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Study on the interference law of inter-well fracturing and prevention of interference by fracture-opening temporary plugging fracturing#

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ABSTRACT

In the Xinjiang Mahu tight sandstone reservoir, the phenomenon of fracturing interference between newly fractured wells and fractured horizontal wells is increasing. Fracturing interference has a significant impact on the production of the affected wells, including oil production, water production, and production oil pressure. There are two types of fracturing interference in horizontal wells in Xinjiang Mahu Oilfield: fracture communication interference and pressure wave interference. The changes in liquid production volume and production oil pressure vary for different types of fracturing interference. Based on the production data from different types of interfered wells in Mahu Oilfield, this study analyzed the changes in liquid production and oil pressure after interference, explored the effects of different types of interference on these wells, and finally provided methods to prevent fracturing interference. The results show that: (1) Production wells experience severe interference due to fracture communication; after interference, there is a significant shift in liquid production volume with an increase in water production and noticeable fluctuation in production oil pressure. (2) Production wells experience weak interference due to fracture communication; after interference, there are slight changes in liquid production volume with a small increase in water production but no obvious fluctuation in production oil pressure. (3) By adopting fracture-opening temporary plugging fracturing technology, it is possible to control the liquid volume of individual clusters and reduce the possibility of dominant fractures expanding further away. This has an evident effect on preventing fracturing interference.

Keywords: fracturing interference, fracture communication, interference prevention, temporary plugging fracturing

1. INTRODUCTION

The dense sandy conglomerate reservoir in the Mahu area of Xinjiang is a mega dense conglomerate reservoir with an estimated total petroleum geological reserve of more than 1 billion tons discovered in recent years, which has become the main object of oil and gas field development in Xinjiang because of its better development effect on the use of horizontal well volume fracturing technology [1, 2]. However, with the continuous progress of horizontal well volume seam network fracturing technology, the scale of fracturing is gradually increased, and at the same time, encrypted wells make the distance between wells and wells gradually decrease, and the phenomenon of fracturing interference gradually becomes significant. Fracturing interference may result in local stress changes, liquid clossflow in the fracture and other phenomena, causing changes in the wellhead pressure, daily liquid production of the produced wells, daily gas production, etc., and even causing the invasion of fracturing liquids into the neighboring wells, damage to the neighboring wells, and a great impact on the production capacity [3].

Inter-well fracturing interference is usually the interference generated by wells to their neighbors during fracturing construction, and the reasons for this are more complicated, mainly from two aspects. First, geological factors, it is generally believed that between fracturing wells and production wells, there are natural weak surfaces, such as natural fractures, laminations and faults, which increase the possibility of inter-well fracture network trenching [4, 5]. Compared to hydraulic fracturing, fluid scuttling through faults has a wider range and can often reach long distances; whereas fluid scuttling through natural fractures is generally weaker than that produced by hydraulic fractures and may take some time to pass before it is observed, thus, fracturing interference through faults have a greater impact [6,7].

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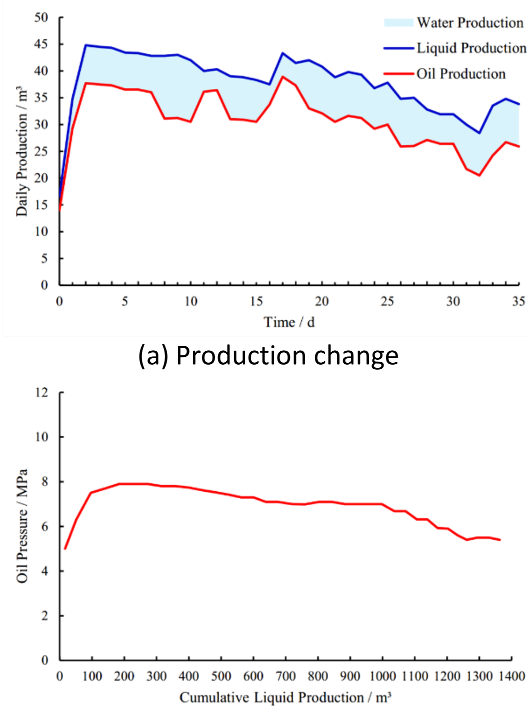
In addition to the natural weak surface, geological factors such as formation stress, formation minerals, formation structure and other geological factors also affect the fracturing interference [8] , and the size distribution of the ground stress field is the main controlling factor of the hydraulic fractures extension, when the production wells are produced for a period of time, the outflow of fluids causes the formation deficit, which causes the lowering of the pore pressure of the reservoir in the region of the production wells and the increasing of bedrock and closure stresses, which results in the non-uniform distribution of the ground stress field, and it is easy to cause hydraulic fractures to expand to the deficit region [9-11]. Secondly, the construction factor, due to the encryption of the well network, the distance between wells is reduced, which greatly increases the risk of fracturing interference [12], and also due to the overlapping of the fracturing and reforming areas of adjacent wells will also produce interference effects [13]. Uneven expansion of hydraulic fractures during the construction process can also cause interference in neighboring wells [14, 15]. According to the formation mechanism of fracturing interference, the interference can be categorized from different angles. It can be categorized into fracture communication and pressure wave according to the formation reason [16,17]. Fracture communication is the direct communication and natural weak surface connection through hydraulic fractures. Pressure wave is through the reservoir rock to neighboring wells. From the perspective of time, it can be divided into interference in the fracturing stage and production stage [5]. It can be categorized into positive and negative effects from the point of view of changes in production [18-20]. Kumar et al. [21] also showed that fracture communication occurs in the early stages of production in producing wells through tracers as well as pressure tests. As production continues, the connected fractures will gradually close.

