Capacity Analysis and Understanding of Pilot Test Well in Gas Storage A

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Abstract. There is a relatively simple gas reservoir structure in gas storage A, with good trap sealing, large cap rock thickness, relatively inactive fault activity, good overall reservoir connectivity, large storage capacity, water invasion occurs in only a few wells in the low part of the structure, so there are the geological conditions for building gas storage reservoir. This paper analyzed the capacity and maximum recovery capacity of horizontal wells in this block, and the pressure influence range during the recovery process of high-speed pilot production through the pilot test of reservoir construction; moreover, it got the following understanding: the horizontal wells with good development effect, high recovery capacity, and the pressure influence range in this block are mainly within 400m from the well distance; there are differences in the gas production capacity of different types of reservoirs, and the capacity contribution of Class I reservoirs is large, while the capacity contribution of Class II and III reservoirs is small, together these believe that Shengping gas storage has the capacity conditions for building reservoir.

Keywords: gas storage A; pilot test; capacity analysis; high-speed pilot production; pressure influence range; capacity contribution of different reservoirs.

1. Introduction

Block A has been developed since 2007, the development technology policy has always upheld the principle of "overall consideration and classified governance", implements the development method of "low drainage and high control", drains gas wells in low parts and produces gas with water, while produces gas with water control gas wells in high parts, it has been implemented over the years with better results. However, objective conditions such as the development of bottom water and non-homogeneous volcanic rocks in the block have brought challenges to the conversion to gas storage, and the geological understanding and dynamic features obtained from the development are not enough to meet the needs of reservoir construction.

The geological and dynamic understanding is obtained through the deployment of two pilot test horizontal wells, which provides important data support for the reservoir construction. It mainly includes two aspects: first, drilling cap rock of pilot wellbore and coring reservoirs, conducting connected processing and interpretation, core test and supporting comprehensive research of 200 square kilometers of seismic data to meet the geological evaluation requirements of reservoir construction; second, carrying out gas production tests, gas-water interface monitoring, gas production profile test, full gas reservoir shut-in well pressure test and other pilot test tests, analyzing the capacity of injection-production horizontal wells, the maximum production capacity at high-speed pilot production, the pressure influence range during pilot production, and the capacity distribution features of different types of reservoirs, etc.

2. Capacity Analysis of Pilot Test Well

2.1 Capacity Verification

Taking A Ping 1 well as an example: in the first gas testing, capacity test was conducted for six working systems, in total, the test gas pressure changes were small in the six production working systems (see Table.1-1); for working system 2, 4, 5, 6, multi-point regression binomial method calculate the open flow capacity $145\times10^4 m^3/d$; multi-point regression exponential method calculate the open flow capacity $166\times10^4 m^3/d$.

Table.1-1 gas testing and pilot production data table of well A Ping 1

category	production parameter	working system					
		1	2	3	4	5	6
gas testing	output ($10^4m^3/d$)	15	22	30	34	42	52
	wellhead pressure(MPa)	21.4	21.36	21.16	20.51	19.92	19.27
pilot production	output($10^4m^3/d$)	42	55	70	100		
	wellhead pressure(MPa)	20.61	19.33	18.01	15.22		

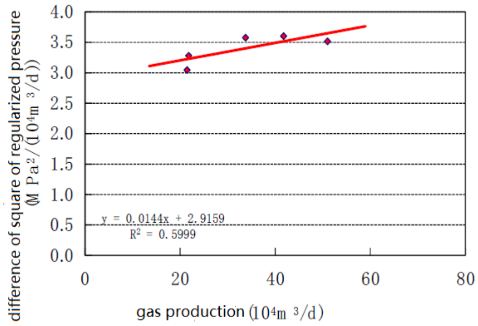

Fig.1-1 multi-point regression binomial curve (gas testing)

