IOP Conf. Series: Earth and Environmental Science **170** (2018) 022070 doi:10.1088/1755-1315/170/2/022070

Study on Multi-clusters Fracturing interference by Finite Element Method in Tight Sandstone Reservoir

Peng Yang[1], Jun Zhou[2,*], Yang Zhang[1], Linsong Feng[1] and Lin Guo[1]

[1]No.6 Oil Production Plant of Changqing Oilfield Company, CNPC, Dingbian, 718606, China
[2]Sinopec Research Institute of Petroleum Engineering, Beijing, 100101, China

*Corresponding author e-mail: zhou_sripe2015@126.com

Abstract. The disturbance effect between fractures enhanced by the characteristic of large scale and high fracture distribution density while staged multi-clusters fracturing technology has been widely applying in horizontal well of tight sandstone reservoirs. For tight sandstone well fracturing, treatment tools and bridge plug need to be set between stages, and this procedure takes no less than 4 hours, which provide plenty of time for fracturing fluid's leaking-off, generate the pore pressure decreasing around hydraulic fracture, and this will reduce the induced stress field strength. In this paper, finite element method (FEM) has been employed, combining with the actual treatment procedures, we analysed the distribution of induced stress field between stage and clusters space respectively.

1. Introduction

In hydraulic fracturing of tight sandstone reservoirs, the priority of hydraulic fracture internal space is occupied by the fracturing fluid, external surrounding rock of fracture is extruded, resulting in induced stress. The change of in situ stress field distribution effect the initiation and extension of neighboring fracture, known as the interference effect between fractures. The effect of the interference of tight sandstone fracture has two sides: (1) forcing new fracture divert to increase complexity of fracture network system, which is helpful to form a higher volume of reservoir reconstruction (2) induced stress and fracture diversion to increase the extension resistance of new fracture, may lead to some change of the perforation can't fracture initiation. Therefore, fully understand and reasonable tradeoff between fracture interference phenomenons is of great significance for the development of tight sandstone reservoirs.

2. Induced stress field and interstitial interference

The essential reason of interference between fractures is induced stress. Therefore, we need to describe the induced should force field distribution of hydraulic fracture at any point in the reservoir. Starting with the assumption, extension of hydraulic fracture following KGD model. Fracture expanding along the maximum horizontal principal stress direction, and with wellbore orthogonal.

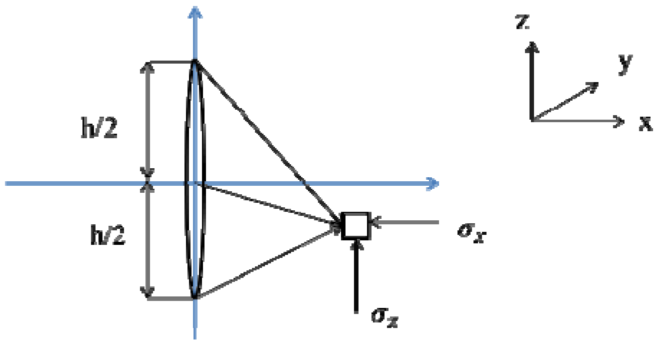

Figure 1. Physical model of induced stress.

X is the trajectory direction along the horizontal section in the figure, Y represents the maximum horizontal principal stress direction, z direction on behalf of the vertical direction. The maximum horizontal principal stress is σ_H MP, minimum horizontal principal stress is σ_h MP. Assumes that the distance of point from the center of the fractures as the L, h is fracture high, m; Net pressure on the fracture extension is p, MP. Induce stress for fracture extension is

$$\begin{cases} \frac{\sigma_x}{p} = 1 - \frac{L/h}{\sqrt{(L/h)^2 + 1/4}} + \frac{L/h}{4(\sqrt{(L/h)^2 + 1/4})^3} \\ \frac{\sigma_z}{p} = 1 - \frac{L/h}{\sqrt{(L/h)^2 + 1/4}} - \frac{L/h}{4(\sqrt{(L/h)^2 + 1/4})^3} \\ \frac{\sigma_y}{p} = \nu(\frac{\sigma_x}{p} + \frac{\sigma_z}{p}) \end{cases} \tag{1}$$

When induced stress increases to a certain degree, the difference value of original ground stress is greater than that of the horizontal direction of maximum and minimum horizontal principal stress, such as Eq.(2)

$$\sigma_x - \sigma_y \geq \sigma_H - \sigma_h \tag{2}$$

At this point means that in-situ stress direction, lead to hydraulic fracture occurred deviate from the original trajectory. Satisfy the inequality of regional advantageous area is the fracture diversion area.