It can be observed that the formation mechanism of fracking interference is more complex, and there are various types of interference. However, the influence of interference on production wells is still unclear. In this paper, two types of interference, namely, fracture communication interference and pressure wave interference, are studied from the perspective of formation causes, and the influence law of fracturing interference is clarified by analyzing the production data of the two types of interfered wells. Finally, from the point of view of fracturing construction method, the measures to prevent fracturing interference are given.

2. METHOD

2.1 Study of interference law

There are two types of interference in the fractured production wells in the Mahu Depression, which are fracture communication interference and pressure wave interference. The production dynamics of the wells that did not receive fracturing interference is shown in Figure 1, and the production wells have no obvious changes in liquid and oil production during production, and the production oil pressure is relatively stable. And the production data of the production wells show a certain change rule after the interference of the new fractured wells. Table 1 shows four different examples of interference in the Mahu Oilfield, in which well X1 and well X2 are interfered by only one well, while well X3 and well X4 are interfered by multiple wells. In this section, the changes in production data of the four interfered wells will be used to explore the interference patterns of different interference types.



(a) Production change

(b) Pressure change

Fig. 1 Production change of normal production well

2.2 Fracture-opening temporary plugging fracturing

In actual reservoirs, due to the non-homogeneity of reservoir properties, when horizontal wells are fractured by segmented multi-cluster fracturing techniques, the hydraulic fractures in the fractured section do not expand together as expected. Individual clusters of shot holes formed rapidly expanding hydraulic fractures, while other clusters of shot holes did not even form effective hydraulic fractures eventually. There is a risk of uncontrolled expansion of individual dominant fractures that receive the majority of the fracturing fluid. Excessively long fractures may communicate with hydraulic fractures in neighboring wells to form serious inter-well interference. Therefore, slit mouth temporary plugging can be used to make each cluster of injection holes inject a comparable amount of liquid, and when a particular cluster of injection holes is fractured, slit mouth temporary plugging can be used for the remaining clusters of injection holes.

In this paper, the conventional hydraulic fracture propagation and sealing fracture morphology are simulated under the condition of heterogeneous reservoir, well spacing of 300 meters and liquid injection volume of 2000 m^3.

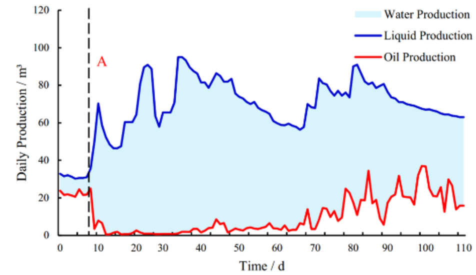
Table 1. Cases of interference in Mahu Oilfield.