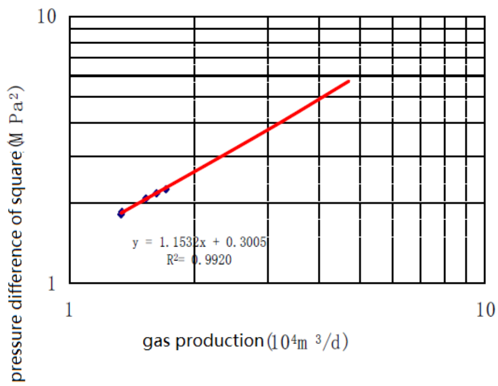

Fig.1-2 multi-point regression exponential curve (gas testing)

The multipoint regression binomial and exponential equations are as follows, respectively.

$$P_r^2 - P_{wf}^2 = 2.9159Q + 0.0144Q^2$$

$$Q = 0.5488\left(P_r^2 - P_{wf}^2\right)^{0.8672}$$

In the second gas testing, the capacity test is carried out with four working systems, in total, there is significant change in the gas testing pressure of the four output working systems (see Tables 1-2). The single-point correction binomial method is used to calculate the open flow capacity and binomial capacity equation of each working system, respectively, obtain the open flow capacity between 199~244×$10^4m^3/d$. can be seen that: the capacity calculated using working system 1 is high, and the capacity calculated using working system 2, 3 and 4 is very close, concentrated in 199~207×$10^4m^3/d$, 204.09×10^4m^3 /d on average.

Table.1-2 capacity equation and open flow capacity with single-point correction binomial method (pilot production phase)

work system number	output ($10^4m^3/d$)	wellhead pressure (MPa)	inflow model of extraction process	open flow capacity($10^4m^3/d$)
1	42	20.61	$P_r^2 - P_{wf}^2 = 2.079968Q +$	244.56
2	55	19.33	$P_r^2 - P_{wf}^2 = 2.480916Q +$	207.44
3	70	18.01	$P_r^2 - P_{wf}^2 = 2.580711Q +$	198.90
4	100	15.22	$P_r^2 - P_{wf}^2 = 2.445118Q +$	205.93

Similarly, five working systems are tested for well A Ping 2, in total: the gas testing pressure variation of the five capacity working systems is also small (see Table.1-3). The single-point correction binomial method is used to calculate the open flow capacity and binomial capacity equation of three working systems in the pilot production phase, obtain the open flow capacity between 243.53~260×$10^4m^3/d$, as shown in Table.1-4.

Table 1-3 data table of gas testing and pilot production of well A Ping 2

production parameter	working system				
	1	2	3	4	5
output($10^4m^3/d$)	10	20	33	40	53
Wellhead pressure(MPa)	21.51	21.22	21.11	20.81	20.30

Table.1-4 capacity equation and open flow capacity of single-point correction binomial method of well A Ping 2 (pilot production phase)

work system number	output ($10^4m^3/d$)	wellhead pressure (MPa)	inflow model of production process	open flow capacity ($10^4m^3/d$)
1	33	21.11	$P_r^2 - P_{wf}^2 = 1.990026Q +$	260.73
2	40	20.81	$P_r^2 - P_{wf}^2 = 2.141329Q +$	243.53
3	53	20.30	$P_r^2 - P_{wf}^2 = 1.950351Q +$	263.96

2.2 Determination of Maximum Gas Production Capacity

According to the gas testing and pilot production capacity evaluation of well A Ping 1, the inflow and outflow curves of well A Ping 1 well are built, and the maximum production capacity is 120×$10^4m^3/d$ at the current formation pressure when the wellhead pressure is 12MPa.

