Study on well control and killing in deep well drilling

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Abstract: In the process of deep well drilling, due to the relatively harsh and complex operation environment, the downhole is very complex, so it needs perfect well control technology to support. In this paper, the principle and classification of well control technology, the design of deep well control technology, deep well control technology, and the optimization of well killing methods are studied. According to the actual situation, how to use the relevant equipment and well control technology to improve the safety and reliability of deep well drilling is proposed to avoid engineering accidents to the greatest extent. It is helpful to enhance the awareness of early treatment after shut in and improve the whole process emergency management ability of drilling well control.

Key words: Deep well, Drilling, Well control, Kill well, Method.

1. Introduction

Since the new century, the pace of economic globalization has been accelerating, which has also brought opportunities and challenges for China's social and economic development. The demand for oil resources among countries in the world is also increasing, and more and more countries have increased the exploitation of oil resources. In the process of rapid development of domestic economy, people's living standards and consumption power continue to improve, resulting in the demand for oil resources increasing year by year. As far as the current situation of oil exploitation is concerned, the technology is also developing and progressing. Now the area that can be exploited is also expanding, and even can be exploited in the worse regional environment. Especially in the deep-sea area and the area with relatively complex geological environment, it is faced with many risk factors, such as low temperature of seabed, low temperature of sea floor, low temperature of sea floor, low temperature of sea floor, low temperature of sea floor, low temperature of sea floor, high temperature of sea floor, low temperature of sea floor, high temperature of sea floor, high temperature of sea floor Sea bed instability and other factors. In the process of oil exploitation, deep drilling is also a common environmental type at present. In the process of exploitation, it will face many problems, which will also have an important impact on the success of the exploitation of oil resources. The well control technology also has an important impact on the stable development of the oil industry. The importance of the well control technology used in the process of deep well drilling is self-evident[1].
2. Principle of well control technology and classification
In this environment, it is easy to have blowout and deep well collapse and other related accidents. In order to further improve the safety of drilling construction, it is necessary to continuously improve the application and practice of well control technology. The application goal of well control technology is to reduce the unexpected situation in the operation process as much as possible, and reduce the loss caused by these adverse factors. Therefore, the main work is pressure balance. In the actual operation, it is necessary to ensure that the actual pressure of the formation is smaller than the bottom hole pressure [1]. As far as the current situation of technology development is concerned, mastering well control technology mainly includes drill pipe, well killing operation, cementing plug and other operation types. Because the operation process is relatively complicated, in the actual operation process, the difficulty is relatively high, and the professional ability of professional construction personnel is also relatively high. There are many types of well control technology design operations, so the number of equipment used is also very large, and the difficulty is relatively large. It mainly includes formation pressure, packer and other related facilities. The actual working performance of all application equipment will have a direct impact on the drilling efficiency. In addition, it is closely related to the safety of operators[2].

Generally, well control is divided into three levels. First, the first level well control mainly controls the formation pressure balance through the well pressure, so as to avoid the formation fluid gradually infiltrating into the well; The second is secondary well control, which mainly means that formation pressure can not be controlled by well pressure, and well pressure can not be well balanced. When formation liquid enters the well, blowout accident or overflow will occur[3]. At this time, blowout prevention equipment should be shut down in time, and relevant measures should be actively adopted to balance well pressure, so as to achieve primary well control; The last three levels of well control, mainly refers to the blowout accident, and at this time has been unable to control, we must use appropriate equipment and related technology to minimize the harm caused by the accident, to effectively control the accident, to avoid the gradual expansion of danger.

3. Well control design of deep well drilling
Deep well drilling is a very important part of the whole engineering design. Scientific and reasonable methods are the premise to ensure the safety of drilling work, and also the key to ensure the smooth construction and maximize economic benefits. Well control design plays an important role in the process of drilling construction, and it is also an important means and technology to ensure construction safety. The geological design and engineering design of deep well drilling should include the actual requirements and specific contents of well control[4,5].

3.1. Geological design of deep well drilling
In the process of deep well drilling geological design, it is necessary to timely obtain the wellbore structure, wall thickness, size, cement and other related materials, and timely provide the water layer, oil, gas and other related data and pressure data, so as to ensure the quality of cementing, timely feed back the data, feed back the daily high pressure layer and toxic and harmful gas, and pay close attention to the water injection status of wells. In addition, we should also pay close attention to the environmental conditions around the construction area, such as the data of schools, residential buildings and the distance between factories and mines.

