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Study on Influence of Ball Seat on Pressure Drop in Horizontal Open Hole Staged Fracturing

Jun Zhang*[a],Tao Wang[b],Feng Shi[b]

[a] Yangtze University College of Technology & Engineering, Jingzhou, China
[b] Engineering Technology Institute of Tuha oil company, Xinjiang, China
595591752@qq.com

Horizontal wells open hole staged fracturing technology has become an important technology of horizontal well increase production. The ball seat is an important part of the whole process, directly related to the effect of fracturing. Established a geometric model for the horizontal open hole staged fracturing ball seat, used FLUENT software to study influence of the ball seat on the level of pressure drop. Analysis results show that when production is less than 20t/d, influence of the ball seat on pressure drop can negligible; and when the production is greater than 30t/d, influence of the ball seat on pressure drop is larger, and with the increase of production, the pressure drop increases parabolically. If the ball seat is in bottom hole and production is different, horizontal section pressure drop is parabola relationship with well depth, and the greater the flow, parabola correlation is more obvious; with the increase of production, the same wellbore pressure drop increases significantly increased. Field test was carried out in 131 wells and Ma 57 well in Xinjiang oil field. The test results were in agreement with the simulation results, which indicates the research conclusion is reliable.

1. Introduction

Horizontal wells open hole staged fracturing technology has become an important technology of horizontal well increase production. In China, horizontal well staged fracturing technology was begun since 2002 and formed a horizontal well fracturing technology which can be adapted to different completion condition after several years of rapid development (Zhang and Wang, 2015). The horizontal well open hole sealing packer sliding sleeve fracturing technology was developed after 2011(Li and Shen, 2015), which is a new horizontal well fracturing and transforming technology, with the characteristics of the full process of hydraulic action, no fracturing ball and strongly transforming according to reservoir layer, which has been send wide field application and successful field effect in shale gas and tight oil horizontal wells (Feng and Zhang, 2013).
The ball seat is an important part of the whole process, which directly related to the effect of fracturing (Ding and Li, 2014), (Ding and Shi, 2014). Under normal circumstances, after the end of the fracturing, the ball seat should be drilled, but the whole process was very complex and trivial; put the ball seat in the bottom of the well, and will affect the future oil and gas production pressure, that lead to recovery rate is reduced. Therefore, study influence of horizontal well staged fracturing ball seat for on- way pressure drop is great significance. (Ma et.al, 2010)

2. Structure of horizontal well sectional fracturing ball seat

The open hole packer and the sliding sleeve sectional fracturing technology is opening the sliding sleeve to realize sectional fracturing by putting into different sizes fracturing balls (Ettema R, 1990), (Cai et.al, 2011). Xinjiang oil field Ma131 open hole completion well casing programme as shown in Figure 1, open hole packer and fracturing pipe string structure as shown in Figure 2, the internal diameter of casing is 124mm, horizontal segment length is 1200m, and 23 sliding sleeve ball seat arranged according to table 1 gives the design size, spacing between 50m.

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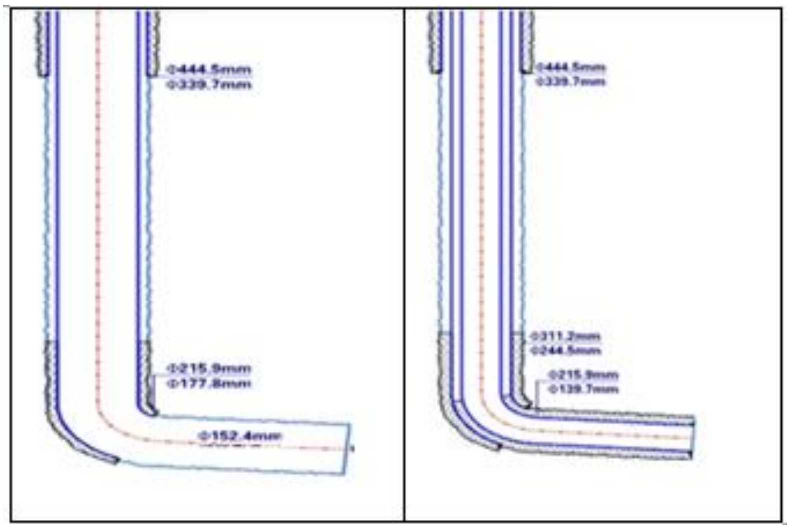

