IOP Conf. Series: Earth and Environmental Science **153** (2018) 022009 doi:10.1088/1755-1315/153/2/022009

Parameter optimization of gravel packing sand control method for natural gas hydrate production

Jibin He[1, a], Li Yu[2] and Chengming Ye, Xiaojie Li[3]

[1]Center for Hydrogeology and Environmental Geology, China Geological Survey, Baoding, HEBei 071051, china,hejibin123@126.com.

[2]College of civil engineering and architecture, Hebei University, Baoding, Hebei 071002, china.

[3]Center for Hydrogeology and Environmental Geology, China Geological Survey, Baoding, HEBei 071051, china.

[a]hejibin123@126.com.

Abstract. According to the research on the method of sand control for oil and gas wells at home and abroad, it was considered that gravel packing sand control method was an effective sand control method for gas well mining. In order to solve the problem of large amount of sand out for natural gas hydrate production, related problems of difficult sand control, that technology was explored of sand control and optimization method that was suitable for mud sand reservoir of natural gas hydrate production. Based on the low pressure strata in the northern South China Sea area of our country, characteristics of low cementation, it was initially chosen particle size of 0.150-0.200mm sand control gravel through theoretical calculation, through it, the best gravel size range was 0.200-0.250mm and the thickness was 40mm.

1. Introduction

Natural gas hydrate (combustible ice) is a kind of ice-like cage crystalline compound formed by natural gas and water in low temperature and heavy pressure environment. Natural gas hydrate (combustible ice) is a kind of ice-like cage crystalline compound formed by natural gas and water in low temperature and heavy pressure environment. Natural gas hydrate in the sea area is widely distributed in the depth sea of more than 100-250 meters and 400-650 meters (equatorial area) under the deep seabed hundreds to more than 1,000 meters of sediment content. Natural gas hydrates (combustible ice) account for 80% to 99.9% of the methane, which combustion pollution is much smaller than coal, oil and gas, and is abundant in reserves, which is enough for humans to use for 1,000 years. At present, more than 30 countries have carried out or are carrying out the investigation and research work of gas hydrate. In recent years, great progress had been made in mining tests abroad. From the United States, Canada, Germany, India and other countries, different sand control measures had been adopted, all of which have been forced to stop because of serious sand production.

According to the domestic and external research on sand control of gas well, Gravel packing and sieve tube is an effective method of sand control [1-3]. The gravel packing method needed to design the gravel particle size range and thickness, etc, the selection of these parameters was directly related to the success or failure of sand control. Selection of gravel size， commonly used methods at present such as Saucier, Depirester method, Schwartz method and so on [4-6], but these methods were all suitable for more than 0.04 mm of sand control. It was still blank for sand control research that argillaceous siltstone, which phase particles were less than or equal to 0.04 mm and accounts for more than 80 % of the reservoir.

According to the Chinese Sea natural gas hydrate production reservoir condition, the theoretical analysis of the sand control preliminary selection had been carried out.

On this basis, according to the principle of "optimum gas production and minimum sand production", the self designed sand proof physical model test device was used to orthogonal test, the parameters of grain size range and thickness were optimized, which had provided reference for the natural gas hydrate production of sand control. .

2. Analysis of mixed particles pore diameter

According to the composition characteristics of gravel particle, the industrial gravel of a certain gradation was the Granular accumulation body which different from the size of the grain, continuous and gradual. Particle arrangement of xalsonte mainly cube arrangement, random arrangement and trapezoid arrangement, when arranged in a cube formed between the gravel pore (red equivalent circle) maximum as shown in Fig.1 (a) shows, the minimum pore (red equivalent circle) formed in a trapezoid was minimal as shown in Fig.1 (h), the pores formed in random arrangement were between the two, which were shown in Fig.1 (b), (c), (d), (e), (f).

