Design and Development of Horizontal Well and Complex Structure Well Combined with Computer Data Evaluation Technology

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Abstract. This article briefly introduces the completion structure and key support technologies of drilling, conventional horizontal Wells, lateral horizontal Wells and branch horizontal Wells under computer data evaluation. The problems existing in the process of well completion in complex structure Wells and the development direction in the future are put forward.

Keywords: Oil Field, Complex Structure Well, Horizontal Well, Sidetracking Well, Completed Well, Computer Data Evaluation Technology

1. Introduction

With the continuous development of oil and gas exploration worldwide, drilling technology has three stages of development [1-2]: experience-based drilling, scientific drilling, and automatic intelligent drilling. New drilling technology, new technology and new drilling equipment have been continuously developed and improved. Cluster well, horizontal well, sidetracking horizontal well, extended-reach well [3], branch well and other complex structure wells have emerged, developed and matured constantly [4-5]. The cluster well technology can be used to drill dozens or even hundreds of different types of wells on one platform, and can simultaneously develop different reservoirs in a larger area, to reduce platform construction costs and subsequent oil production costs [6]. Hence, it has been rapidly developed and applied worldwide.

The horizontal well technology started in the 1930s. As the horizontal section of wellbore is drilled along the oil layer, it can expose the oil and gas layer to the maximum extent, which can improve the production and recovery of oil and gas wells, make horizontal exploration of oil and gas reservoir, determine the boundary of stratigraphic trap and the position of fault closure, reduce the influence of water cone and gas cone, lower the cost of land occupation and other engineering construction, and reduce the cost of water cone and gas cone effectively. By the end of the 20th century, 23,385 horizontal wells had been completed in the world, which was developed in the direction of comprehensive application and integrated system and used in the overall development of oil fields.

2. Completion technology and structure of horizontal wells
2.1. Completion technology of horizontal wells

1) Gravel pack sand control completion technology

Due to the complexity of gravel packing construction, high investment cost and many other problems to be considered in the construction such as hanger design, pipe string centering, reservoir protection, gravel selection, screen pipe selection, prevention of thermal expansion and contraction, sand carrying fluid packing compaction, displacement, sand ratio, sand control pipe string, etc., domestic applications are relatively few at present. In the oil fields, only one well, lengping-3 well was put into operation in January 1993. The oil well has been stable with high yield for a long time. The crude oil at the wellhead contains no sand. The daily output at the initial stage is 45t/d, which is 3-5 times that of the adjacent vertical wells.

2) Technologies of running casing, cementing, perforating and completion

The technologies are mainly applied to thin oil wells with active edge and bottom water, heavy oil horizontal wells and horizontal wells with remaining oil on the development water ridge. Due to the poor cementing quality and high cost in the horizontal section, it is generally required to carry out secondary sand control in the horizontal section after application to heavy oil and ultra-heavy oil loose sandstone reservoirs in the oil field.

3) Drilling liner completion technology

Drilling liner completion technology is mainly applied to special lithologic reservoirs, which are characterized by dense lithology, proper cementation and difficulty to produce sand. The liner uses a 5-inch casing as the base pipe, and a small hole of a certain size is evenly drilled based on a specific size and distance, generally 16 holes/m. As long as it can support and strengthen the well wall, it can meet the production requirements for horizontal wells.

2.2. Sand control and completion structure of horizontal wells

1) Screen sand control completion structure

Completion method for hanging 7in screen in 95/8in casing

In the wellbore structure, three opening method are adopted. The surface casing is used to isolate the surface water splashing layer and the shallow complex formation. In the technical casing, 95/8in casing is adopted, and 7in combined string is suspended on the 95/8in casing. The structure can be used to sidetrack and exploit the potential directly in the upper well section after the original horizontal well 3 fu production or completion string sand control failure or deformation. In this way, it can reduce the drilling and workover investment. It is suitable for thick massive heavy oil, super heavy oil reservoir.

