Monobore completion techniques as potential solutions

A vast majority of operators are looking forward at monobore completion techniques as potential solutions to economic and operational challenges. This technique can enhance the completion process and the benefits of this concept influencing different phases of the well technology that can result in to a wide range of operational advantages. However, this philosophy requires employing purpose built equipments in order to avail its advantages. The oil and gas industry is paying attention at operational efficiency and cost cutting methods and thus, the professionals of this industry are in search of the techniques that have the potential to improve in these areas.

Monobore completion techniques tend to provide a great level of flexibility for maintenance operations that the operators are doting to achieve. As per its design, the tubing does not seem to impose any restriction over any equipment that has been used in the liner. This technique reduces service costs since special tools are discarded for such wells. But these operational savings are usually not recognized until very late in the development of the well since the cost savings via monobore concept are very much anticipated and not instant which makes it hard to calculate the precise amount of additional expense for the completion process that is vital for making decisions regarding the intricacy of the down hole components. The limitation of monobore technology is that the conventional seal bores introduce may influence the potential performance of other down hole services which include those demanded by production logging. The conventional design concepts can not be used to design the criteria for monobore completions. For instance, due to the reduced diametrical clearance, monobore completions will not comply with the typical designs of sub surface flow control devices. Moreover, traditional lock mandrel systems depend on interference engaging packing so that the plugs and the chokes can be sealed.

This research paper tends to compare monobore drilling technology with its conventional counterpart on the basis of the case studies of some specific oil fields. Also, it will discuss the monobore technology in detail by specifying its costs and benefits. Furthermore, the paper describes the different components of monobore drilling and also, studies different technical aspects of monobore technology.

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Figure 2 showing the design process with the extensive fluid dynamic simulations to illustrate the fluid characteristics through the completion process. 11

It was essential to identify the areas where the residual cement was left behind after the cement was pumped out. SPM was found to be the most critical area which might make it hard to replace the gas lift valve or the dummy valve. The areas highlighted in the figure 2 are those where the design enhancements were assured to cause turbulence and let these critical components clean on their own? Safety valves use the same design concepts to restrict the collection of sand in them and this illustrated the necessity of turbulent flow across the SPM body. 11

Introduction

Monobore completion techniques are gaining more attention in the contemporary world of well drilling. 'Monobore' refers to the completion that employs constant size of the completion string ID through out the well. The benefits of such completions are classified in to two basic categories: well production and remedial operations due to which monobore completions are given preference over conventional completions. However, it has certain limitations too. Monobore wells are basically pursued due to reduced drilling cost and number of specialized equipments as these directly influence the cost of completion. A lot of the wells would have been impractical if they have to be completed through the traditional technique. However, such unfeasible wells would become better marginally, or profitable or even highly profitable in some cases if they employed a system in which both the rig time and the equipment list, such as packers, sliding sleeves, etc., could be reduced while managing to safely complete the well. The earliest methods included cementing the completion in the wellbore. Later methods include staging the cement process so that the equipments increasing the well's life and ascertaining its safe operation could be included.

This paper discusses several methods regarding monobore well design that saves significant time through reducing the entire cost of completion. A significant number of studies have been recently executed in order to establish a system that is more sustainable to complete these wells and increase their productivity that makes them even more attractive to the operators. Detailed procedures will be discusses with the help of the illustrations that explains the various strengths and limitations of each completion method in a well completion process. Each method will be supported through case studies.

1. 1 AIM

The study is aimed towards investigating and evaluating the appraisal methods of current and future techniques of monobore wells.

1. 2 Objectives

In order to attain the above mentioned aim, the following objectives should be achieved in this study.

Describe and explain the monobore wells along with their costs and benefits in comparison to the conventional drilling techniques.

Study the concept of monobore wells and the different methods of monobore completions.

Conduct feasibility of a well to deal by comparing the conventional and mono-bore drilling with each other.

Apprehend the future development of mono-bore wells, and recommend research and development work that may cause the current applications to expand.

Literature Review

Contemporary well could be categorized as short life or harvest wells out of which some are economically unfeasible since they employ high end completion rigs and methods. This dilemma could be resolved through monobore wells. A well is classified as a monobore completion if it has single production tubing size right a way from pay zone through out the surface of completion. Despite the fact that there monobore completions have some limitations but they also have various benefits such as reduced drilling cost and lesser variety of rigs, which includes packers, sliding sleeves, etc., involved in the drilling process in comparison to its other counterparts. A lot of wells that were infeasible through the conventional completion regimes have found to be safely and efficiently completed with monobore completion system. That is why this completion technique has acquired the attention of many operators and researchers and thus, it is extensively applied to horizontal wells today.

