Fracturing Effect Evaluation of Shale Gas Horizontal Well In Weiyuan Area

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Abstract. Shale gas is mainly stored in the dense shale formation in free and adsorbed states, and the industrial production can not be obtained by traditional development technology. In order to obtain gas production speed and total gas production rate with economic benefits, multiple fracturing in horizontal well is the main measure to exploit shale gas reservoir. For the evaluation of shale gas horizontal well fracturing effect, the static geological model is established and the actual fracturing pressure is fitted by simulation. The fracture morphology is analysed systematicly and the effective stimulated volume is calculated. It shows that the average half length of hydraulic fractures of shale gas horizontal well in Weiyuan area are up to 168.96 meters, with 20.79 meters high. The SRV is $2885\times10^4 m^3$ and EUR is $1.2\times10^8 m^3$. The research shows that the fracturing technology has good effect and can meet the demand of shale gas development in Weiyuan area.

1. Introduction

Shale gas, as an unconventional gas reservoir, is characterized by tight reservoir and poor porosity and permeability. Large volume fracturing in horizontal wells is the key technology to shale gas development, through which effective seepage channels in shale reservoirs can be built and it releases production capacity to achieve the goal of efficient development [1]. The analysis and evaluation of the effect of fracturing can be carried out by means of microseismic monitoring, well test analysis, gas production profile testing and production logging [2-4].

However, these methods all have some shortcomings. Microseismic monitoring is affected by many factors, such as geophone position, detection distance and interpretation means. It will cause a deviation, and it records the energy response of rock burst events. It is difficult to distinguish effective and invalid volume. Well test analysis can be used to analyze the seepage dynamics of gas well, so as to get the morphological characteristics of hydraulic fracture, but the seepage mechanism after fracturing is different from conventional gas reservoir, and its theoretical basis still needs further improvement. Gas production profile test and production logging can obtain gas contribution in each section of horizontal well, but it can not describe the shape of the hydraulic fracture.

Considering the shale gas reservoir geological and engineering factors, using software to establish the static geological model, through the actual injection process, fit fracturing pressure, and calculate hydraulic fracture morphology and stimulated volume, fast evaluate the fracturing effect, which is validated by the actual production data with good accuracy.

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2. Fracturing technology of shale gas reservoir in Weiyuan area

Currently, the volume stimulation subsection technology in Weiyuan area is pumping bridge plug and perforation joint operation, the main fracturing technology is pumping slug sand with low viscosity slickwater, the gel is treated as a supplement. The scale is 1800-2000 m^3 per section of liquid, and the amount of sand is 60-70 m^3 per section.

2.1. Fracturing fluid

The slick water system should be easy to configure, the drag reduction effect is good, the damage rate is low, easily flowback. It can adapt to various types of water quality, and meet the requirements of continuous factory operations. Its viscosity is low, penetration ability is strong, it is easy to induce structural weak plane to occur shear slip failure [5], and forms the fracture net as large as possible. The drainage area of the reservoir is increased and the ultimate recovery is improved.

The glue system has good hydrating capacity, low residue and good flowback effect. Its viscosity is higher than slickwater, so it has better sand carrying capability. The glue is mainly used for pre slit in the soft section, reducing fluid loss and improving liquid efficiency. When the pressure rises too fast or displaces during construction, a certain amount of glue can be used to clean the near well area or wellbore sand, so as to ensure the safety and smooth of the construction [6].

2.2. Proppant

The combination of 100 mesh and +40/70 mesh low density ceramsite is used. The 100 mesh sand has the effect of grinding and reducing leakoff, temporary plugging, supporting natural and micro cracks. The 40/70 mesh ceramsite is used for supporting artificial fracture. The density of the proppant is low, and it has enough compressive strength to meet the requirements of fracturing and later production.

2.3. Subsection tool

By drawing on the experience at home and abroad [7], Considering the length of horizontal section and horizontal well trajectory, as well as the risk and time consuming in subsequent drilling plug, the fracture subsection tool is mainly based on the large diameter free drilling bridge plug, which avoids the risk of drilling plug and meets the demand for rapid production after fracturing.