 https://doi.org/10.1051/e3sconf/202337501044

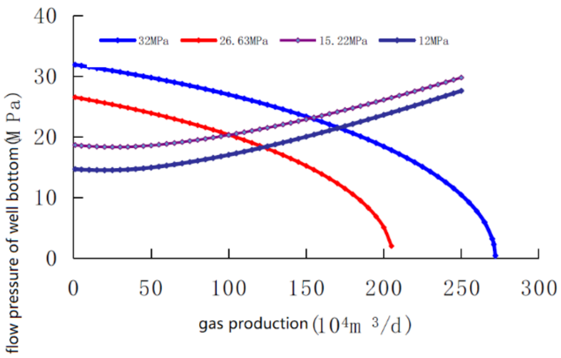

Fig.1-3 maximum production capacity curve of well A Ping 1

According to capacity evaluation of the gas testing and pilot production of well A Ping 2, the inflow and outflow curves of well A Ping 2 are built, and the maximum production capacity of current formation pressure is $130\times10^4m^3/d$ when the wellhead pressure is 12MPa.

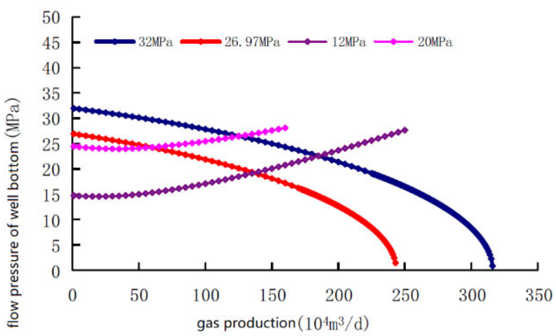

Fig.1-4 maximum production capacity curve of well A Ping 2 well

According to the above capacity analysis, we can see that the increase effect of pilot test horizontal well is obvious, the average daily gas production capacity reaches one million cubic meters, which is favorable for reservoir construction.

3. Pilot Production Evaluation of Pilot Test Well

3.1 Analysis of High-Speed Pilot Production

The pilot test wells of A Ping1 and Ping2 were put into production from August 2020 to the end of April 2022, and the pilot test wells had strong stable production capacity during the pilot production, as shown in Fig.2-1 and 2-2 below.

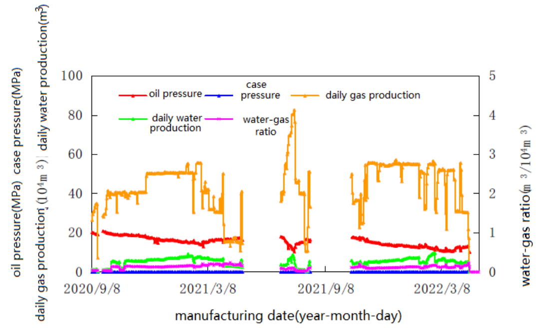

Fig.2-1 pilot production curve of well A Ping 1

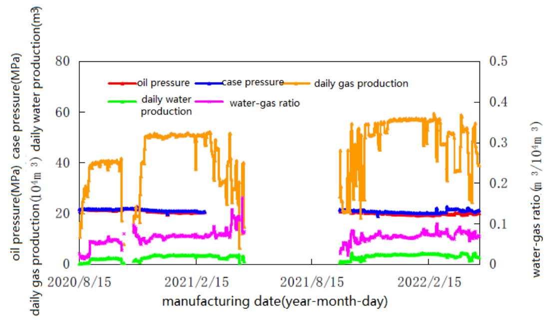

Fig.2-2 pilot production curve of well A Ping 2

The high-speed gas production test was carried out in well A Ping 1 and well Ping 1 in 2021. The production capacity of pilot production of well A Ping 2: the production capacity gradually decreased over time during the pilot production, it generally met the exponential decreasing law; during the medium-speed gas production (40-$50\times10^4m^3/d$), the production capacity was between $100\sim74\times10^4m^3/d$ during the 120-day gas production cycle, decreased by 0.3% every day; during the high-speed gas production ($50\sim83\times10^4m^3/d$), the production capacity was between $90\sim80\times10^4m^3/d$, during 15-day gas production, decreased by 1.1% every day (Fig.2-3).