Figure 1: Sketch of casing programme

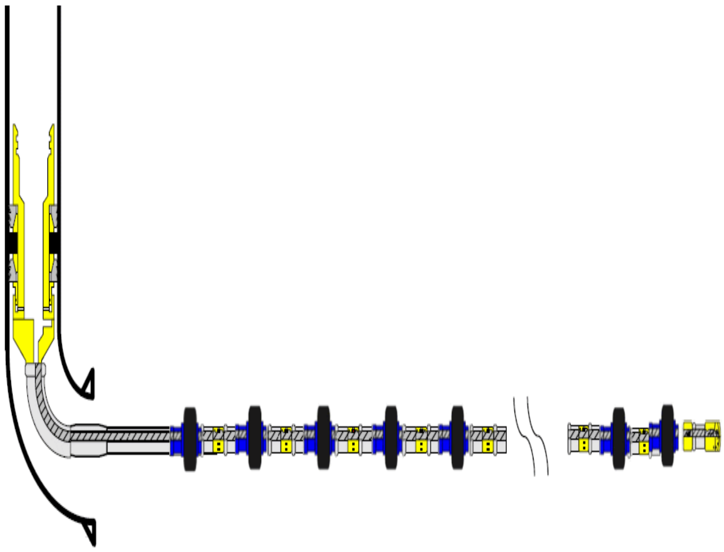

Figure 2: Open hole packer and pipe string structure of sliding sleeve ball segment fracturing string

Table 1: The 24 section of the sliding sleeve fracturing ball seats size list

Serial number	Ball external diameter(mm)	Ball seat internal diameter(mm)	Serial umber	Ball external diameter(mm)	Ball seat internal diameter(mm)
1	27.94	26.04	13	63.5	57.79
2	30.48	28.58	14	66.68	60.96
3	33.02	31.12	15	69.85	64.14
4	35.56	33.66	16	73.03	67.31
5	38.1	36.2	17	76.2	70.49
6	41.28	38.74	18	79.38	73.66
7	44.45	41.91	19	82.55	76.84
8	47.63	45.09	20	85.73	80.01
9	50.8	48.26	21	88.9	83.19
10	53.98	51.44	22	92.08	86.36
11	57.15	54.61	23	95.25	89.54
12	60.33	57.79			

3. CFD model and boundary conditions

Assumed production crack is a ring groove (Pendyala R et.al, 2015), groove width is 20mm and high is 114mm. built CFD model of horizontal section ball seats as shown in Figure 3, the ball seats and oil inflow as shown in Figure 4, no ball seat at the grid model respectively as shown figure 5. The left end face is pressure outlet boundary condition, as a quasi base to calculate the pressure field, pressure is 0. Fuild viscosity is 0.013 p_a•*s*, and density is 850 kg/m^3.