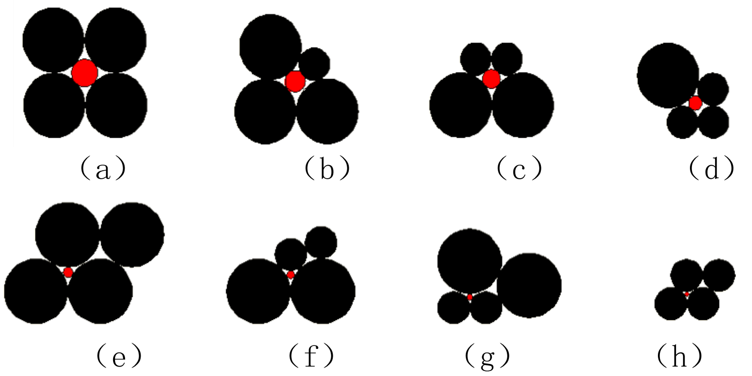

Fig.1 gravel particles arrangement

For the convenience of theoretical calculation, filling gravel with certain gradation was divided into two adjacent grades, and assumed all the particles are spheroids, the mean diameter of large scale was D_M, and the mean size of small classification was D_m. it obeyed uniform distribution after compacted filling and completion, the arrangement of gravel accumulation was shown in Fig.1. Black was gravel and red was inner cut pore. As shown in Figure 1, the arrangement of Fig.1 (a) was cube sphere arrangement for the classification of particles, which pore sphere particle size d_a was the largest and saw Formula 1.

Gravel packing cube arrangement as shown in Figure 1 (a), the formula (1) for pore diameter calculating was as follows:

$$D_M = 2.414 d_a\text{；}\ D_m = 2.414 d_a \qquad (1)$$

Gravel packing cube arrangement as shown in Figure 1 (e) and (h), the formula (2) and (3) for pore diameter calculating was as follows:

$$D_M = 6.463 d_e \qquad (2)$$

$$D_m = 6.463 d_h \qquad (3)$$

Gravel packing cube arrangement as shown in Figure 1 (f) and (g), the formula (4) and (5) for pore diameter calculating was as follows:

IOP Conf. Series: Earth and Environmental Science **153** (2018) 022009 doi:10.1088/1755-1315/153/2/022009

$$D_m = \frac{\frac{D_M}{D_m} - 1 + \sqrt{\frac{2D_M}{D_m} + 1}}{\frac{D_M}{D_m} + 1 - \sqrt{\frac{2D_M}{D_m} + 1}} d_f \quad (4)$$

$$D_m = \frac{1 - \frac{D_M}{D_m} + \sqrt{\frac{2D_M}{D_m} + \frac{D^2{}_M}{D^2{}_m}}}{\frac{D_M}{D_m}(1 + \frac{D_M}{D_m} - \sqrt{\frac{2D_M}{D_m} + \frac{D^2{}_M}{D^2{}_m}})} d_g \quad (5)$$

The arrangement method (b), (c) and (d) were the random arrangement of the large and small graded pellets, and the corresponding pore sphere particle size was $d_b > d_c > d_d$ .The arrangement pattern (e), (f) and (g) were the arrangement of large graded particles and the trapezoid of large and small graded spheres， and the corresponding pore sphere particle size was $d_e > d_f > d_g$.The arrangement *h* was the arrangement of the equal spheroid trapezoids with small graded particles and the corresponding pore sphere particle size d_h was the smallest.

By comparing the equivalent particle size of the tangential circle in the pore, it could be obtained that relationship between big size and small size of gravel pore diameter was as follow:

$$d_a > d_b > d_c > d_d > d_e > d_f > d_g > d_h$$

It was considered that the particle size of the mixed gravel was continuous and gradual change, and the large graded particle number was far greater than the small. it was also considered that the gravel in the construction was uniform mixing and compacted filling, so the gravel particles arrangement was mainly shown in the form of Figure 1 (f) and (g). Therefore, it was based on the characteristics of particle size composition. In the case of Figure 1(f) and (g), the stacking gravel particles arrangement was calculated and analyzed，the influence regular pattern was obtained for median particle size ratio of adjacent graded particles to pore diameter of gravel particles size.

It was assumed that the median particle size ratio of the adjacent size classification was as follow:

$$D_M / D_m = C \quad (6)$$

It was arranged the formula form (6) substituted (4) and (5):

$$\frac{D_m}{d_f} = \frac{C - 1 + \sqrt{2C + 1}}{C + 1 + \sqrt{2C + 1}} \; ; \; \frac{D_m}{d_g} = \frac{1 - C + \sqrt{2C + C^2}}{C(1 + C - \sqrt{2C + C^2})} \quad (7)$$

Formula (7) was to consider the composition of particle size, conglomerate granular accumulation of certain gradation, that was the quantitative mathematical relation between the median grain diameter ratio of adjacent graded gravel and the size of gravel accumulation pore diameter, the influence rule was shown in Figure 2.