2.4. Perforation mode

Perforating in the region of low stress and high porosity with large aperture [8]. The well has toe valve during well completion, when the toe end valve is successfully opened, using the method of combined operation of pumping bridge plug with cable and cluster perforation, perforate step by step and fracturing follow-up sections. When the well has no toe valve, or the valve can not be successfully opened, the first section is perforated with a coiled tubing using perforated gun to establish the flow passage. The follow-up sections is going to use the method of pumping bridge plug with cable and cluster perforation.

2.5. Sand adding model

It is mainly sanding with slug, in the case of conditions allowed, continuous sand adding can be adopted to improve the strength of the stimulation.

3. The establishment of static model and pressure fitting

In order to evaluate the effect of fracturing, take well A in the area as an example, the static geological model is established through geological data, logging interpretation results, real drilling trajectory and perforation data, as shown in Table 1, Figure 1 and Figure 2.

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Table 1. Base data of the model

parameters	value	parameters	value
Well name	A	Casing O.D.(mm)	139.7
Horizontal length(m)	1500	Casing thickness (mm)	12.7
MD(m)	4890	Cluster spacing (m)	20
VD(m)	3303	Secondary fracture interval (m)	5, 7.5, 10
Fractured number/clusters	19/57	Well spacing(m)	400
Porosity (%)	5	Original formation pressure (MPa)	47.8

