

The Research and Application of Vertical Wells Multilayer Fracturing Technology

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Abstract: The difficulty in oil mining is increasing and the quality of the remaining oil reduced gradually after Daqing oil field came into the late high water contamination stage. There are several factors that prevent the convention from single layer fracturing technology to multilayer fracturing technology. Firstly, about 20% of fracturing rate could be achieved by elevating the K Series packer 3 times in the 5 fracturing techniques, but the performance of the plastic tube cannot be guaranteed. Secondly, the fracturing success rate is not guaranteed if Y series are elevated 4 times to complete the 5 layer fracturing, besides consistent intervals between the five layers must be maintained, which is very difficult. To further enhance the vertical well fracturing multilayer capability, we carry out multi-layered vertical well fracturing technology research, and have achieved good results in the field application.

Keywords Vertical wells transformation; Multilayer fracturing; String; Increase the production

INTRODUCTION

The difficulty of the oil mining is increasing and the quality of the remaining reserves becomes poorer gradually after Daqing Oil field came into the late high water contamination stage [Jiang Ruizhong *et al.*, 2004]. The vertical wells multilayer fracturing techniques have been carried out to improve the single well production. But there are many problems which prevent the convention from single layer fracturing technology to multilayer fracturing technology. First, although about 20% of the proportion of 5-stage fracturing can be achieved by elevating the K series 3 times, the plastic tube performance cannot be guaranteed. Secondly, the fracturing success rate is not guaranteed if Y series are elevated 4 times to complete the 5 layer fracturing, besides consistent intervals between the five layers must be maintained, which is very difficult. In order to further improve the vertical wells fracturing ability, it is very necessary to carry out straight wells fracturing technology research actively [LIU Peng *et al.*, 2008].

THE SLIDING SLEEVE TYPE FRACTURE SAND BLOWER FRACTURE MULTILAYER TECHNOLOGY

This kind of un-tripping string is mainly composed of safety joint, hydraulic anchor, level 2 K344 packer, grade 1 guide pressure sand blower, 4-7 class guide pressure sandblasting packer and plug. And it can

fracture without pulling string above 10 layers [ZHANG Yan-chen *et al.*, 2006] [LI Xingyu *et al.*, 2008].

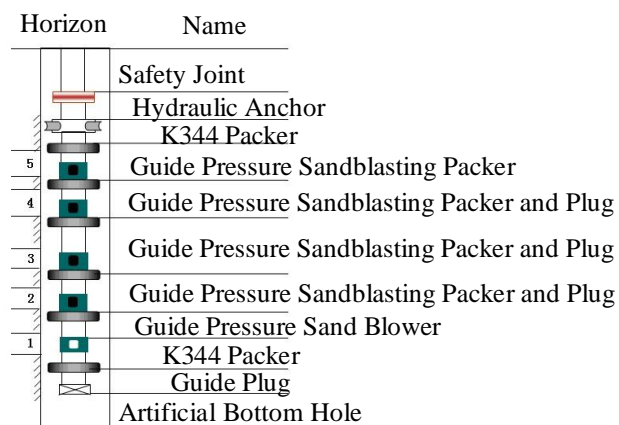


Figure 1. The sliding sleeve type fracture sand blower fracture string diagram

Technical parameters

The maximum outer diameter of the tool: $\phi 115\text{mm}$;
 The minimum diameter of the tool: $\phi 33\text{mm}$;
 The biggest single sandblasting sand volume: 60m^3 ;
 The highest pressure on the string: 70MPa ;
 Service temperature: under 120°C .

Technical feature

- 1) The new pressure transmitting sandblasting packer can increases the available pressure layer (10 layers).

- 2) The tool's abrasive resistance has got enhanced to ensure multilayer construction which can be taken with large amount of sand (300m³).
- 3) Packer is easy to be unlocked, so we can put it into operation after the gas well tubing string fractured.

Field application

For example, XX1 well is a low yield shut-in old well in Wangjia village. We take normal fracturing construction by low damage carbon dioxide foam

fracturing method which foam quality up to 80%.

And we found that sliding sleeve pin shear pressure showed obvious, and oil set connected after flow back which proved that packer rubber tube had been recycled. We got 17000 m³ of gas per day in the test [Wang Zunce *et al.*, 2009].

There are 195 wells in field used this technology, the success rate is 97.2%. It can fracture 10 layers with pulling string. The fixed column could product directly after fracturing.