Interference wells	Fracturing wells	Interference date	Interference type
X1	Y1	2021	Fracture communication
X2	Y2	2018	Pressure wave
X3	Y3	2018	Fracture communication
	Y4	2018	Fracture communication
X4	Y5	2018	Fracture communication
	Y6	2018	Pressure wave

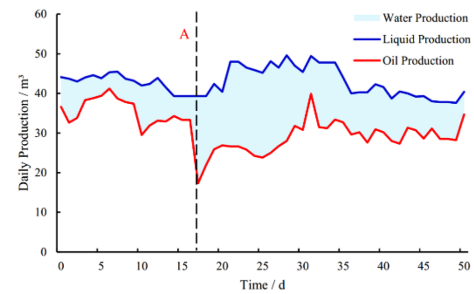
3. RESULTS

3.1 Law of change in liquid production

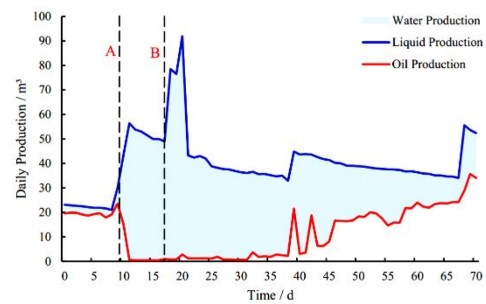
Figure 2 shows the variation of liquid production in the four producing wells after fracturing interference. Where A and B are interfered points. It can be seen that when the fracture communication between production wells and fracturing wells is interfered, the amount of liquid produced by the interfered wells has obvious changes, water production increases dramatically, oil production decreases, which has more serious negative impacts, and the interference time is longer, this is because when the fracture communication is interfered, the liquid from fracturing wells enter into production wells through the fracture, which makes the production wells produce dramatically more water. When pressure wave interference is formed between production wells and fracturing wells, there is no obvious fracture communication between the wells, and there is a small change in the liquid production of the interfered wells with a shorter impact time, because high pressure will be formed when the fracturing wells are fractured, and the liquid in the territory will be transported towards the direction of lower pressure in the production wells, and due to the low porosity and low permeability of tight reservoirs, the liquid diffusion is slower, and therefore, the change in liquid production of the interfered wells has a smaller amplitude.



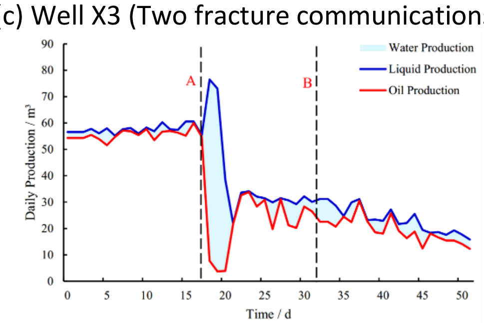
(a) Well X1 (Fracture communication)



(b) Well X2 (Pressure wave)



(c) Well X3 (Two fracture communications)

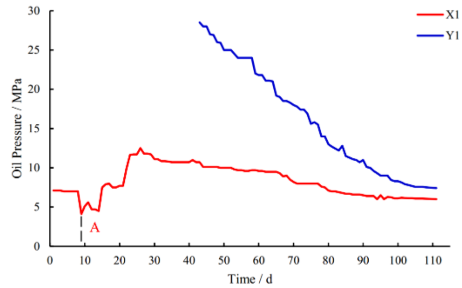


(d) Well X4 (Fracture communication and pressure wave)

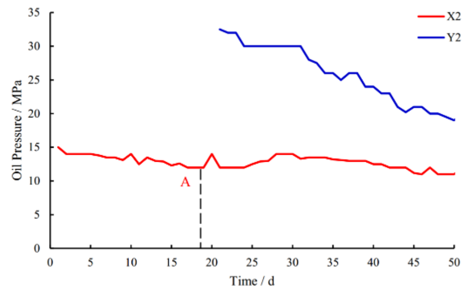
Fig. 2 Changes in liquid production from different interference wells

3.2 Law of change in oil pressure

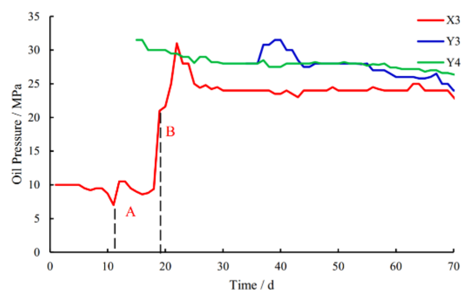
Figure 3 shows the variation of oil pressure in the four producing wells after fracturing interference. Where A and B are interfered points. It can be seen that when