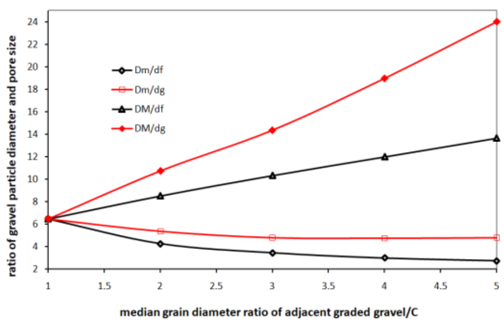

Fig.2 the influence rule of particle size ratio of mixed gravel particles on pore size of gravel particles

As shown in Figure 2, with the increase of the median ratio C in farticle size of adjacent graded boulders, The ratio between median diameter of small graded gravel and gravel accumulation pores tended to decrease to stability. But the ratio between median diameter of big graded gravel and gravel accumulation pores tended to linear enlargement. Therefore, the critical value 3 was used to be the median particle size of adjacent graded particles, the following formulas were obtained for the linear regression analysis of graph 2.

When 1 ⩽ C < 3, the quantitative relationship between large and small grade of particle size and particle accumulation pore was as follows:

$$\frac{D_M}{d_g}=3.18C+2.28;\frac{D_m}{d_g}=\frac{3.18C+2.28}{C} \quad (9)$$

When C ⩾ 3, the quantitative relationship between large and small grade of particle size and particle accumulation pore was as follows:

$$\frac{D_M}{d_g}=3.86,\ \frac{D_m}{d_g}=3.86C \quad (10)$$

According to the above formula, the pore size was calculated under the tight arrangement of the mixed particle size. According to experience, the pore was approximately equal to 3 times the pore throat. As shown in Table 1, the size of the mixed gravel could be selected directly in the case of the medium value of the known reservoir granularity, and the pore distribution and the median of the particle size was list when 1⩽C<3. Similarly, the loose arrangement could also be calculated.

Table 1 calculation range of sand mixing theory for mixed gravel size

standard sieves	particle diameter (mm)	Median grain size (mm)	Combined particle size	C= D_M/D_m	1≤C<3 *da* (mm)	1≤C<3 dg (mm)	particle size of the sand control (mm)
3~4	6.73~4.75	5.74	D_M	1.414	2.378	0.599	0.793~0.20
4~6	4.75~3.35	4.06	D_m				
6~8	3.35~2.39	2.87	D_M	1.311	1.189	0.340	0.396~0.113
8~10	2.39~2.01	2.19	D_m				
10~30	2.01~0.58	1.3	D_M	2.6	0.539	0.047	0.18~0.016
30~40	0.58~0.42	0.5	D_m				
40~50	0.42~0.30	0.36	D_M	1.286	0.149	0.044	0.050~0.015
50~60	0.30~0.25	0.28	D_m				
60~70	0.25~0.21	0.23	D_M	1.045	0.095	0.039	0.032~0.013
70~80	0.23-0.20	0.21	D_m				

3. conclusion

In this paper, through theoretical analysis, the sand control gravel particle size for sand control had been chosen by 60-80 mesh (0.20~0.25 millimeter), which provided a reference for the production of natural gas hydrate.

Acknowledgement

The support by Center for Hydrogeology and Environmental Geology, China Geological Survey, Baoding, Hebei 071002,china, hejibin123@126.com, with source of funding: Center for Hydrogeology and Environmental Geology, China Geological Survey-"Project implementation and resource pilot production of natural gas hydrate in sea area", "Sand control numerical simulation for project implementation and resource pilot production of natural gas hydrate in sea area", and the project of "one province one school" in Hebei Province.

Reference

[1] wang lihua, Lou shan, deng jinghong, ma xiaoyong, Chen yu. Optimization of sand control method in shallow and shallow gas fields [J]. Oil drilling technology, 2013, (01) : 98-102.
[2] Deng jinghan, li ping, zhou jianliang, he baosheng, Chen shenghong, wang lihua. The optimal sand control method for sand blasting in China's offshore porous sandstone [J]. Journal of petroleum, 2012, (04) : 666-680.
[3] Deng jinghen, zheng xun, yan xinjiang, liu shujie, lai xiang-dong, Chen zijian, Lin hai. Research on the optimization of sand control scheme in deep-water field [J]. Block oil field, 2012, (03) : 382-385
[4] Dong changyin, feng shengli, li hongxia, ji wenjing, Yang jiuju. Analysis, improvement and application of the design method of gravel size of the julester. [J]. Oil drilling technology, 2008, (05) : 80-84.
[5] Dong changyin, wang bin, li zhifen, deng shan, zhang qi. Schwartz: the analysis, improvement and application of gravel size design methods [J]. Oil drilling technology, 2008, (03) : 77-80.
[6] Dong changyin, zhang qi, sun wei, wang Ming. Optimization design of sand control process parameters for gravel packing [J]. Journal of China petroleum university (natural science edition), 2006, (05) : 57-61