3. Results and analysis

3.1. Influence of fracture spacing

Fixed the middle fracture, the stress distribution of fracture spacing which is 20m, 30m, 40m have been calculated. As shown in Figure 2, red represents compressive stress, green represents tensile stress. In the case of 20, 30 meters distance, middle fracture is common compressed by other fractures, which hold back the expansion of the fracture in the middle.

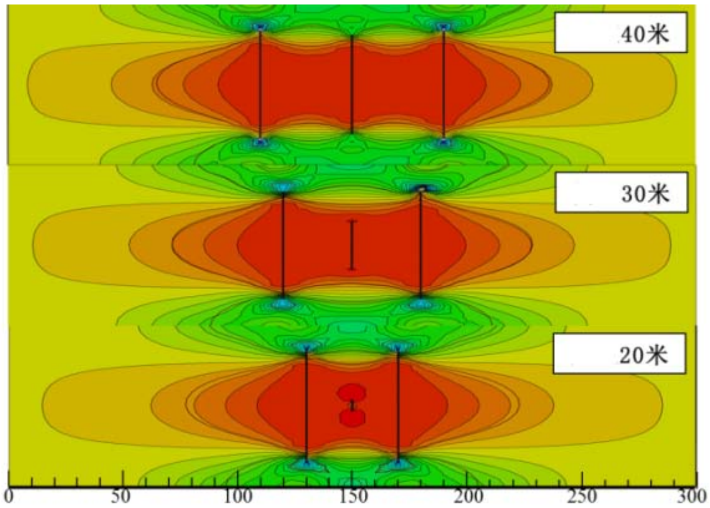

Figure 2. Distribution of induced stress difference by changing fractures space

Two diversion area are mainly concentrated in two sides of the middle fracture. This is because the induced stress superposition area of three fractures concentrated around the middle fracture to form a higher strength stress field. Thence, a stress deflection might be appeared around the middle fracture.

3.2. Influence of in-situ stress

In considering the minimum horizontal principal stress σ_h is the normal stress for tensile fracture, which namely the closure stress. This is one of the important factors directly affect the fracture extension scale. This study is fixed σ_H , the only change σ_h . Set σ_h is respectively 23 MPa, 27 MP and 32 MPa.

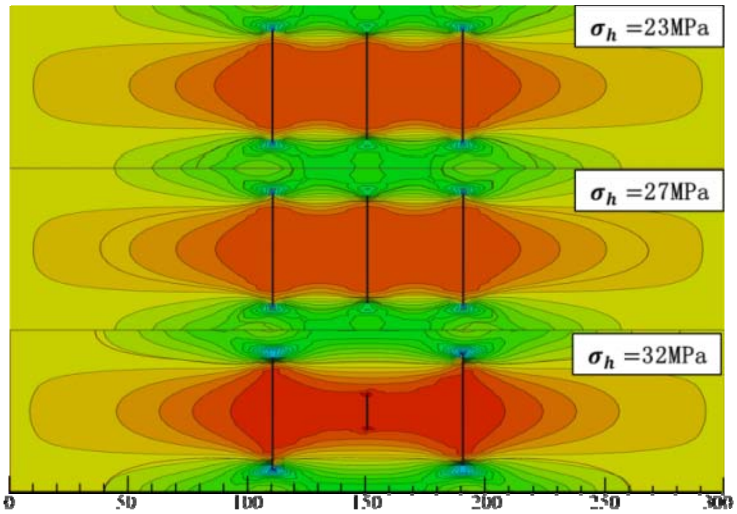

Figure 3. Distribution of induced stress difference by changing in-situ stress

In the process of the minimum horizontal principal stress gradually increases, fractures induced stress difference is decreases. Until σ_h is 32 MP, induced stress difference is greater than that of original ground stress, stress deflection area began to appear. It shows that the smaller the difference of the in-situ, the more conducive to fracture divert.