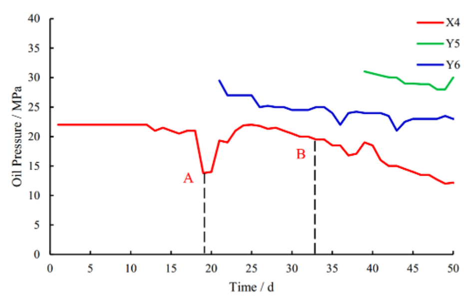
(a) Well X1 (Fracture communication)



(b) Well X2 (Pressure wave)



(c) Well X3 (Two fracture communications)



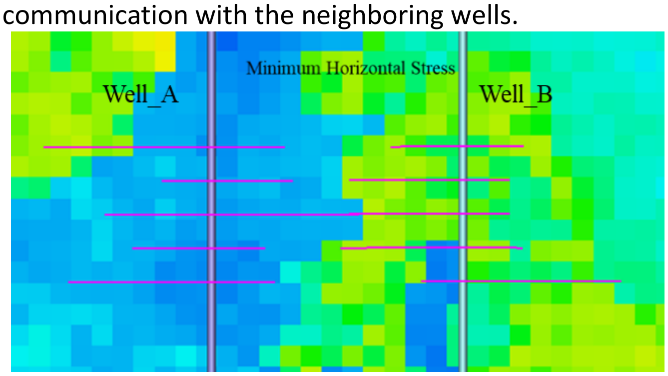
(d) Well X4 (Fracture communication and pressure wave)

Fig. 3 Changes in oil pressure from different interference wells

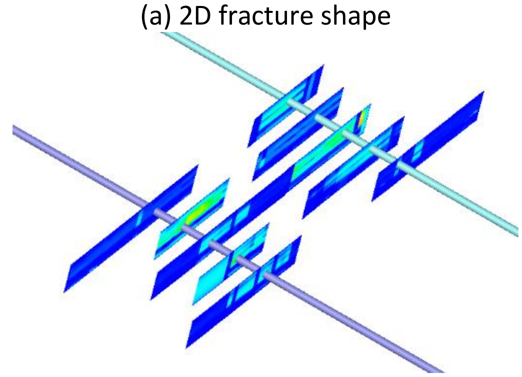
the interference of fracture communication is formed between the production wells and the fracturing wells, the oil pressure changes of the production wells are large, both have obvious steep increase, and stabilize after a period of time. When the production wells and the fracturing wells are co-produced for a period of time, the pressure changes of the two wells are close to each other, which is because the liquid volume of the fracturing wells will invade into the production wells along the fracture after the fracture communication, which results in the drastic change of the pressure in the bottomhole of the production wells, the fracturing wells are quicker to release pressure after fracturing, and the oil pressure in the production wells will, gradually, stabilize, and a dynamic equilibrium will be formed between the two wells during co-production. When the pressure wave interference is formed, the oil pressure change of the production well is small, and there is no obvious steep increase phenomenon, when producing together, the oil pressure change of the two wells has no obvious correlation, this is because there is no fracture communication between the wells, and affected by the low porosity and low permeability of the reservoir and the compression coefficient of the rock, the liquid volume of fracturing wells is not even diffused, and the slower propagation of the pressure wave does not have any strong impact on the pressure formation of the production wells.

3.3 Fracture-opening temporary plugging fracturing

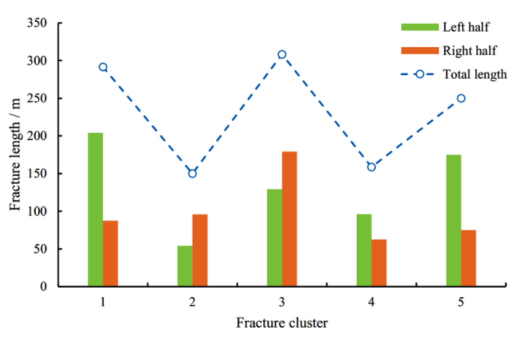
As shown in Figure 4, the fracture pattern under single-stage multi-cluster cage fracturing in horizontal wells, it can be seen that under the condition of non-homogeneous minimum horizontal stress, the fracture in two flanks of horizontal wells expands asymmetrically, and there are advantageous fracture obtaining more fracturing fluid, expanding farther, and forming fracture communication with the neighboring wells.