Cementing the completion in the wellbore is regarded as one of the most primitive methods used. Then this method was enhanced by staging the process with the help of equipments in order to make the well last long along with operational safety. A lot of researches and studies have been carried out so that a more reliable and improved system of completion could be developed for completing these wells with increased output. Reservoir and wellbore hydraulics simulations have been studied for a long time. Researchers are now concentrating on the interaction between the fluid flows of reservoir and wellbore since the horizontal wells are extensively applied. The benefits of employing monobore completions are now easily acquired since the industry is inclined towards high rate gas completions. These benefit of monobore completions are categorized as: well production benefits and remedial operations benefits.

Well Production Benefits:

Increased tubing size in monobore completions that also increases the deliverability of a well.

Lesser number of wellbores is done to efficiently drain the reservoir.

This can reduce the number of required platforms, especially in case of the offshore projects.

Reduction in the operational and maintenance cost due to the decrease in the number of well bores.

Increased durability and reliability since the monobore completions are simpler in comparison to their traditional counterparts.

Further, the gas turbulence areas are reduced due to the elimination of internal restrictions.

Remedial Operations Benefits:

Remedial operations benefits are actually known towards the end of the field's life.

The elimination of internal restrictions also makes it simple to run services and for intervention equipments.

Moreover in monobore completions, the liner top can be completely accessed which enables easier mechanical isolation or squeeze.

The necessity of bringing compression on line can be delayed due to the increased tubing size as it reduces the frictional pressure drop whilst production.

Field development time is also reduced through running 95/8 in. monobore. This decreased time enables the operators to produce first gas earlier or start the project as late as the time being saved. Thus, the net present value of a large project is dramatically affected. Usually, this increase in value is higher than the cost of increasing the tubing size.

Monobore completions can deliver higher output than the expected production.

Monobore Systems

The Oil and Gas industry has the prime concern to complete the well in the most efficient and cost effective manner. A lot of researches, as mentioned earlier in this paper, have been conducted over the periods of time to make the process of well completion as safest and productive as possible. Like any other technology, well completions also have several advantages and disadvantages which vary with the different techniques used for well completions. Out of these various well completion techniques, monobore completions have found to offer better benefits as compared to their conventional counterparts. The basic definition and various benefits of the monobore completion systems have been discussed in the previous section. So, this chapter will focus on the various methods of monobore completions since the application of the right method will be most beneficial for the well completion. The monobore completion system works as a single trip mechanism that enables the operator to drain out the cement by being offline, so that the platform can employ the equipments at its different locations. Different methods of monobore completions along with their costs and benefits are described further.

3. 1 Disposal Monobore Completions

This method is based on open or cased holes and is also named as upper hole completion. Since tubing is the only conduit to the surface therefore successful cementing is very essential in this method. Most of the times very limited number of rigs which include packers, gas lift mandrels, sliding sleeves and surface controlled sub-surface safety valves, are required by these completion methods. The prime objective of this method is to minimize the cost of the completion. Such wells are perforated across the pay zones that is why zonal issue is one of their problems.

3. 2 Cement thru Completion System

This is a real monobore system that operates after the cement is drained out. It employs pressure cycles for the various rigs to operate. The method is aimed towards finding out the impact of the residual cement on the well bore integrity. Such systems increase the potential to eradicate additional trips that minimizes the associated safety issues. This method also reduces rig time extensively. Short life wells using this method significantly save cost and also improve safety and productivity. Furthermore, this method minimizes the fishing operations that add up to cost and time. Staged cementing technique can be used in an application in which open hole cementing method could not possibly be employed.

3. 3 Monobore Injection wells

This method reduces rig time of water injection well completion. Subsidence formation is the basic problem in this method that usually damages the casing disabling the well. The method maintains tubular integrity and reduces the rig time almost by 4 days with reduced number of rigs used due to its ability to cement through the tubing.

Figure 1 showing the typical completion used and estimated for each of the completion types.

Source: Ingvardsen et al., 2009.