3.3. Influence of pump rate

Pump rate determines the net pressure of fracture in the hydraulic fracturing, so the effect of net pressure on mute-cluster fracturing could be calculated by change the pump rare. Setting σ_H and σ_h is the original state, the pump rate is respectively 6, 8,10m3/min.

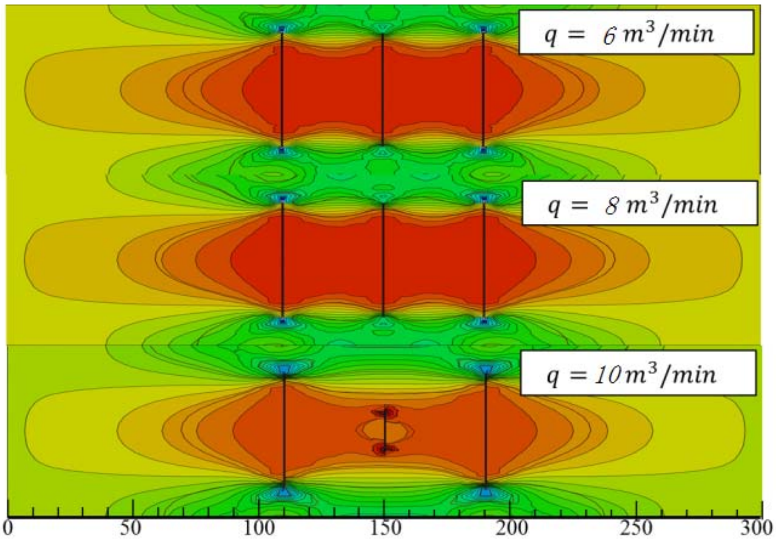

Figure 4. Distribution of induced stress difference by changing pump rate

With the increase of pump rate, induced stress difference showed a trend of rising, which means large pump rate is in favor of increasing fracture deflection area. When the pump rate increased to 10m3/min, the extension scale of middle fracture is restricted. In order to avoid the difference influence on construction and subsequent production, if field decided to adopt large pump rate fracturing, we advise to increase the fracture spacing appropriate or directly use two clusters perforation to hydraulic fracturing.

4. Conclusion

In this paper, by studying the induced stress field distribution, fracture interval and pump rate influence on hydraulic fracturing, the relationship between the size of the fracture length and stress change scope has been deeply discussed in various conditions.

(1) Through simulation calculation in a variety of conditions, we found central perforation clusters extended fracturing, due to the interference on both sides of the crack induced stress, always in a state of weak extension in the clusters fracturing.

(2) Appropriate increase cluster gets larger fracture spacing is advantageous to the diversion area. Large pump rate may inhibit the expansion of the middle fracture.

(3) Simulation calculation is based on the fracture propagation path which is determined under the premise. However, due to the effect of stress field, fracture propagation path may be bent, thus reducing the inhibition of the weak fracture.

References

[1] Kresse, Weng, Wu, et al. Numerical Modeling of Hydraulic Fractures Interaction In Complex Naturally Fractured Formations[J]. Rock Mechanics/Geomechanics Symposium, June 2012, 24-27.

[2] WU Q,XU Y, WANG T, et al. The revolution of reservoir stimulation:an introduction of volume fracturing[J]. Natural Gas Industry,2011,31(4): 7－12.

[3] M. K. Fisher, J. R. Heinze, C. D. Harris et al. Optimizing Horizontal Completions in the Barnett

Shale With Microseismic Fracture Mapping.[J] Journal of Petroleum Technology, 2004:57(3).

[4] SU Y, YUAN B, LI S X et al. Influential factors of Horizontal Well Volume Fracturing Productivityin He 8 Tight Gas Reservoir. Science & Technology Review[J]. 2013:31(19)20-25.

[5] Cai Bo, Tang B Z, Ding Y H. Influence of stress shadow on horizontal well fracturing[J]. Natural Gas Industry. 2014:34(7)55-59.

[6] Shao S Q, Tian S Z, Li G S, et al. Fracture Spacing Optimization for Fracture-Network Fracturing in Horizontal Wells[J]. PETROLEUM DRILLING TECHNIQUES. 2014:12(1)86-90.