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Gas production channel unplugging technology of production well based on chemical washing

Yi Shi[1,*], Di Gao[1,2,3], Di Chen[1]

[1]*College of Resources and Environment, Henan Polytechnic University, Jiaozuo, 454003, China*
[2]*Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing, 102249, China*
[3]*Collaborative Innovation Center of Coal Work Safety and Clean High Efficiency Utilization, Jiaozuo, Henan, 454003, China*
[*]*Corresponding author*

Abstract: *The pollution of drilling fluid and the blockage of coal powder during the drilling and production of coalbed methane well will cause pollution in the near well area, reduce the permeability of coal seam, and even completely block, resulting in the failure of gas production. Therefore, it is necessary to find scientific and reasonable plugging measures, effectively communicate micro-cracks and cracks, and form gas production channels. According to the blockage types of mud pollution, water seal, water + rock seal and so on, a chemical well washing and plugging removal process is proposed, which can achieve good plugging removal effect.*

Keywords: *Chemical well washing; Drilling fluid pollution; Production well*

1. Introduction

Type of gas production channel blockage in production well

1.1 Drilling mud pollution

During the drilling process of coalbed methane well, drilling fluid will invade coal reservoir under the action of pressure difference, which first leads to the expansion of clay minerals in the reservoir and occupies the natural pores and fractures in the coal reservoir. Subsequently, drilling fluid penetrated into the internal structure of coal reservoir, causing the Poisson's ratio and compressive strength of coal seam to decrease until disappearing [1]. When the flow and migration of solid components such as clay and plugging materials are narrowed or the flow velocity is reduced, single or multiple particles are blocked at the pore throat, blocking the migration channel of coalbed gas. Liquid phase formation will cause clay minerals in coal reservoirs to expand in contact with water, and scale will occur when the compatibility with coal seam water is not good. In addition, due to the existence of capillary resistance, the filtrate is difficult to be dislodged by small reservoir pressure flooding, thus causing water lock damage and blockage [2]. Secondly, the intrusion of polymer mud into coal seam will cause flocculation and blockage of clay due to adsorption of polymer and expansion and blockage of clay due to carboxyl hydration. A small number of colloidal particles may enter the matrix pores of coal seam and form blockage, affecting the desorption, diffusion and migration of gas [3]. Thirdly, the study area is mostly structural coal, and more primary coal powder is generated during drilling construction, which enters the coal reservoir with drilling fluid and blocks the primary porosity and fracture system of the coal reservoir, thus reducing the porosity and permeability of the coal reservoir and causing blockage [4]. Finally, pore deformation of coal reservoir has the characteristics of plastic deformation, and reservoir cracks will close to a certain extent under pressure difference, and it is difficult for cracks to recover and open during pressure relief after closure, resulting in blockage, as shown in Figure 1.

1.2 Cement slurry

The cement slurry will invade the coal reservoir with fractures, and the cement slurry and its filtrate will also invade the coal reservoir along the fractures under the action of pressure difference. The degree of intrusion changes with the development of fractures and pores, and the more developed the fractures and pores, the higher the degree of intrusion [5]. The cement slurry invading the coal core fills in the

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cracks and pores, and gradually solidifies in the cracks, and closely covers the surface of the coal core, seriously blocking the flow channel of coalbed methane. If the cracks are not closed but continue to extend, the cement slurry can continue to invade the deep part of the coal core along the cracks, causing more serious blockage. After the cement slurry is invaded, it is hydrated and solidified to fill the internal pores of coal and rock tightly and fully cement the coal and rock matrix, which greatly improves the compressive strength of coal and rock, and the solidified cement product is difficult to acid decompose [6].

