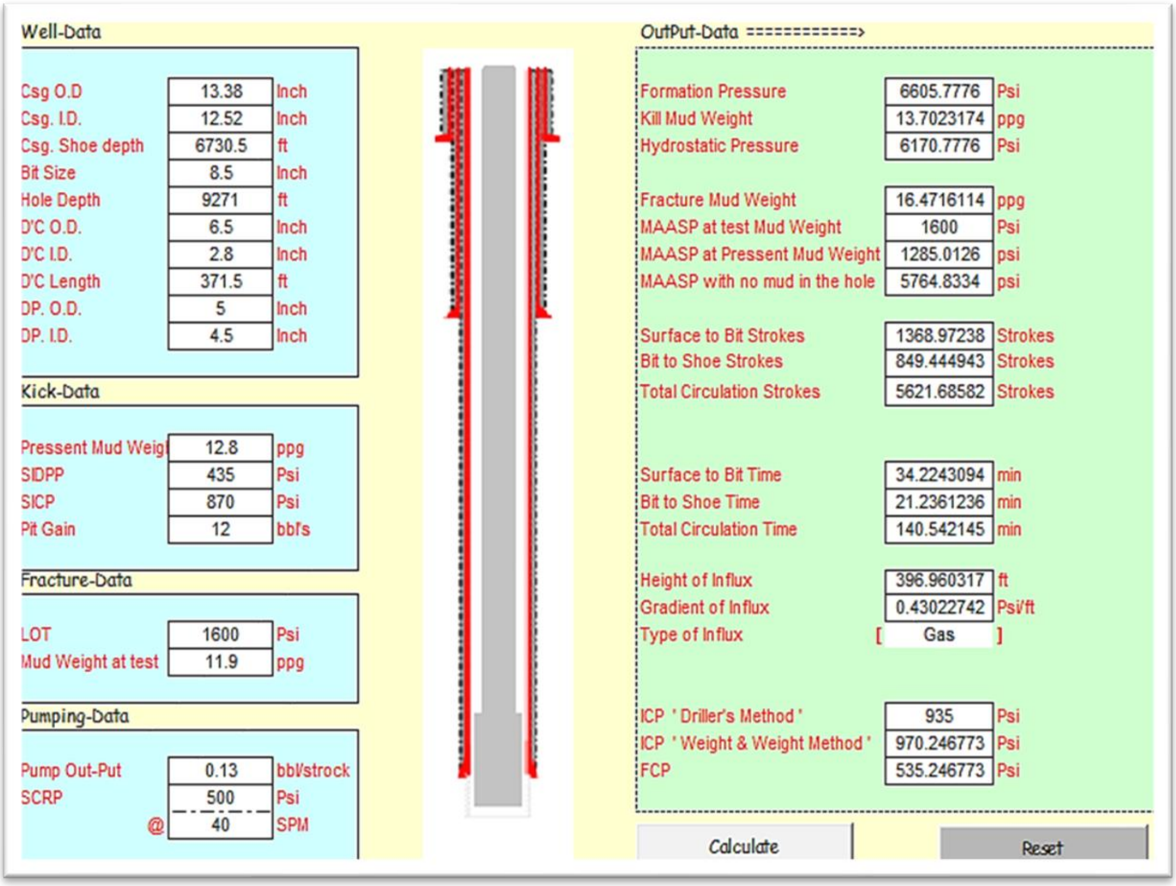


Fig. (4. 3) Driller Method Excel Sheet

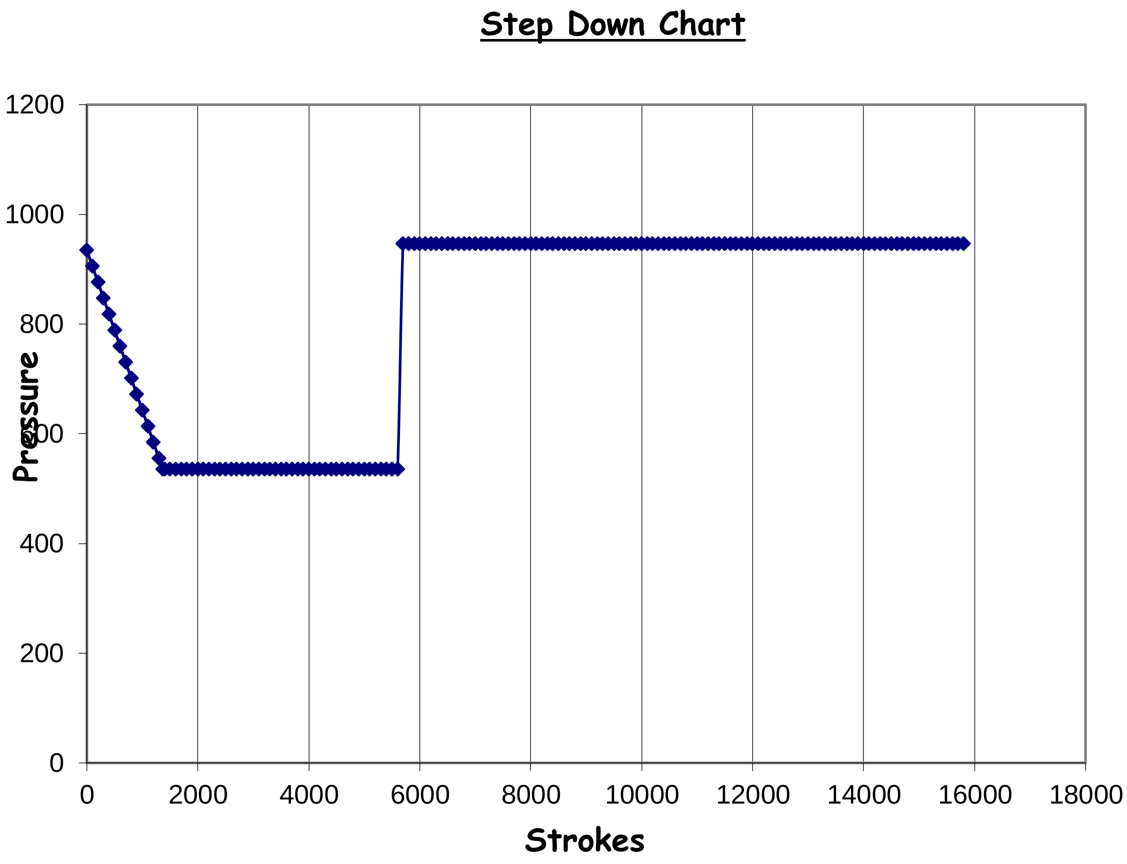


Fig. (4. 4) Pressure vs Stroke

4.3 Output Results:

Table (4. 3) Result Driller & Weight and Wait Methods

Result	Driller Method	Weight & wait Method
MAASP	1285psi	1250psi
Drill string volume	154.58	154.58
Total annuals volume	441.66	441.66
Total volume system	596.24	596.24
Kill Mud Weight	13.8ppg	13.8ppg
ICP	935psi	935psi
FCP	539psi	539psi

4.4 Results discussion:

After calculation by used the two methods, it’s found that different results in computing MAASP as shown in the table (4.3).

Referring to above table (4.1) and figures (4.1, 4.3), we have different results in MAASP for driller method and weight and wait method. That difference is result of the change of the mud weight that is using in the two methods.

Regarding to the weight and wait method mechanism, the current kill mud used to kill the well by pump it one time to take one circulation inside to get-out the influx from the well during short time.

While in the driller method which has much time for two circulations, prepare and mix additional mud weight which is needed then pump it to kill the well.

So that is the cause of the difference in the MASSP when using the weight & wait and driller methods in Table (4.3).

Chapter 5

Conclusions and Recommendations

5.1 Conclusions:

The main purpose of this research was to analyze well control problem for FNED-01 well; determine MAASP, ICP, FCP.

The Two different well control methods have applied to kill the well driller; wait and weight methods; calculations have been completed to each method individually.

The Driller's Method does offer some distinct advantages over the W&W Method. The W&W Method may be advantageous to achieve lower shoe and surface pressures.

Wait & Weight has Less lost circulation, also it has shortest circulating time(one circ.),More time to organize crew.

After making the comparison between driller and weight & wait then we found out the best method to apply well control is to apply due to mud system compartment and need a very high experience from rig crew.

From the previous well FNED-01 study we find that the most important issues is to used weight and wait method as the first choice when conventional method

For most of Sudanese oil field to use weight and wait method, its more safe cheaper and simple.

It is recommended because it can accurately monitoring through bleed volume.

5.2 Recommendations:

Apply Concurrent method to kill the well and comparing both driller and W& W methods; which it is not common in the oil industry and is the first time to be applied in the Sudan for drilling rig.

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