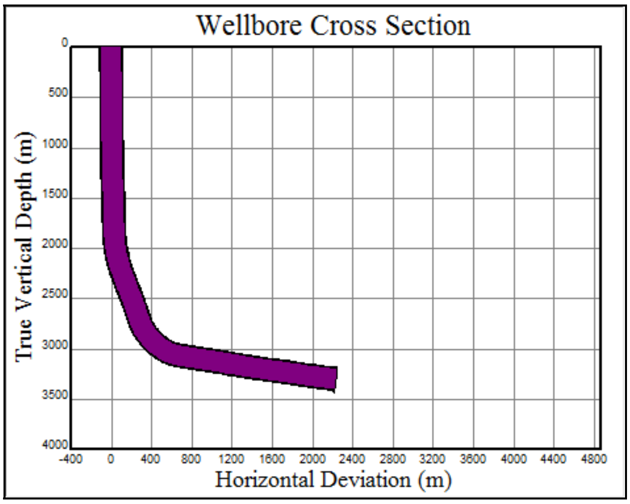

Figure 1. Trajectory map of horizontal well drilling

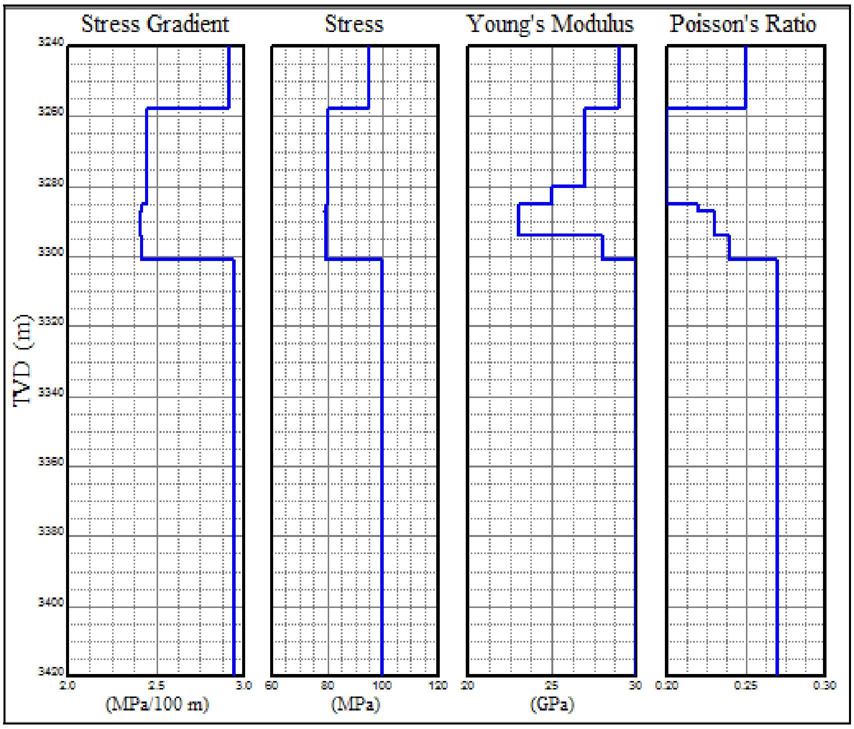

Figure 2. Reservoir mechanics parameter

The actual fracturing construction data is imported into the static model, and each construction pressure is fitted. The liquid properties are measured in the laboratory, and the viscosity of the liquid is detected in the job site, as shown in Figure 3 and Figure 4.

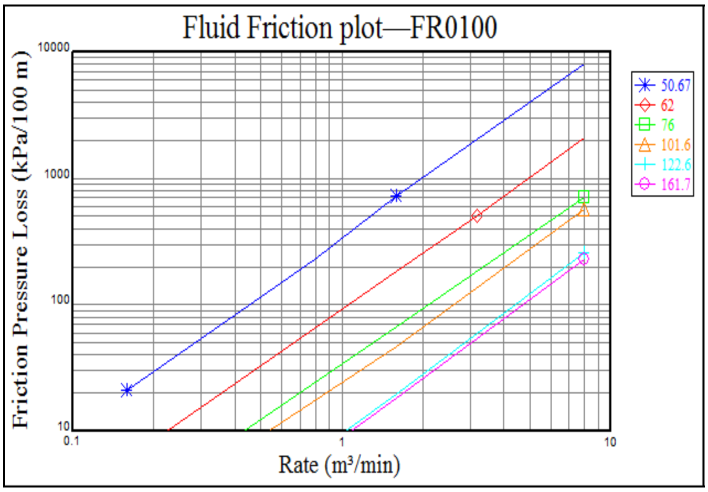

Figure 3. Friction data of liquid

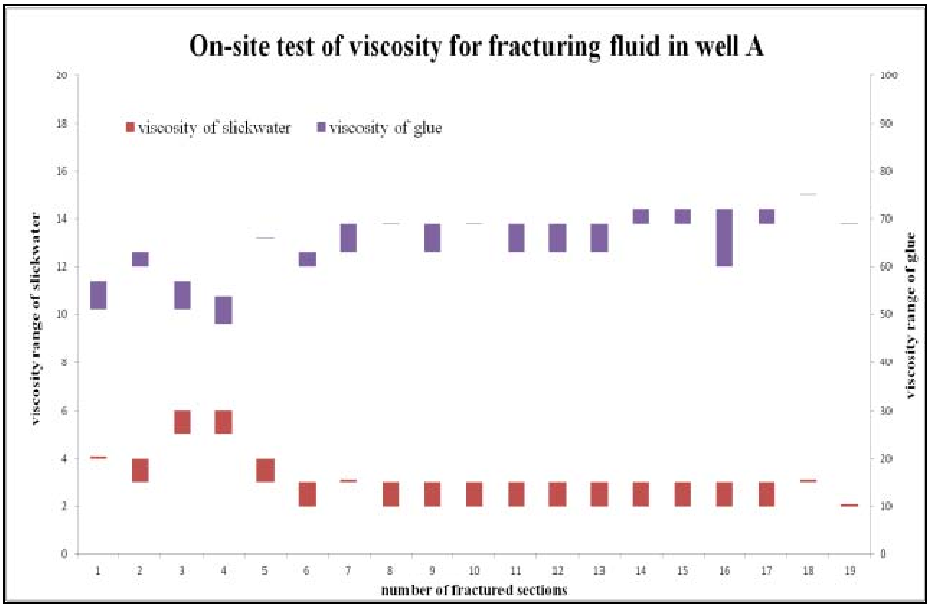

Figure 4. Viscosity of fracturing fluid

By adjusting the value of parameters, the construction pressure of each section is fitted gradually. The fitting results is shown in Figure 5.