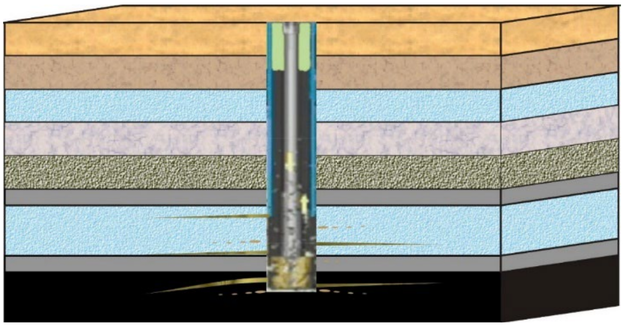

Figure 1: Schematic diagram of reservoir contaminated by drilling mud

2. Chemical well washing

2.1 Chemical well washing technology

Chemical well washing is a process in which chemicals are pumped into the wellbore to dissolve and disperse pulverized coal and scale, and dredge gas production channels (Figure 2). Generally using pickling method, acids are mainly divided into two categories, respectively, organic acids and inorganic acids. Inorganic acids include hydrochloric acid, hydrofluoric acid, fluoroborate acid, phosphoric acid, etc. Organic acids include formic acid, acetic acid, etc. In order to ensure the unblocking effect, some additives that can change the physical or chemical properties of the acid are often added to the acid system, and the commonly used acid additives mainly include corrosion inhibitors, drainage AIDS, resistance reducing agents, viscosifiers, anti-emulsion demulsifiers, anti-swelling agents, retarding agents, etc. [7]. With the help of the additives, the dissolution effect of the acid solution on the blockage will be further improved, and the unplugging effect will be better. Before acid plugging removal, the characteristics of blockage and formation rocks and regional pressure distribution should be analyzed to determine the chemical composition of the blockage, test the actual reaction in the acid plugging solution, calculate and judge the invasion depth of the residual acid solution into the formation, and simulate the reaction mechanism type of acid solution on blockage and rock. Avoid the infiltration slip caused by the precipitation of regenerated minerals.

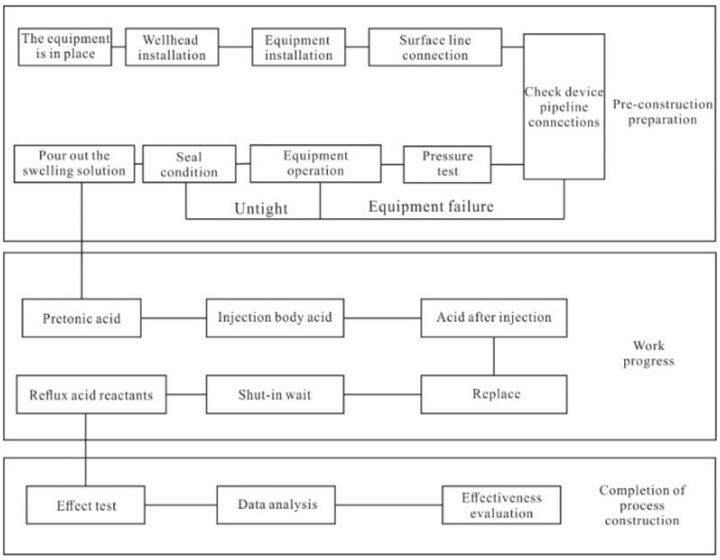

Figure 2: Chemical well washing process flow chart

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When the acid dissolves the blockage, the specific acid solution is injected into the blockage location, and without the help of external agitation, the acid solution will react with various scales and dissolve it in the liquid. In addition, with the help of positive and negative circulation, the transfer rate of active acid is appropriately increased, and the dissolution efficiency of the clogging substance is accelerated. During pickling, pipeline coatings, paraffin, asphalt and other substances do not dissolve in acid. In order to prevent these insoluble impurities from plugging hole cracks again after other scale dissolves, the pickling flowback speed should be controlled to avoid damage to the reservoir caused by acid solution.

2.2 Chemical well washing experiment

2.2.1 Sample taking

According to the characteristics of strata and rock powder in the study area, acidizing experiments were carried out to test the permeability before and after core pollution and before and after acid dissolving plugging. The samples were taken from the coalbed methane well core (Table 1, Figure 3) of Shoushan No. 1 mine in Pingdingshan Mountain, and the mud was taken from the construction site (Figure 3-B, Figure 3-C).

Table 1: Sample collection table for acidification experiment

Sample number	Top depth(m)	Bottom depth(m)	lithology	Sampling depth(m)
SY-80	560.83	563.13	Fine sandstone	562.00
SY-78	569.09	575.57	Argillaceous siltstone	574.41

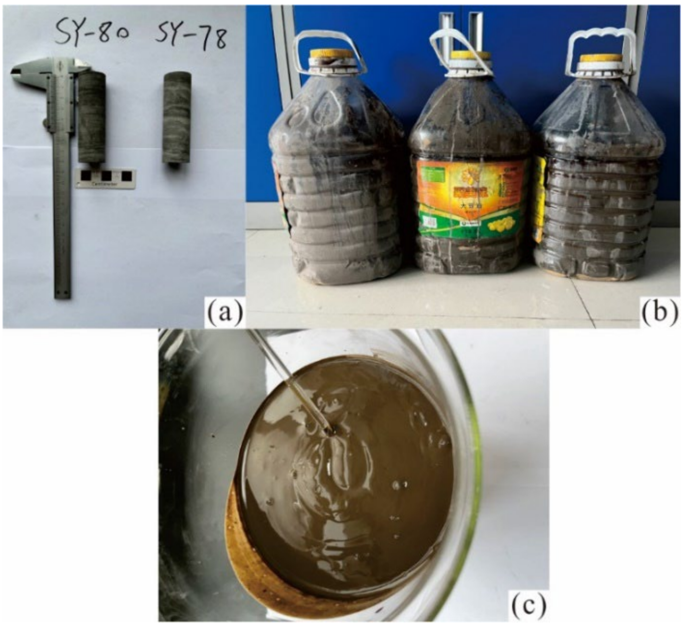

Figure 3: Acid plugging test sample (a: core sample; b, c: mud taken on site)