The production capacity of pilot production of well A Ping: the production capacity gradually decreases over time during pilot production, and generally meets the exponential decreasing law; in the medium speed gas production stage ($40\sim50\times10^4m^3/d$), the production capacity is between $160\sim140\times10^4m^3/d$, decreased by 0.1% every day in 120 days of gas production cycle; the stable production capacity is stronger in comparison with (Fig.2-4).

According to the analysis of the high-speed pilot production, we can see that the increase effect of pilot test horizontal well is obvious, the gas production capacity of horizontal well reaches one million cubic meters, and has the capacity conditions for building storage.

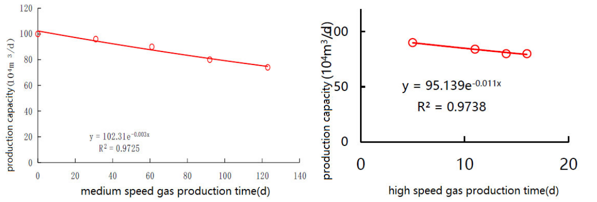

Fig.2-3 evaluation of continuous production capacity of medium-speed and high-speed pilot production in well A Ping 1

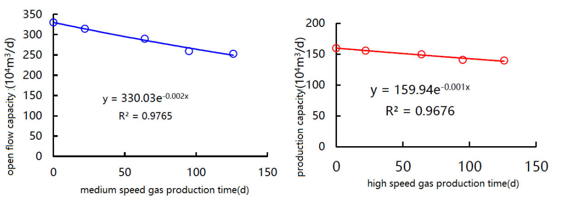

Fig.2-4 evaluation of continuous production capacity of medium-speedand high-speed pilot production in well A Ping 2

3.2 Influence Range of High-Speed Gas Production

The central pressure of the gas layer of the static pressure test of well A Ping 1 is 23.52MPa, and the flow pressure and flow temperature reflect no liquid accumulation in the wellbore above 2570m; the central pressure of the gas layer of the static monitoring of well A Ping 2 is 25.95MPa, and the flow pressure and flow temperature reflect no liquid accumulation in the wellbore above 2400m.

The interpretation results of the old wells in the block suggest that: the influence range of Class I wells is 148 to 447 m, the influence range of Class II wells is 114 to 435 m. The interpretation results of the pilot test wells suggest that: the influence range of well A Ping 1 is 398m, the permeability is 1.028md; the influence range of well A Ping 2 is 420m, the permeability is 8.64md. The influence range of high-speed gas production is generally less than 400 m. (Fig.2-5 to Fig.2-6).

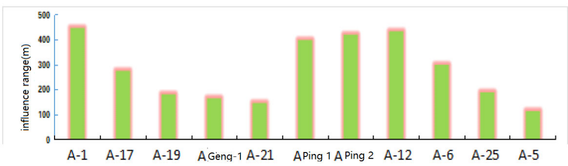

Fig.2-5 distribution of interpretation results of the gas production influence range of old wells and pilot test wells

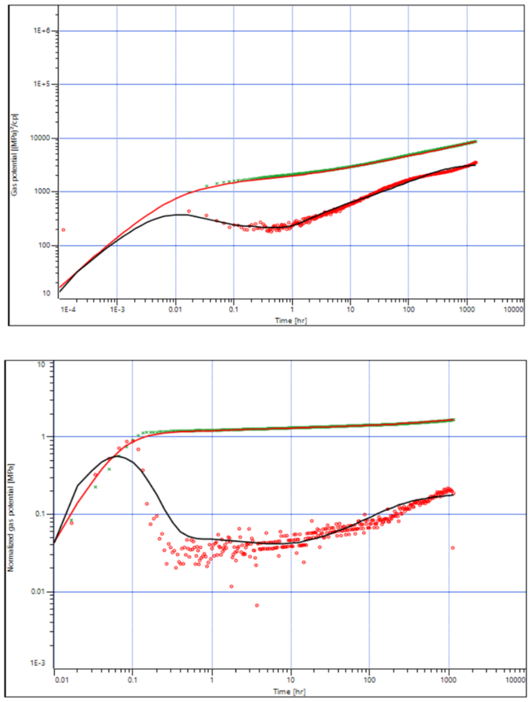

Fig.2-6 double logarithmic curve of pressure recovery of well A Ping 1 and A Ping 2 from April to June 2021