(a) 2D fracture shape



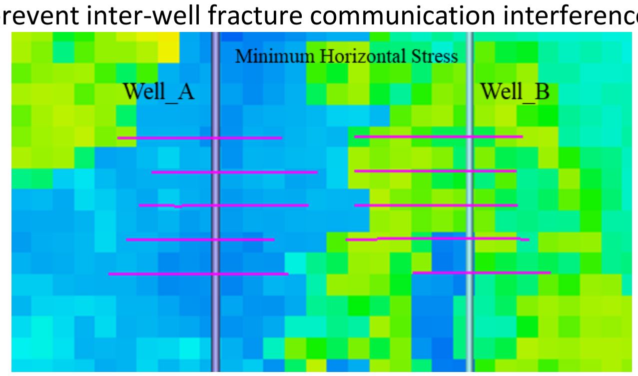
(b) 3D fracture shape



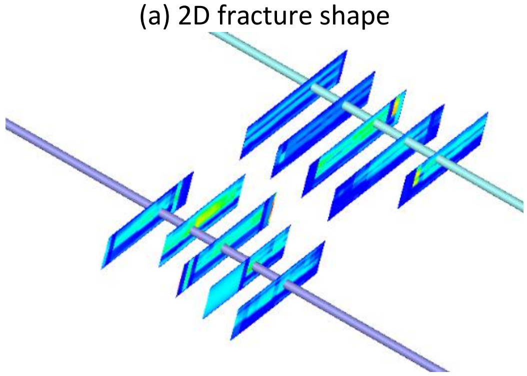
(c) Fracture length of well A

Fig. 4 Conventional hydraulic fracturing

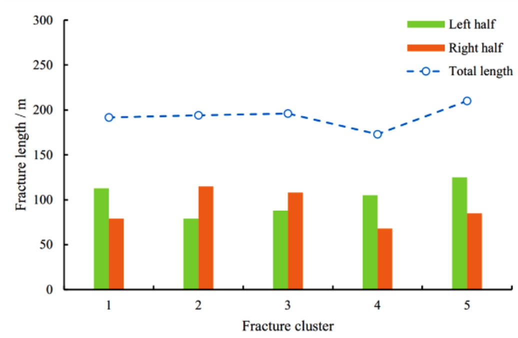
Figure 5 shows the hydraulic fracture extension of single-segment multi-cluster hydraulic fracture in the horizontal well after temporary plugging of the fracture opening is carried out, and the volume of liquid injected per cluster is about 400 m^3. It can be seen that the fracture extension is still affected by the non-homogeneity of the formation, and the fracture lengths of the two flanks are still different, but the use of temporary plugging of the slit controls the liquid injection volume per cluster, reduces the possibility of excessive extension of individual fractures, and controls the length of the fracture in each cluster, which reduces the possibility of inter-fracture interference. Therefore, the temporary plugging technique can effectively prevent inter-well fracture communication interference.



(a) 2D fracture shape



(b) 3D fracture shape



(c) Fracture length of well A

Fig. 5 Fracture-opening temporary plugging fracturing

4. CONCLUSIONS

In this paper, four different fracturing interfered production wells in Mahu tight oil field are taken as examples to analyze the dynamic changes of fluid production and oil pressure after these Wells are interfered, and to clarify the influence laws of fracture communication and pressure wave interference on production wells. Finally, some suggestions to prevent interference are given. The conclusions reached are as follows:

(1) When the interference of fracture communication is formed between production wells and fracturing wells, the interfered wells have obvious changes in fluid production, drastic increase in water production and decrease in oil production, which have serious negative impacts, and the interference lasts for a long time. The oil pressure varies greatly after the interference, and there is a significant steep increase, which tends to stabilize after a period of time, and there is a certain correlation between the pressures of the two wells when the production wells and the fractured wells are producing together for a period of time.

(2) When pressure wave interference is formed between production wells and fracturing wells, there is no obvious fracture communication between the wells, and the fluid production of the interfered wells has a small change, with a short impact time. The oil pressure changes are small after the interference, and there is no obvious steep increase, and there is no obvious correlation between the oil pressure changes of the two wells when producing together.

(3) The use of fracture-opening temporary plugging fracturing at the seam mouth controls the amount of fluid injection per cluster, which can prevent the dominant fracture from obtaining more fracturing fluid to expand farther, effectively control the length of the seam per cluster, and reduce the possibility of fracturing interference between wells.

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