2.2.2 Sample preparation

The rock samples in this experiment were all core Wells, and the 25mm×50mm cut pipe was used in the laboratory to drill along the vertical bedding direction to ensure that the original physical properties of the rock samples were not damaged. In the process of sample preparation, keep the slow and uniform speed of drilling, and smooth the initial sample after drilling to ensure that the smoothness of the rock sample is less than 0.02%. Then the prepared rock samples were stored in a closed dry space to avoid other factors affecting the experiment.

2.2.3 Acid preparation

37%HCl, 40%HF and pure acetic acid were used to prepare the acid solution. Combined with previous research results [8], the ratio of acid solution in this conFigureuration was: HCl: HF: CH_3COOH = 3:9:4. To prepare the acid solution of 3%HCl+9%HF+4%CH_3COOH with volume V, the volume of HCl, HF and CH_3COOH shall be:

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$$\text{HCl:}\ V_{HCL}=\frac{V\times\rho_V\times3\%}{\rho_{HCL}\times37\%} \tag{1}$$

$$\text{HF:}\ V_{HF}=\frac{V\times\rho_V\times9\%}{\rho_{HF}\times40\%} \tag{2}$$

$$CH_3COOH\text{:}\ V_{HAC}=\frac{V\times\rho_V\times4\%}{\rho_{HAC}\times100\%} \tag{3}$$

$$V_{water}=V-V_{HCl}-V_{HF}-V_{HAC} \tag{4}$$

Where, V_{HCl}, V_{HF}, V_{HAC} and V_{water} are respectively the volumes of HCl, HF, CH_3COOH and water; 3%, 9% and 4% were HCl, HF and CH_3COOH concentrations, respectively. The densities of HCl, HF and CH_3COOH, respectively; V is the configured acid volume; For the configuration of acid density. After calculation =1.04g/ml

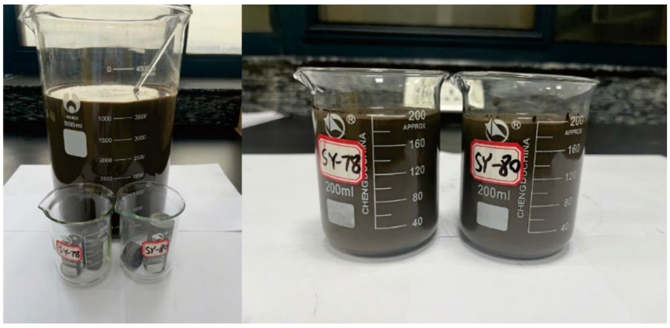

Figure 4: Mud contamination experiment

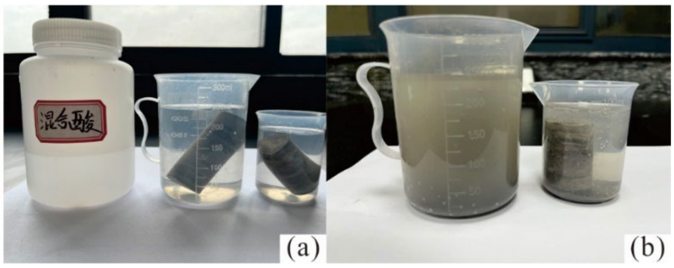

Figure 5: Acidification experiment (left picture just soaked, right picture soaked for 12 hours)

After mud contamination experiment (Figure 4) and indoor acidification experiment (Figure 5), the change characteristics of sample size and quality before and after are shown in Table 2.

2.2.4 Permeability measurement

A measuring device for pore permeability and adsorption of briquette samples of HB-2 was used in the experiment. Using Boyle's law and Darcy's law of steady flow, the porosity, permeability and stress-strain of samples under different conditions can be measured.