3. 4 Performance of Monobore Systems

The conventional completion is proven but consequently most expensive than its other counterparts due to the inclusion of zonal isolation, cased well bore, safety valve and conventional gas lift side pocket mandrels. The monobore completion shown in the figure above is the disposable well completion that includes safety valve, tubing and cemented in place. It is most cost effective completion due to its simplicity. However, it does not offer unloading the well and the production increase for the well. Moreover, it does not let the remedial work to install any rig so that the life of a well can be increased since the packed is not included in this design.

Figure 2 showing the design process with the extensive fluid dynamic simulations to illustrate the fluid characteristics through the completion process.

Source: Ingvardsen et al., 2009.

It was essential to identify the areas where the residual cement was left behind after the cement was pumped out. SPM was found to be the most critical area which might make it hard to replace the gas lift valve or the dummy valve. The areas highlighted in the figure 2 are those where the design enhancements were assured to cause turbulence and let these critical components clean on their own? Safety valves use the same design concepts to restrict the collection of sand in them and this illustrated the necessity of turbulent flow across the SPM body.

Figure 3 showing the comparison between the completion time of the previously known disposable completion system and the latest cement thru completion system.

Source: Ingvardsen et al., 2009.

Feasibility Study on a well to deal with the differences between conventional and mono-bore drilling

This paper will further summarize the development of a monobore well system emphasizing over the selection criteria for the materials, field trials and other system development stages. This section of the report will particularly address the different operational and deployment methods and stages for the development of the well system along with the chronicle testing program that includes field trials.

4. 1 Description of the System

The system under consideration here characterizes a stage approach for the monobore well development program. This system deploys an expandable liner through the casing section of intermediate length. The liner is expanded below this intermediate length casing section along with maintaining the same ID as that of the intermediate string. A recess profile stationed at the then end of the intermediated string is used to connect the system with the intermediate casing string. The method of top down expansion is employed to switch the casing to and from its 'run in' and 'post expansion' states after being deployed to depth.

4. 2 System Deployment Method

The first stage of the system is concerned with executing a special recess shoe at the end of the intermediate casing string instead of the standard casing cement shoe. The protective ID of this recess shoe inhibits cement from reaching the shoe ID and is bored easily by the standard bits. The expandable liner is deployed such that the conventional casing having the caveat material and connections are able to expand along with maintaining the pressure integrity. Rubber coated pipe sections providing the annular sealing potential, are located at the desired points in casing string. These rubber components stretch out as the pipe expands against the open hole wellbore. Future systems will use the cement as the annulus sealing medium.

4. 3 System Expansion Method

The liner expands from top to down after the line has been arranged down hole with the help of the hydraulic mechanical system. The same tool is used in this expansion system as the one that was to take the liner to the depth. A taper shaped circular cone is used to expand the pipe. This cone moves through the liner to increase the run in size of the liner to its post expansion size. The mechanism of hydraulic piston and anchor combination is used for producing the energy required to move the cone through the pipe. This system starts operating when the pressure applied to the wellbore drill pipe is converted in to mechanical linear force with the help of the down hole piston that is connected with the expansion cone. A hydraulic anchor experiences the force generated by the piston which means that the piston concurrently activates the pressure. The anchor protects the upper portion of the piston through to the surrounding casing and hence, applies the reaction force that inhibits the drill pipe from moving upward with in the hole since the piston strokes the cone down the wellbore which makes pipe expand along its stroke length.

The figure 4 provided below illustrates a well onshore Egypt in which " shales packed off around the drill string before the 12 ¼-in. open-hole section could be completed. The well had been planned to 4, 600 m and needed to have a 9 5/8-in. casing below 2, 950 m to achieve exploration objectives. The 9 5/8-in. casing stopped at 2, 859 m. The monobore expandable liner was brought in. The first attempt failed, but the second attempt was successful. The 8 ½-in. open-hole section was drilled out of the expanded liner to 3, 890 m" (Drilling Contractor Magazine, 2010).

Figure 4: A well onshore Egypt saved due to the Deployment of Monobore Expandable Liner Extension.

Source: Drilling Contractor Magazine, 2010.

The application is the advancement of the current and validated technique of the Hydraulically Expandable Tubular System that can be used in other expandable products as well. The application considered some elements of

Finite Element Analysis (FEA) modelling supporting the system design. The expansion method is executed such that:

the liner is hung

fixed in place by using the cement

hanger is sealed

desired mechanical properties of the system are achieved

This paper illustrates the feasibility study for a hydraulic expandable liner hanger. Studies have been conducted with the aim of finding the possibility of employing the Hydraulically Expandable Tubular Technology (HETS) in order to develop the slim well liner hanger system that minimizes the down-hole equipments along with providing a life of well, load bearing, metal to metal and pressure tight connectivity. According to its nature, such a design will consider much smaller clearances between the current casing and the liner in contradiction to the conventional hangers.