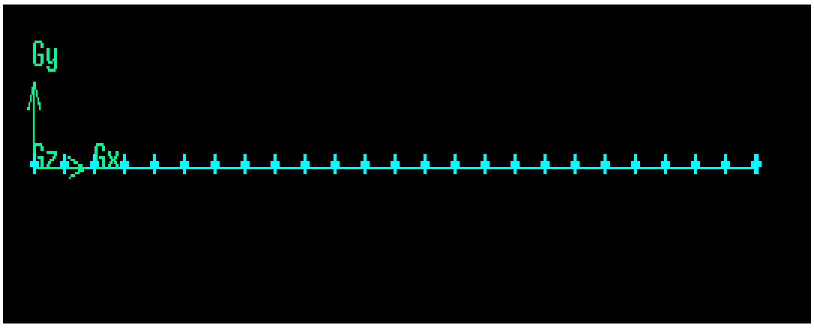

Figure 3: CFD model of horizontal section ball seat and the inflow

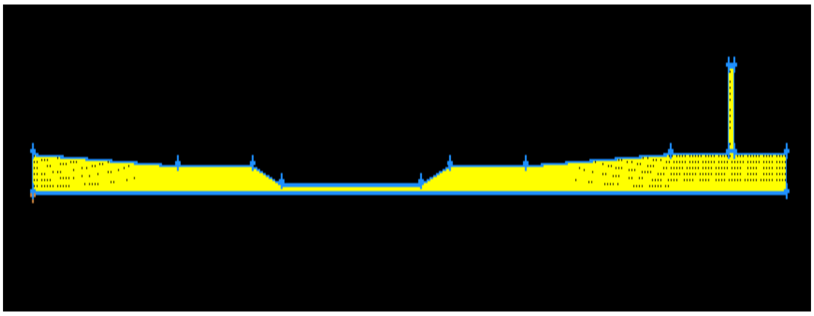

Figure 4: Ball seat and flow entrance grid

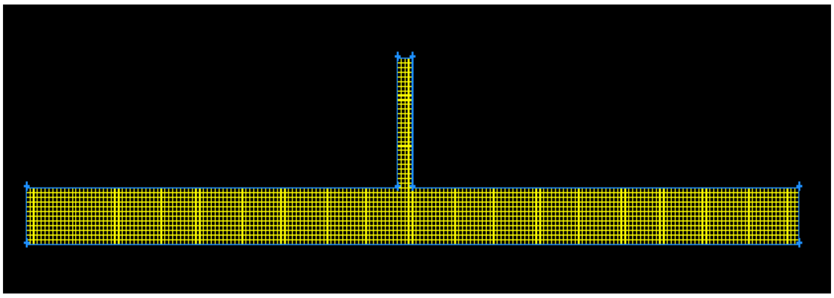

Figure 5: No ball seat and flow entrance grid

4. Simulation result analysis

4.1 Influence analysis on the ball seats on pressure drop

Under different production, pressure drop is severally calculated when ball seats are in levels segment well and are not in which. The calculation results are shown in table 2.

When the production is different, levels stage pressure drop when ball seats are in well and not as shown in Figure 6. Can see that with the increase of production, and both the pressure drop was parabola increased. When ball seats are in well, pressure drop obviously is bigger than the absence of ball seats. With the increase of production, the difference between the two increases gradually.

Table 2: The pressure drop of the sliding sleeve when the production is different

Production (t/d)	No ball seat pressure drop (MPa)	Ball seat pressure drop (MPa)	The difference between the two (MPa)
5	0.017	0.031	0.014
10	0.083	0.147	0.064
15	0.186	0.305	0.119
20	0.34	0.521	0.181
25	0.481	0.730	0.249
30	0.678	1.002	0.324
35	0.914	1.323	0.409
40	1.18	1.686	0.506
45	1.52	2.135	0.625
50	1.852	2.601	0.749

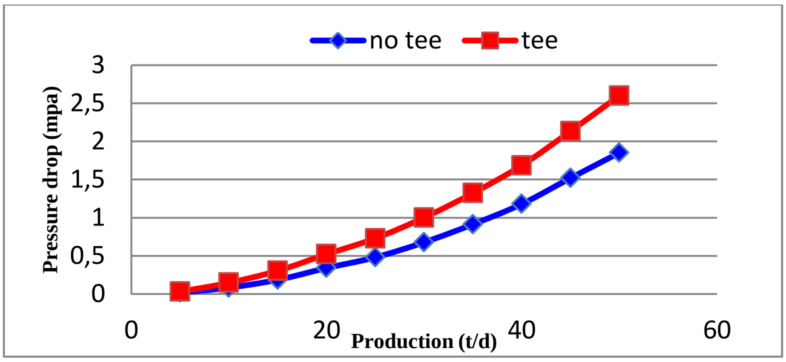

Figure 6: The pressure drop of ball seats and no ball seats when production is different

4.2 Analysis on the horizontal section pressure drop distribution

When the production was 20t/d, the pressure drop was calculated in different horizontal section depth. The calculated results as shown in Figure 7. Can be seen, along with the increase of well depth and horizontal interval, the pressure drop was a parabola increases gradually whether ball seats are in well or are not in well, with a well section, the ball seats was in well when the pressure drop was bigger than which was not in well. well depth increasing, the greater the difference between the two.

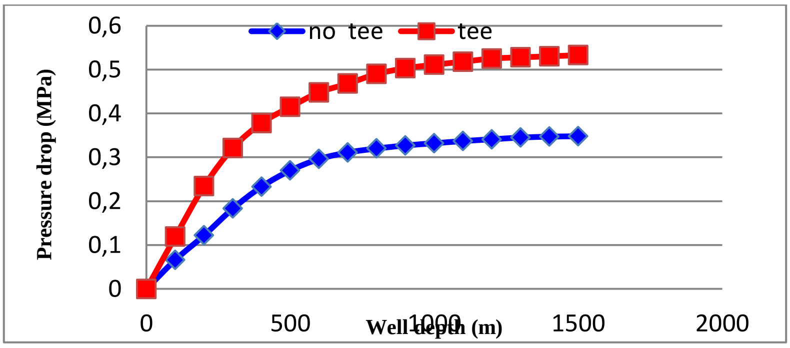

Figure 7: The pressure drop when ball seats are and no are in well at different depths

4.3 Analysis on pressure drop distribution along the horizontal section

When there are ball seats in well, the pressure drop of different production and well depth iscalculated. the result is shown in figure 8. It can be seen the pressure drop are along the well depth is parabola relationship, and the production is high, the more obvious parabola relationship. With the increase of production, range of pressure drop Increasing significantly increased