The pressure influence range test of well A Ping 1 suggests that: well A-7 with less than 400m away from adjacent wells is affected, while well A-6 and well A-Ping 1 with more than 400m are not affected. The pressure influence range test of well A Ping 2 suggests that: well A-17, A Geng 2 with less than 400m away from adjacent wells are affected, well A-21 and A-25 beyond this distance are not affected.

4. Capacity Distribution of Different Types of Reservoirs

The gas production section test requires monitoring the production section of long gas production layer, i.e., the perforation section of well is relatively long, and two wells meet the conditions after screening. The depth of perforation section of well A-17 is from 2910m to 2940m the length is 30m, the depth of perforation section of well A Geng-1 is from 2928.4m to 2990.8m, the length is 62.4m, both have condition for testing the gas production section in pilot test.

The gas production section test of well A-17 suggests that: 2938-2940m is the main production layer of the well, production contribution reaches 95%; compare the reservoir type with production contribution: the Class I high-quality reservoir of the well contributes more to the production capacity, as shown in Fig.3-1.

The gas production section test of well A Geng-1 suggests that: the production contribution 2 Class I high-quality section reaches 88%, compare reservoir type and production contribution: Class I high quality reservoir of the well contributes more to the production capacity, as shown in Fig.3-2.

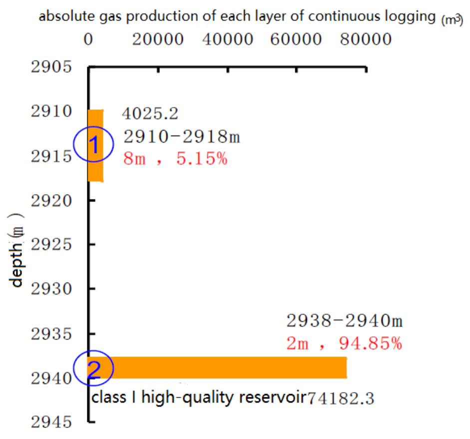

Fig.3-1 gas production section test of well A-17

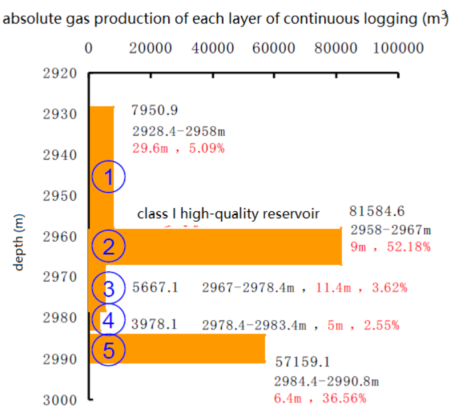

Fig.3-2 gas production section test of well A Geng-1

5. Conclusion

(1) It can be seen that the production capacity of horizontal well is high by analyzing the pilot test horizontal well capacity and maximum production capacity, the increase effect of high-speed gas production is obvious, the gas production capacity is up to one million square meters, and it has the capacity conditions for building reservoir.
(2) The influence range of different types of reservoir gas wells in the block is different, they are generally within 450m, the influence range of high-speed gas production pressure of pilot test wells is mainly within 400m, the overall connectivity of the block is relatively good, which provides favorable conditions for the balanced injection and production of gas storage and efficient operation.
(3) The features of gas production capacity of different types of reservoirs are made clear, Class I reservoirs have good physical properties and large capacity contribution, and Class II and III reservoirs have smaller capacity contribution.

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