Cementing and completion method of 7in casing and 7in screen

The second opening method is used for the wellbore structure. The surface casing is adopted to isolate the surface shallow water layer and the shallow complex formation. After the second opening, it is directly put into the 7in screen pipe. The upper part of the screen pipe relates to the 7in casing to the wellhead. The casing above the horizontal section requires proper cementation, and the 7in screen pipe is put into the horizontal section facing the oil layer. Such deep structure drilling and completion process is simple, shorten the drilling cycle, reduce the cost, drift diameter completion is more suitable for subsequent operations, suitable for thin-layer edge and bottom water-heavy oil reservoir.

Completion structure of sidetracking horizontal well

In sidetracking horizontal wells, hanging cementing in the vertical well section is adopted, and the screen pipe is directly used for well completion.

The pipe string structure is as follows: shoe guide + length adjusting pipe + metal fiber screen pipe (flexible joint is added in the middle) + cup sealing + swirl nipple + 1-2 casings + drillable float collar + casing (expansion joint is added in the middle) + hanger + drill pipe.

2) Well cementation, perforation and completion structure

In the completion structure, only three open 95/8in casing hanging 7in casing cementing methods are adopted, such as cold 42-flat 4; in addition, two open 7-in casing or 5in casing cementing and perforating methods are also used to analyze the sensitivity of perforating parameters and reservoir
parameters to horizontal well productivity. The influencing factors are as follows: ① Perforating depth; ② Hole radius; ③ Perforating density; ④ Phase angle; ⑤ Formation pollution depth; ⑥ Formation pollution process; ⑦ Hole compaction depth; ⑧ Hole compaction degree; ⑨ Anisotropic coefficient.

Figure 1. Relationship between the depth and yield of horizontal downward square hole

3. Problems in well completion with complex structure

3.1. The quality of sidetracking well and cementing is poor, and the casing of thermal production well is prone to deformation
The cement distribution is not uniform or the cementing channeling results in the early water outflow of the sidetracking well; the cementing quality of the tailpipe overlapping well section is poor or there is no cement, so the water channeling is easy to occur. In addition, due to multiple rounds of thermal recovery, the j-bone of the casing is seriously broken or deformed.

3.2. After completion of sidetracking and branch horizontal wells, the internal diameter of the string is small, and the later operation or measures are difficult
For sidetracking and branch horizontal wells, a small-diameter metal cotton screen or slotted screen is used. For some wells, a screen with an internal diameter of only 86mm is used upon completion. Once deformed or sand is produced in the production process, they cannot be treated.

3.3. Horizontal well completion technology is relatively simple
Except for a few horizontal wells that adopt cementing and perforating completion, all other horizontal wells adopt screen pipe or liner completion. The screen pipe or liner is facing the oil reservoir section of the horizontal section. The mudstone section in the horizontal section adopts casing with the same steel grade and wall thickness for separation. The horizontal section is of the same pressure system, without strict separation.

3.4. Completion technology of some complex structure wells is not combined with oil production technology
After the completion of the branch horizontal wells, only two wells can be jointly developed. In addition, the technology of separate production of two branch wells is complex, which affects the development effect of the branch horizontal wells. Some horizontal wells deployed in special lithologic reservoir need to take fracturing and acidizing stimulation measures, and these technologies are not only complex in technology and difficult to implement, but also high in cost.

3.5 Optimization of the completion mode based on the characteristics of complex structure wells
The completion technology of complex structure well is a system engineering. It should be based on
the geological characteristics of the reservoir, the mechanical rock properties of the reservoir and the physical properties of the reservoir. What's more, it should study the supporting and adaptability among the geological conditions of the reservoir, the exploitation technology of complex structure well, the measures of maintaining production increase and the downhole operation technology. The influence of maximum on production pressure difference and mining history. Only vertical wells and horizontal wells are taken as examples, and well logging data of well Gao 114-6 is used to calculate parameters, according to the working system provided by well test analysis report data of well Gao 114-6. The 0 Ma corresponding to the production pressure difference generated during the production of 6mm, 8mm, and 10mm nozzles is calculated, as shown in Figure 2 below.