Generally speaking, effective stress refers to the difference between the ground stress acting on coal rock strata and the fluid pressure existing in pores or cracks. The effective stress in the experiment is described by the average effective stress, and the effective stress in the experiment is described by the average effective stress [9], that is

$$\sigma_e=\frac{1}{3}(\sigma_a+2\sigma_r)-\frac{1}{2}(P_1+P_2) \tag{5}$$

Where: and 0.1MPa is taken from the test pressure (MPa) at the inlet and outlet of coal sample respectively; Axial pressure (MPa); Is the circumferential pressure (MPa).

3. Test results

According to the experimental results, mud pollution has a greater impact on fine sandstone, and the permeability decreases by 50% from 0.07887mD to 0.03942mD. The permeability of argillous siltstone decreased from 0.10825mD to 0.02897mD, a decrease of 26.8%. Acid plugging removal shows that the plugging removal effect of fine sandstone is more obvious, increasing from 0.03942mD to 3.6432mD, an increase of 92.4 times, and the permeability of argillous siltstone increases from 0.02897mD before

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acidification to 0.40409mD, an increase of 13.9 times (Table 3, Figure 9). In addition, the solubility of fine sandstone is 14.8%, and the solubility of argillous siltstone is 11.5%. The relationship between the mean effective stress, confining pressure and permeability of the initial sample, the sample after mud contamination, and the sample after acidification is shown in Figure 6-8.The results show that the effect of acid on plugging removal is obvious, especially for the lithology with larger grain size.

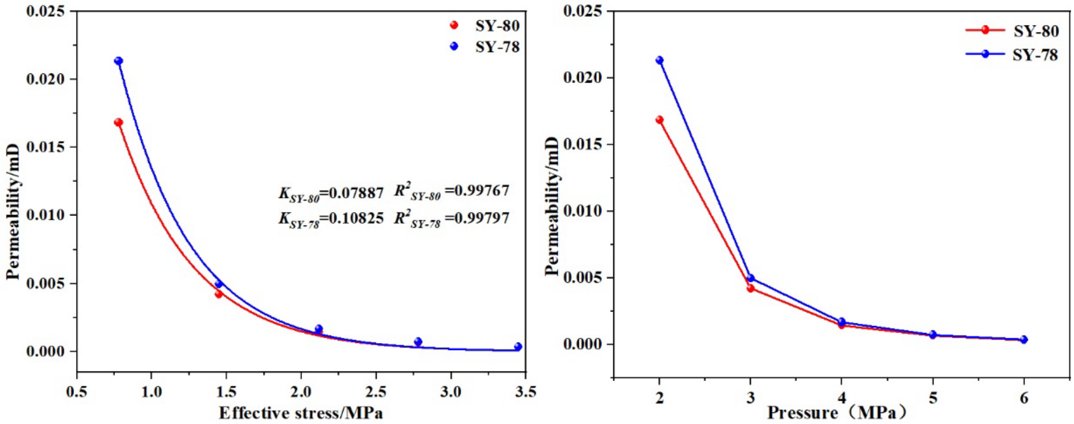

Figure 6: The relationship between the mean effective stress and confining pressure of the initial sample and the permeability

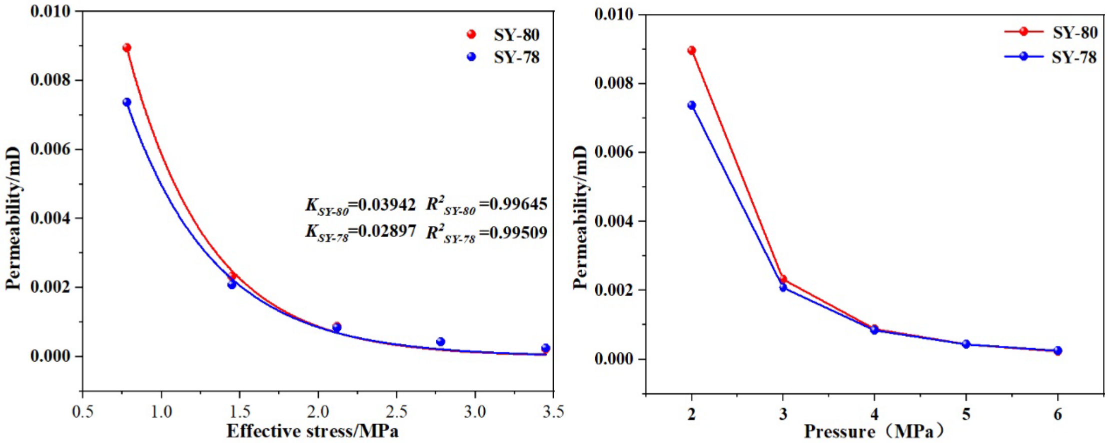

Figure 7: The relationship between mean effective stress and confining pressure and permeability after mud contamination