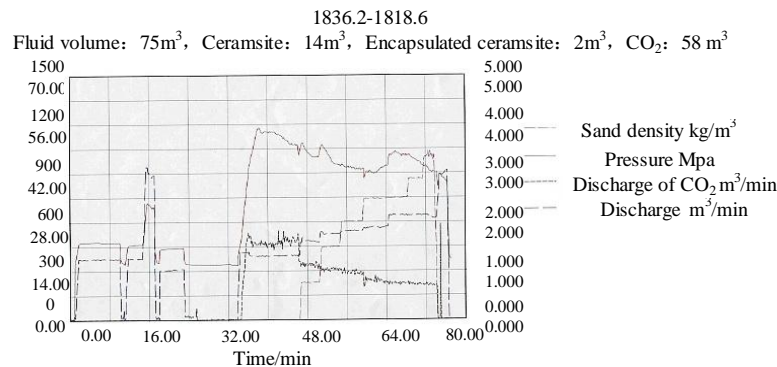


Figure 2. The second layer fracturing graphs

THE SLIDING SLEEVE TYPE SPRING SAND BLOWER FRACTURE MULTILAYER TECHNOLOGY

The pipe string we used in this technology is mainly composed of working barrel, 6 class K344-115 packer, level 5 high-capacity spring sand blower, pipe plug. Meanwhile it can fracture about 5 or 6 layers without pulling string (sand volume 300 m³) and 9 layers with pulling string.

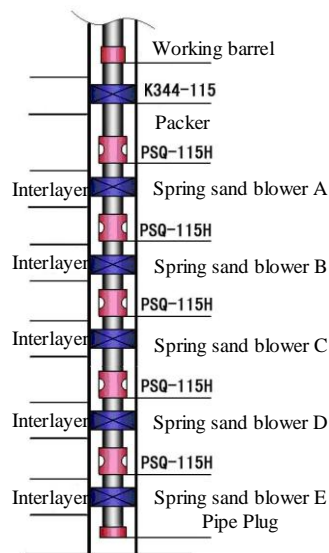


Figure 3. Springs sandblasting fracturing string diagram

Technical parameters

The maximum outer diameter of the tool: ϕ 115mm

Ball level: ϕ 35、38、41、44mm

The maximum single sandblasting sand volume: 60m³

The maximum bearing capacity of string: 55MPa

Technical feature

The new high-capacity sand blower can pray sand 60m³ per machine.

The ability of packer has been improved, so that it can fracture 9 layers with pulling string.

Three to four times compared with the conventional process has been improved in working efficiency, and made the cost reduction at the same time(saved the string replacement and fracturing crews cost).

Field application

For example, XX2 well, this well is located in the edge of sand body and in the flexible mining now. We took the method of multilayer fracture, fractured without pulling string 6 layers and with pulling string 8 layers. Totally, 714.0m³ modified guanidine gum fracturing fluid, 1800.0m³ clean fracturing fluid, 160.0m³ ceramist were used in this process. In the early of fracture, daily fluid increased from 1.2 t to 11.2 t, increased 9.3 times. Up to March 2014, the well has been in flexible mining for 820 days, produce oil 4605 t.

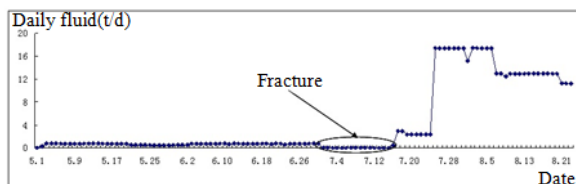


Figure 4. XX2 wells yield curve

There are 146 wells in field used this technology, the success rate is 96.5%. It can fracture 9 layers with pulling string and provides strong technical support for large-scale multilayer net fracturing.

THE DOUBLE SEAL SINGLE GRIP WITH PULLING STRING MULTILAYER FRACTURE TECHNOLOGY

The technology is the use of double seal single grip layer fracturing, it realized that single string could fracture multiple layers by backwashing and pulling string. Coordinate with coiled tubing on the operation can improve the efficiency, reduce the risk of well control [Bu Yuhuan *et al.*, 2011].

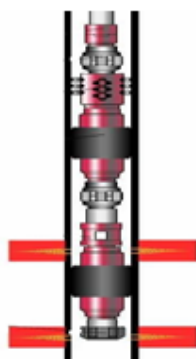


Figure 5. Double seal single grip string schematic diagram

Technical indicators

The craft column's temperature limit is 100 °C, pressure limit is 80MPa 8 segments can be fractured per day, single string can complete 15 segments fracture.

The sand capacity of single string is 196 m³.

The maximum distance between two grips is 112m.

Conclusions should state concisely the most important propositions of the paper as well as the author's views of the practical implications of the results.

Field application

For example, XX3 well, we completed 8 segments by the method of double seal single grip and coiled tubing, the maximum construction pressure is 55MPa, the amount of sand is 58m³. The largest construction displacement is 3m³/min. 8 segments were completed in 6 hours by continuous construction.

In the early of fracture, produce fluid 6.1tand oil

5.2t, it's 4 times as much as the under 4 segments well around.