Figure 2. Relationship between maximum stress and production pressure difference of well Gao 114-6

In addition to factors influencing the vertical well, some factors also affect the completion of horizontal wells, such as the influence of the bending degree of wellbore on the string and the influence of the length of horizontal section on the stability degree of the wellbore. These two factors are important factors that affect the completion of the horizontal well. For horizontal wells, the completion method is mainly selected from the curvature radius index. The shorter the curvature radius is, the greater the curvature degree of the wellbore is, and the greater the impact on the selection of completion string and completion method is.

Completion of long radius horizontal well: due to the small curvature, it is relatively easy to run the casing or liner. Various vertical well methods can be applied to completion. In general, the whole well casing to the bottom of the well can be used to seal the production layer or liner for well cementation and perforation, or screen pipe completion and packer completion can be used. The selection is based on reservoir, lithology, physical properties of crude oil, stimulation measures and other factors. With the rapid development of horizontal well technology and the continuous growth of horizontal well section, especially in the production process of the sandstone reservoir, the formation inevitably collapses, so the open hole completion method is not suitable. In the aspect of perforating, it is difficult to transport the perforating gun by cable, so it is necessary to transport it by tubing and initiate it by hydraulic action. The primary consideration of the well completion method is the stability of a long open hole section. If the stability of the rock stratum is excellent, it is not a problem to continue drilling or running casing; if the rock stratum is unstable, it should be addressed from the performance of drilling fluid and the structure of the wellbore.

Completion of horizontal well with a medium radius: due to the small radius of the build-up section, the curvature of the borehole is severe, and the increasing slope per meter is close to 1 degree. The determination of completion mode depends on the stress of the casing in the curved section. When running casing and cementing, the bending tension of casing and the tightness of casing thread shall be inspected to ensure the running in for the casing. When there is a specific danger for casing to pass through the bending section, it is not allowed to run casing for cementing, when open hole completions, liner completion, packer completion and other methods can be selected.

The completion of horizontal well with a short radius of curvature (sidetracking horizontal wells): Sidetracking technology is often used in old wells. The diameter of the horizontal well is limited by the old wellbore. Compared with the horizontal well with medium and long radius, the diameter of the horizontal well is smaller. In the 7-in casing, the horizontal well is no more than 140 mm. In the

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51/Zin casing, the horizontal well is only about 110 mm, and the well is severely curved, which is limited by the diameter of the wellbore and the curved well section. It is tough to drive casing into horizontal well with medium and short radius, so casing perforation is rarely applied to completion. Currently, there are open hole completions, liner completion, packer completion, etc.

Branch horizontal well completion: two or more branch wells are drilled for a main well, which is characterized by multiple branches, and the difficulty is sealing and selective entry. The completion methods include the open hole section, liner, casing cementing. Different from the conventional horizontal well, branch downhole casing cementing is more complicated, which is a completion method at a higher level.

4. Conclusions
The corresponding studies are carried out in the aspect of completed well-supporting technologies to meet the requirements of complex structure well production technology. Among them, systematic research is performed in the completion technologies for sidetracking and horizontal wells to form the completion technologies of inner string two-way choke tailpipe, impact tailpipe, hanging screen pipe after sidetracking, and sand control by screen pipe in horizontal wells. Through massive field inspection, the overall technology is mature with complete supporting facilities, which has solved the technical difficulties in the completion of sidetracking and horizontal wells. Currently, complex structure well has developed into an essential means to exploiting the remaining oil potential and guaranteeing the recovery for secondary development. It has been proven in practice that the completion technology of complex structure well can be applied to the oil field in large scale.

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