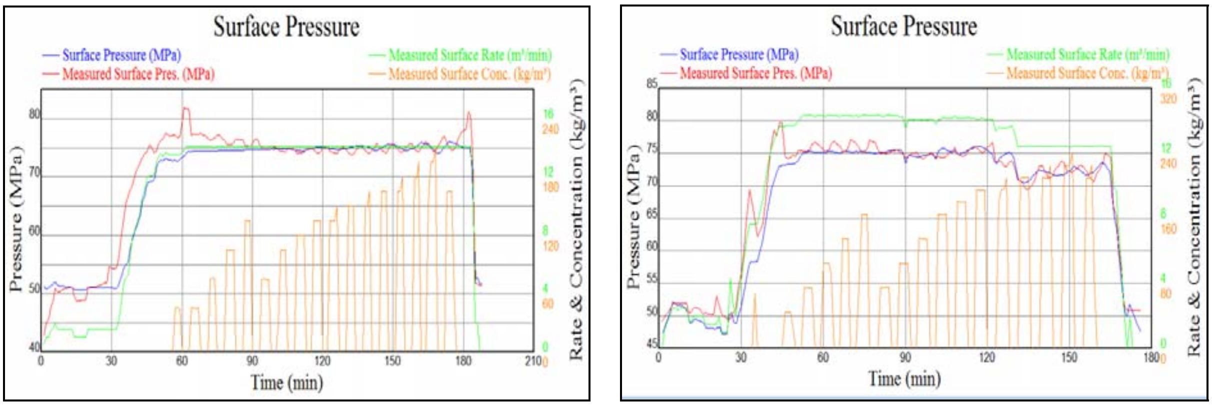

Figure 5. Pressure fitting diagram of well A

4. Evaluation of fracturing effect

Through the simulation, the fracture parameters and stimulation volume are obtained each fracture section of this well, as shown in Table 2.

Table 2. Interpretation of fracture morphology after farcturing

Fractured number	Simulation calculation		Microseismic monitoring		
	Half length of fracture(m)	Fracture height(m)	Fracture length(m)		Fracture height(m)
			east	west	
1	153	24.98	200	300	46
2	145.4	21.97	190	310	50
3	188.23	21.64	220	180	52
4	190.13	26.93	148	272	55
5	169.83	25.2	114	158	30
6	133.5	25.3	127	156	31
7	182.5	24.52	157	140	36
8	174.03	23.56	121	150	30
9	182.13	26.4	107	122	33
10	167.77	18.43	96	58	19
11	183.63	19.64	107	50	31
12	185	17.08	145	143	32
13	170.27	16.92	120	133	30
14	135.98	33.17	149	132	24
15	125.95	20.67	85	168	33
16	154.53	17.72	166	156	40
17	210.53	8.59	89	364	50
18	172.52	12.51	162	191	25
19	185.23	9.76	96	94	35
average/total	168.96	20.79	136.79	172.47	35.89

The results show that the fractures formed in this well are an average of 168.96 meters for half length and 20.79 meters high. The well adopts underground microseismic monitoring which explains that the average half length of fractures are 154.63 meters and the heights are 35.89 meters. The half fracture length of the simulated calculation is larger than the result of microseismic monitoring, but the height is smaller. The well distance is 400 meters, and the change of the monitoring pressure in the adjacent wells is not obvious during the fracturing process, which indicates that there is no interference between wells, and the simulation and interpretation of the length of the fracture is credible.

Figure 6 is a comparison of stimulation volume between microseismic monitoring and simulation interpretation. The total SRV of well A is 2885×$10^4$$m^3$ by simulation, while the microseismic monitoring result is 1115.7×$10^4$$m^3$. Through the actual production of the well (Figure 7), using Blasingame plate to predict the EUR of the well is 1.2×$10^8$$m^3$. The shale density is 2.53g/cm^3, the gas content is 5m^3/t calculated according to the log interpretation, and the recovery is 30% based on the simulation, 85% through the micro seismic monitoring interpretation, which shows that the simulation is more reasonable.