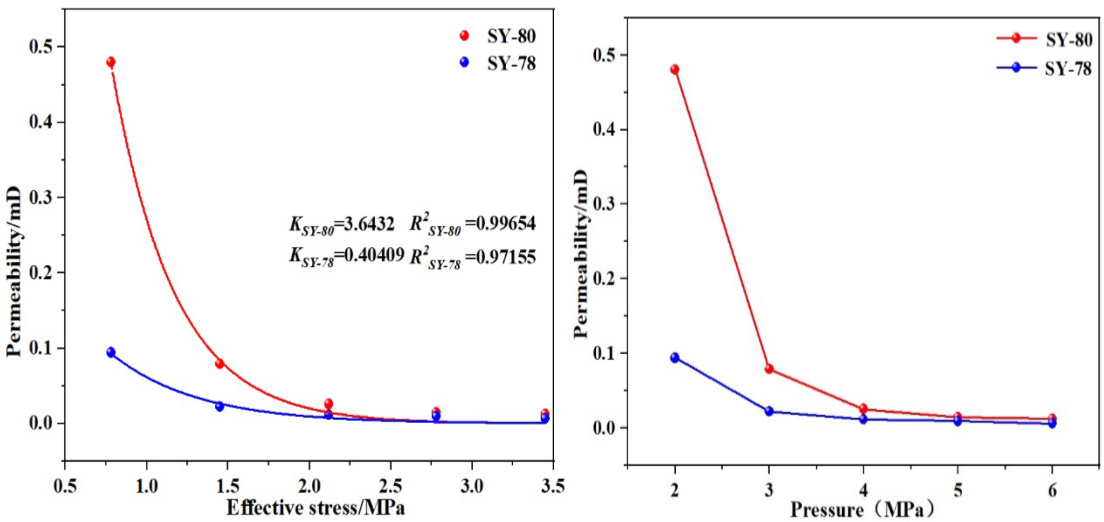

Figure 8: Relationship between mean effective stress, confining pressure and permeability of acidified samples

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Table 2: Characteristics of sample size and quality changes before and after acid leaching

Sample number	Pre-acid quality/g	Length before soaking/cm	Quality after acid immersion/g	Length after soaking/cm
SY-80	82.87	6.40	70.61	6.30
SY-78	56.41	4.35	49.92	4.26

Table 3: Permeability variation characteristics of chemical plugging test

Sample number	Permeability(mD)		
	Original sample	Post-mud contamination	post-acidizing
SY-80	0.07887	0.03942	3.6432
SY-78	0.10825	0.02897	0.40409

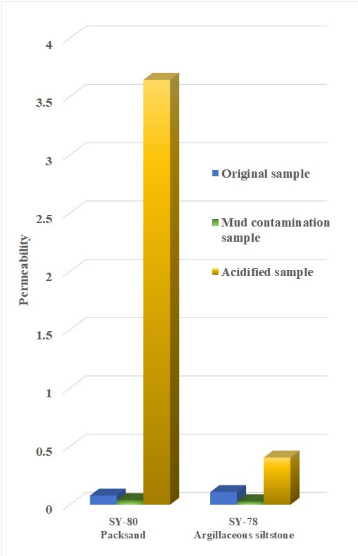

Figure 9: Variation of sample permeability before and after mud contamination and acid removal plugging

4. Conclusions

(1) Chemical well washing technology can effectively solve the problem of reservoir permeability polluted by mud. The acid ratio configured in this chemical well washing scheme is as follows: HCl: HF: CH_3COOH =3:9:4, after 12 hours of full reaction between mud polluted rock sample and acid solution, it has a good acidizing and dissolution effect on fine sandstone and muddy siltstone polluted by mud.

(2) For fine sandstone, mud pollution has a greater impact on its permeability, which decreases by 50% from 0.07887mD to 0.03942mD; The permeability of argillous siltstone decreased from 0.10825mD to 0.02897mD, a decrease of 26.8%.

(3) Acid plugging removal shows that the plugging removal effect of fine sandstone is more obvious, increasing from 0.03942mD to 3.6432mD, an increase of 92.4 times. The permeability of argillaceous siltstone is increased from 0.02897mD before acidification to 0.40409mD, an increase of 13.9 times. In addition, the solubility of fine sandstone is 14.8%, and the solubility of argillous siltstone is 11.5%. The results show that the effect of acid on plugging removal is obvious, especially for the lithology with larger grain size.

(4) According to the types of blockage existing in mud pollution, water seal, water + rock seal, etc., a chemical well washing and plugging removal process is proposed, which can achieve good plugging removal effect.

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