3.2. Drilling program design of deep well drilling
On the basis of geological design, well control technology must be combined in the process of engineering design. The design should also include various data, such as previous operation conditions, providing casing technology, ensuring the main types, performance and construction parameters of killing fluid. In addition, the pressure, quantity and grade of blowout preventer should be determined, and corresponding tools should be selected. The safety protection measures of well control are put forward. In addition, in the production process, it is necessary to timely detect the status of hydrogen sulfide and other related toxic and harmful gases.
4. Well control technology in deep well drilling

4.1. Perfect well control procedure
In order to ensure the safety of drilling construction and maximize the production benefit, and ensure the smooth completion of the construction project, it is necessary to further improve the well control management system according to the actual situation, do a good job in daily prevention work, carry out regular learning and training, comprehensively implement the control concept, and gradually implement it into the practical operation, and improve the well control management system. It is necessary to clearly divide the corresponding rights and responsibilities, carefully divide the rights and responsibilities of well control management, and be specific to individuals. In addition, it is also necessary to strengthen the drilling and training of well control knowledge, so as to guide the drilling staff to comprehensively and deeply understand the well control operation methods and knowledge, Relevant staff should be familiar with the specific implementation process of well control when encountering unexpected accidents, so as to ensure timely containment of the occurrence and spread of accidents [4]. To carry out regular detection and pressure test of deep well blowout preventer, to ensure good functionality and normal use to the greatest extent, well control technology management also includes the supervision link. Therefore, improving the relevant supervision system is also a very important part to ensure the efficient operation of well control measures[6].

4.2. Strengthen well control training
The safety measures of well control work are related to the life safety of every construction personnel. Therefore, in the process of on-the-job training, it is necessary to specify the relevant operation process and knowledge, conduct on-site drills, lectures and answers, and ensure that the on-the-job operators continuously improve their operation skills and sense of responsibility. Through a variety of modes, the safety management machine knowledge training of petroleum enterprises is carried out to ensure the safe and smooth operation of deep well drilling.

4.3. Strengthen the management of well control equipment
Deep well drilling has surface well control devices, which should be improved strictly according to the formation pressure design. After debugging by relevant professional well control staff, it can operate and ensure the safety of supporting installation. The main body of equipment and different valves should be strictly tested according to the standards, and timely adjustment should be made in case of problems. Well control technicians should carry out practical drills on a regular basis, explain in detail the relevant operation procedures and precautions in the installation process for employees, and ensure that the equipment is implemented to the individual. During the installation of equipment, the equipment shall be regularly inspected, and corresponding operation criteria and pressure test standards shall be formulated according to the actual conditions, including daily maintenance, management and operation rules; The equipment shall be numbered strictly in accordance with relevant regulations, followed up, inspected and maintained during subsequent production and use, recorded in real time, and relevant training and learning and emergency drill shall be conducted regularly. To manage the data closely, and ensure the further improvement and optimization of various systems[7].

5. Optimization of deep well killing method

5.1. Well killing options
Well killing operation is the key link of drilling well control. In a sense, well killing operation belongs to the scope of design change management, but it is not only to adjust the density of drilling fluid, but also to optimize the well killing method and scheme. These two methods are often used in well control operation training and well killing simulation on simulator, but the field situation is complex and changeable. Sometimes the conventional driller's method or engineer's method is not the best, or even can not achieve the purpose of well killing. Other well control and well killing methods and
corresponding supporting measures are needed. Positive circulation driller's killing method (conventional driller's killing method); Well killing by positive cycle engineer method (i.e. conventional engineer method); Kill well with reverse circulation driller method; Well killing by reverse circulation engineer method; Well killing by cyclic weighting method; Well killing by backpressure method (extrusion method, horizontal pushing method and hard top method); Well killing by displacement method; Riser pressure control method; Volume control method; Low throttle pressure method[8].

As a part of well killing operation to eliminate overflow, the technology is the most complex and difficult, which is easy to cause out of control blowout accident. In the actual well control and killing emergency decision-making, how to optimize the scheme is particularly important. It needs to be familiar with the appropriate conditions and main influencing factors of various well killing methods, and analyze different well conditions and working conditions to make effective decisions.