We have fractured 23 vertical wells on the field by this technology, and 215 horizontal wells cumulative wells, the success rate is 93.1%. This technology is the subject technology for horizontal well multiple segments fracture in currently.

THE TECHNOLOGY WHICH COMBINES FRACTURE AND FLOW BACK FOR PERIPHERY

For the characteristic of high temperature, high breaking pressure, large-scale sand requiring, in order to further improve the scale and efficiency of fracturing, we studied and supported an integral technology which can fracture 3 layers, flow back after fracture and control the overflow in the pipe. And the single string can fracture 5 layers by pulling two times.

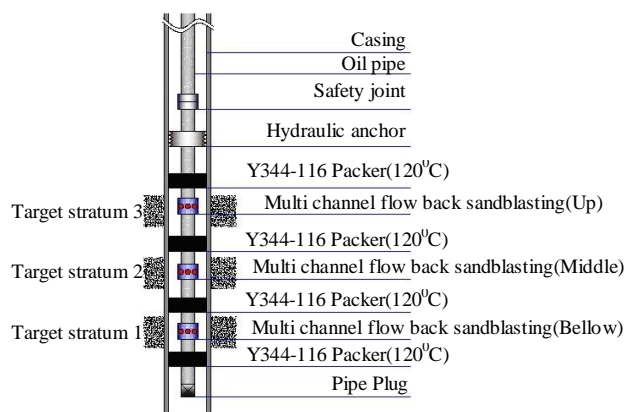


Figure 6. Fracturing without pulling and flow back string schematic diagram

THE HYDRAULIC SPRAY STRATIFIED FRACTURE TECHNOLOGY

Hydraulic spray fracturing is based on Bernoulli's principle, it can increase the pressure on the basis of shaft bottom pressure by the way that the kinetic energy of high-speed jets transmit to pressure energy, so that the pressure in the bottom could breach the target layer, and the spray gun will open to fracture 3 to 4 layers by throw different diameter steel ball.

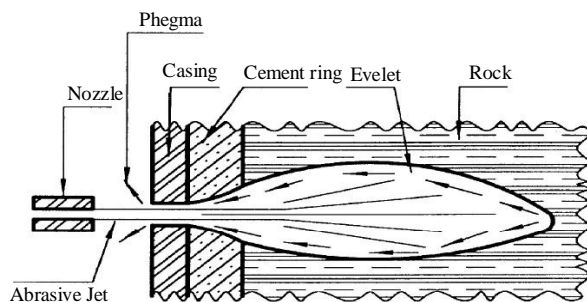


Figure 7. The basic principle of hydraulic spray schematic diagram

Technical advantages

The hydraulic injection stratified fracture technology doesn't require packers, breaks through the traditional mechanical layering method, and combines the perforation and fracture without pre perforation; Also, it can carry out the segment fracturing without packer and bridge plug; Meanwhile, this technology can accurately control the position of crack to fracture a fixed point. It applies to the fracture transformation of casing pipe well, bore well and screen pipe well completion method. This technology can fracture 3 to 5 layer by single string, and it needs 45m^3 sand per layer. Single string could use 135m^3 sand.

Table 1. Hydraulic Spray Perforating Indoor Laboratory Test Data Sheet

Single nozzle	Spray speed	Hole depth	Hole diameter	Hole Increased pressure	Extension pressure difference <5MPa
$0.34\text{m}^3/\text{min}$	$>30\text{m/s}$	700mm	11~13mm	5~8MPa	89.3% well

Technology appellation

There are 58 wells which have used this technology, and success rate is 96.6%. Currently, it can fracture 7 layers by single string, and carry out the accurate change in any position inside the thick reservoir. This is in keeping with the aim of transform for the old area.

TECHNOLOGY APPLICATION AND EFFECT

Above 5 layers and 362 of them are counted wells. The old wells, daily oil production increased for each well on average, this is 1.2 times as much as the well fractured under 4 layers; The periphery old is 4.5 times as much as the periphery old well fractured under 4 layers. It is 1.5 times as much as the others. We found that the fracture above 5 layers could effectively increase the single well productivity, improve efficiency and save cost by the analysis about the effect.

CONCLUSION

In order to improve the new single well oil production and the effect of old well fracture, we continuously innovate the technology to deal with the changing development situation. And this also provides the technology support for the development requirement that maintain production. We got the following preliminary conclusions on the basis of the application of the technology above mentioned.

Vertical Wells multilayer fracturing, compared with conventional fracturing, has the characteristics of high efficiency and low cost, in that case, it can effectively reduce the labor intensity of workers and save cost.

Compared with conventional fracturing technology, the transformation effect is better, production increasing is more. In a word, it is an effective means for improving the productivity of single well.

Vertical wells multilayer fracturing technology can be combined with vertical wells large-scale seam net fracturing technology to further improve the single well productivity and enhance the degree of effective use of peripheral difficult mining reserves.

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