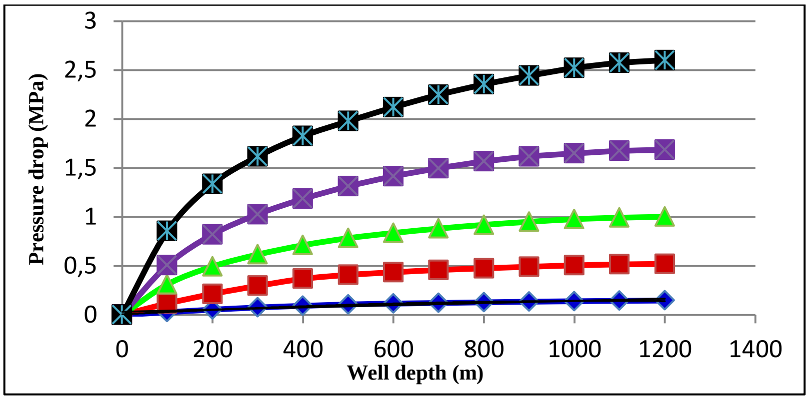

Figure 8: The pressure drop when ball seats are in well at different depths and production

5. Oilfield field test

5.1 Xinjiang oilfield Ma131 well field test

Prediction of daily production of Xinjiang oil field Ma131 well after fracturing is about 18.5t/d, daily production when seat balls are and not in bottom such as shown in Figure 9. we can see, when daily production is less than 20t/d, daily production is not much difference between both. Therefore, don't have to drill seat balls and produce directly.

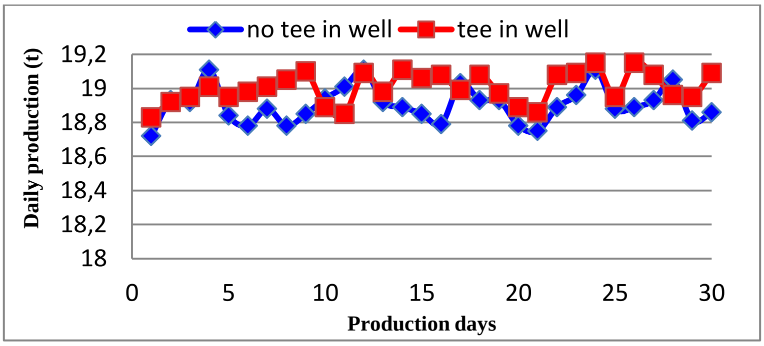

Figure 9: Ma131 well daily production when seat balls are and not in bottom

5.2 Xinjiang oilfield Ma57 well field test

Prediction of daily production of Xinjiang oil field Ma131 well after fracturing is about 31t/d, daily production when seat balls are and not in bottom such as shown in Figure 10. we can see, when daily production is greater than 30t/d, daily production when seats ball are in well bottom is increased about 1.5 t/d than when seats ball are not in well bottom. Therefore, production should be gone on after drilling the seat balls.

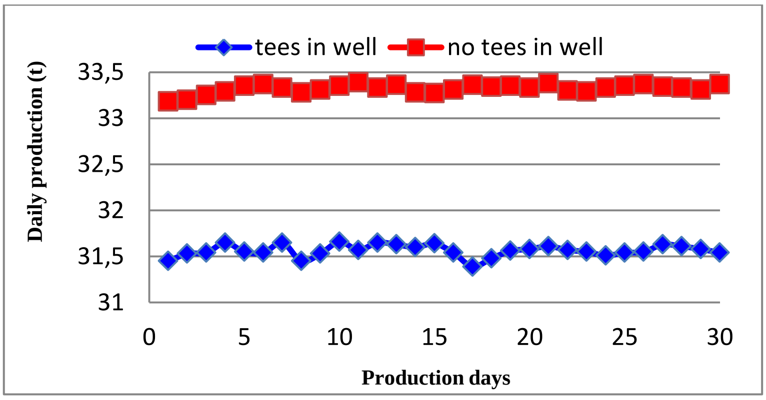

Figure 10: Ma57 well daily production when seat balls are and not in hole bottom

6. Conclusions

when the production is less than the 20t/d, the ball seat influence on pressure drop can negligible; and when the production is greater than the 30t/d, the ball seat on the effect of pressure drop is larger, and with the increase of production, the pressure drop increases parabolically. The pressure drop are along the well depth is parabola relationship, and the pressure is high, the more obvious parabola relationship. With the increase of production, the pressure drop increases with the increase of the well depth, and the difference between the pressure drop and the pressure drop increases with the increase of the well depth. Field test was carried out in 131 wells and Ma 57 well in Xinjiang oil field. The test results were in agreement with the simulation results, which indicates the research conclusion is reliable.

Acknowledgements

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