5.2. Influencing factors of well killing scheme

The situations of various overflows, kicks and shut in are not the same. Sometimes, there are some working conditions, such as hydrogen sulfide in the overflow, lost circulation, bit not at the bottom of the well, empty well and so on. The following factors are worth considering when determining the well killing method and scheme, some of which are even decisive factors.

It is estimated that when the partial pressure of hydrogen sulfide is greater than 0.3kpa, the sulfur resistance of casing, drill string and other pipes, ground equipment and tools should be considered. Although the possibility of free hydrogen sulfide can be reduced by controlling the pH value of drilling fluid above 9.5 and using desulfurizer, when there is a large amount of hydrogen sulfide invasion, it is still a potential safety hazard to recycle the gas containing hydrogen sulfide by conventional methods. In Tongfu 6 well, after blowout due to leakage, the lost circulation was stopped for a long time, but the pressure was not held down. The concentration of hydrogen sulfide in the overflow gas was too high, which made the drilling tools break down due to corrosion, and finally forced to inject quick drying cement to seal the well. The ideal way to control the overflow well killing containing hydrogen sulfide is to press hydrogen sulfide back into the formation[9].

In the process of drilling, the lost circulation will cause the fluid in the well to drop, which will reduce the pressure of the annular liquid column and make it unable to balance the formation pressure. It may cause the fluid in the higher formation pressure to enter the wellbore, induce overflow or kick, and cause up blowout and down leakage or blowout in the same layer. When drilling to high-pressure oil-gas water layer, overflow, kick and blowout may occur, which may lead to lost circulation in upper low-pressure formation due to high shut in pressure or high-density drilling hydraulic well. The location relationship between blowout and lost circulation zones and plugging will affect the choice of killing method and the decision of killing scheme. The practice shows that the success rate of the reverse circulation lost circulation and well killing simultaneous operation method is the highest.

The relative position of bit, overflow layer and overflow material in the wellbore will also have an impact on the selection of well killing program and scheme. For example, if the overflow material is under the bit, it is necessary to comprehensively consider the wellhead equipment matching, casing pressure, presence of hydrogen sulfide, casing pressure, etc. whether there is leakage or not.

5.3. Selection principle of well killing method

Drilling practice shows that only adhering to the idea of early discovery, early shut in and early treatment is the key to ensure the success of secondary well control and resume normal drilling operation. In particular, many adverse factors will affect the choice of well killing methods. After effective shut in, well killing should be carried out as soon as possible. Considering the difference of well conditions, comprehensively analyzing the influence of various factors on well killing operation, it is particularly important to select the corresponding well killing method according to the principle of timeliness, safety, effectivenes and low cost of well killing treatment. Safety is the primary consideration of any engineering operation. The safety of well killing operation mainly involves the following aspects: (1) hydrogen sulfide: if the concentration of hydrogen sulfide is too high and the overflow flow is large, the
potential damage to the drill string and ground equipment should be considered, and the overflow back to the formation should be the first choice. (2) Bottom hole pressure during well killing: during well killing, the pressure acting on the bottom hole should always be relatively stable and can balance the formation pressure. (3) Wellhead pressure during well killing: the killing casing pressure shall not exceed the safety allowable value of wellhead device and casing. (4) Formation leakage: ensure that the well killing process will not cause serious formation leakage due to the weak formation in the fractured open hole section.

6. Conclusion
In the process of deep well drilling operation, we must pay attention to the application of well control technology, strictly do a good job in well control design, well control equipment related work, strengthen well control technology training and management system, continuously improve the safety and efficiency of deep well drilling construction, ensure the safe and smooth drilling work, and lay a good foundation for creating greater economic benefits.

The selection of well control and killing method is an important factor related to the success or failure of drilling well control and killing. When determining the killing plan, for different influencing factors, when optimizing the well control and killing methods according to the above principles, we should also consider the corresponding supporting measures. At the same time, we should follow some basic principles of priority selection, that is, on the basis of safety priority, we should also consider the principles of bottomhole atmospheric pressure method, driller method, reverse circulation method and avoiding blowout. The principle of driller's priority, reverse circulation priority and avoiding smooth blowout is essentially consistent with the principle of safety law priority. Safety priority: that is to say, the safety of well killing methods should be compared and considered before the principle of timeliness, effectiveness and low cost.

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