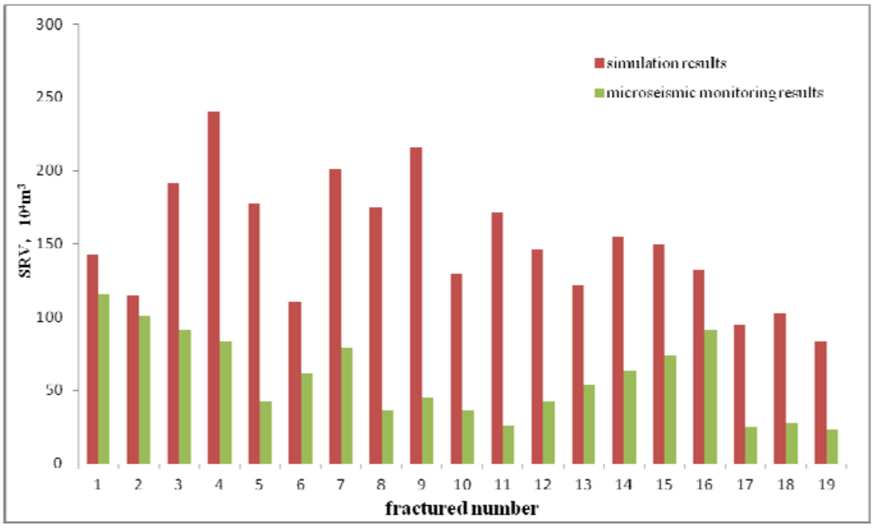

Figure 6. Comparison of SRV of two ways

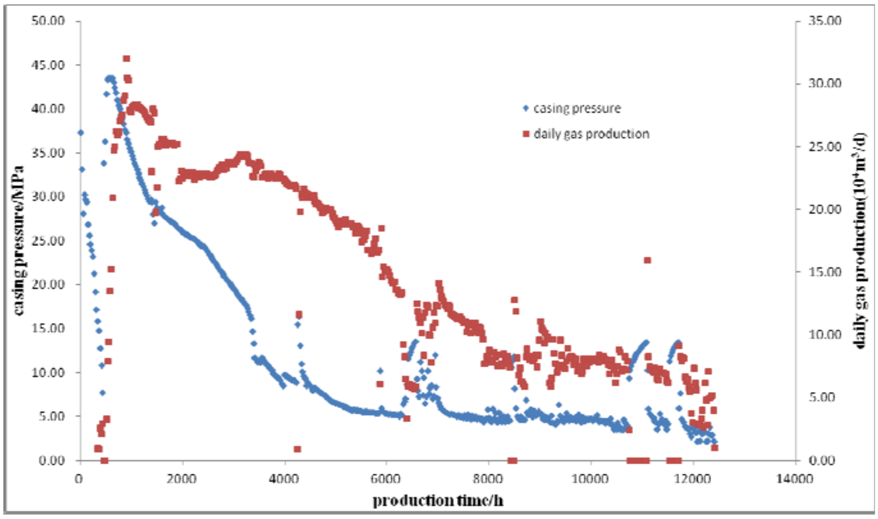

Figure 7. Production performance of well A

5. Conclusion

(1) After continuous exploration and practice, the main fracturing technology of shale gas horizontal well has been formed in Weiyuan area: the main subsection tool is bridge plug with large diameter of free drilling, the method of perforation is combined operation of pumping bridge plug with

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cable and perforation, fracturing fluid is mainly slickwater supplemented by glue, the proppant is composed of 100 mesh sand and 40/70 mesh ceramsite, slug sand is used in sand adding.

(2) The static geological model is established through the geological data and the real drilling data. According to the actual fractured construction data fitting, the fracture morphology of well A is quantitatively characterized.

(3) According to the actual production situation of the gas well, the EUR is analyzed and predicted, which proves that the simulation results are more reasonable.

(4) The current fracturing technology has good applicability in the shale gas reservoir in Weiyuan area.

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