This approach provides numerous potential advantages such as:

Its futuristic design is congruent with the slim well philosophy.

Reliable deployment since the removal of packers and elastomers simplifies the conventional liner hanger.

Better operating reliability due to the simpler metal to metal design seal.

The vital intermediate casing string contingency is attained in the well construction process due to the slim design of the system.

Improved well design envelope such as under the sea applications.

4. 4 Developed Expansion System-Validation of expandable monobore liner extension

Concept: A case study

Initially the purpose of an expandable monobore liner extension was to allow the operator to dig deeper explorations and production wells bearing the larger holes at the reservoir. With the contingency plan the goal is then set to allow the operator to isolate zones possessing reactive shales, formations of low fracture gradient or other drilling limitations with out reducing the casing and size of the hole in the reservoir. The feasibility of the expandable monobore liner extension concept was validated through the creation of a one-trip-top-down expansion system that optimizes the casing configuration along with reducing the cost but with out reducing the size of the drilled hole.

The figure 5 given below shows the Kristin and Kvitebjørn fields that are the HPHT gas and condensate fields at the Norwegian sector of the North Sea. Kristin is situated in the southwestern part Halten Bank whereas the Kvitebjørn is located in east of Gullfaks. Kritin has the pressures at 1300 psi and temperatures at 340oF. The expandable system formed depends on these values. Moreover, Kvitebjørn needed some elastomers as the material to resist chemicals. Both Kristin and Kvitebjørn are depletion drive but later their drilling and completion activities expected to take place in a moderate to high depletion reservoir.

Figure 5: Kristin and Kvitebjørn fields

Source: Drilling Contractor, 2006.

-Objective of the Project

These fields may face the challenge of drilling new wells when depletion has taken place significantly. The fracture gradient reduces along with the depleting zones. Differentially stuck pipe and fluid losses can result in these fields due to the excessive pressure difference between the hydrostatic pressure of the fluid and the pore pressure. Even the pressure maintained fields may face depleted isolated packets resulting in drilling problems. Thus, these fields require the following four objectives to achieve.

safety

pressure and good control of open-holes

reduce non-productive time to support well-bore

economics that require 7 inch production liner for the reservoir

The resulting challenges due to (a) hole stability maintenance and (b) potential reservoir damage control in the development of the fields under consideration require to reject the determined drilling contingencies for improving economics of the fields.

The traditional contingency method would require running 7 inch liner along with 41/2 inch completion for solving the drilling problems. However, for sufficient production during depletion, the 41/2 inch completion would appear to be a significant limitation in spite of accepted in some fields.

-Pre-planning

Different solutions were considered for evaluation for achieving the project objectives. Well and casing design proposed 7 inch production liner to be fixed at 13944 ft vertical depth in total. The history of both the fields signifies that this depth could be achieved through reaching the predicted change of possible pressure of about 870-1450 psi due to depletions. The range of the actual change of pressure would not be determined prior to drilling the shale sections below the estimated 95/8 inch intermediate shoe depth at 12992 ft total vertical depth. To maintain such values of pressures, wellbore stability and reservoir depth for the 7 inch production liner, the planners measured that a less than 435 psi change of pressure would fulfil the standard design and objectives. On the other hand, a change of pressure greater than 435 psi would compel the implementation of a contingency drilling program. However, these measures met all but one project objective of economic goals since the production liner would be decreased to 4. 5 inch. Planners introduced and examined the contingency monobore systems for both the fields on the basis of their influence on all the four project objectives.

-Development

A prototype trial was executed on the proposed expandable liner system. At first the ultra-sonic (UT) inspection was performed over the 75/8 inch liner and then it was executed in the well in which free-end expanded to 22%.

Surface breaking fractures were observed as the pipe retrieves after expansion. After this trial, the size of the tubulars changed from 75/8 inch to 8 inches in outer diameter which further, reduces the expansion percentage to 18% from 22% and also lowers the significant stresses in the pipes.

Another trial was executed on the system in some time after the first trial. Again all the joints were UT inspected before the trial. This inspection of the 36 joints of the casing inferred that pressure test was applied on the string and also, the full length magnetic particle inside (FLMPI) inspection was performed on it. It was found that the two joints have surface indications as can be seen in figures 6 and 7 given below.

Figure 6 (left) and figure 7 (right) showing that the 2 joints of casing carry surface indications as identified in the second trial. This mandates the need for an enhanced pipe inspection.

Source: Drilling Contractor, 2006.

These results identified the need for an enhanced pipe inspection. An improved UT inspection was formulated by using 18 shear transducers. These highly sensitive compression transducers measure even low level defects just below the outer diameter surface.

Later another trial was executed having 27 joints through the new inspection method in order to select the pipe that was considered not suitable. The expanded liner was inspected and retrieved through the wall. It was found that the string carry no flaws with near-surface inclusions.

-Monobore Liner Extension Selection

Several monobore systems were examined carrying out extensive prototype testing and system qualifications to satisfy the operator. The selected contingency system further summarized a staged approach to monobore well program.

The existing system in these fields deployed expandable liner with the help of the current intermediate casing section and run to depth. This new liner is further, expanded below the intermediate section while maintaining the same inner diameter as that of the intermediate section. A recessed profile in the contingency shoe connected the monobore system with the intermediate casing string.

Figure 8 showing the contingency recess shoe for non-cementable expandable liner. The fields used the contingency recess shoe which did not allow for cementation of the expanded liner.

Source: Drilling Contractor, 2006.

The contingency shoe run accompanied by the intermediate liner works as the normal casing shoe, however, it also provides a recess area and location profile for the liner, if required. The one trip monobore expandable liner is used and deployed with the help of the top down techniques for expansion when it is concluded that drilling program contingencies must be employed to achieve the well objectives. When the hydraulic reaches near to the shoe of the expandable liner then it is removed on the same trip through retrieval tool latches upon a retrievable guide shoe. The Kristin employed the contingency recess shoe on the intermediate liner for not cementing the expanded liner as shown in figure 8 above where as the contingency recess shoe for the Kvitebjørn field employed sliding sleeves and ports, as shown in figure 9 given below, to allow for cementation and flow area of the liner.

Figure 9 showing contingency recess shoe for the cementable expanded liner

Source: Drilling Contractor, 2006.

Present and Future Drilling

The developments in oil and gas drilling is not just limited to creating the hole through the latest technology and techniques, they are rather concerned with safety, risk management, strategy, eco-protection, experience, reliability and economics, in particular and at large. The key benefits that the operators expect to achieve from drilling activities and system are stated below:

Reduce non-productive time

Reduce productivity time by making the productivity process fast.

Increase overall productivity of the well.

It has been found that operators like to continue with the existing technologies until the new technologies are proven to provide better results for cost and risk attached with their deployment.

5. 1 Future Development-Hole Enlargement

Hole enlargement is highly important towards the success of the operating expandable tubular and screens. The completion of the job is exquisitely based on the quality of the planned borehole expansion required.

Since the previous 8 years, there have been significant efforts applied in the development of hole enlargement tools in order to enhance its productivity and reduce its cost/expenses. This rising use of expandable tubulars and mono-diameter technology, in particular has introduced new challenges that current tools are incompatible and thus, recommended the need for new Hole Enlargement (HE) technology and products.

5. 2 Future Challenges

Currently, expandable tubulars are providing the basis for the further development of the future technology so that the remaining barriers to developments in deepwater and ultra-deep water can be broken. The new technology is based upon monobore well. Some experts propose that a well comprising of a single casing diameter from the top tree to the bottom would extensively save steel due to fewer cuttings. The future technology would probably combine the expandable tubular technology with the managed pressure drilling integrated with casing and liner drilling. The two most important drilling challenges to come seem to be:

accessing resource, and

availability of technical expertise

This is mainly because of that the oil and gas industry is switching from vertical to deviated- horizontal drilling technologies at a much faster pace. Drilling systems are dependent on drivers for their execution. The important drivers include safety, risk, business strategy, environment protection, and above all oil field economics and operator necessities.

Research

The well construction technology emphasized over the following two basic areas in the year 2009 (SPE 121548).

Well construction projects concerning deepwater completions and high pressure-high -temperature based completions.

Studies and researches on the reliability of carbon capture and sequestration storage (CCS) wells have been carried out.

Beyond the scope of theses primary areas, studies on construction practices concerning with shale plays also came forward in the previous year. The biggest challenge in enabling the deepwater wells to achieve the target depth is the lost circulation which is yet to overcome. The production and depletion in these fields have led to the aggravation of this challenge of lost circulation du