Study on Drainage Technology of Hydraulic Fracturing plus Aggregate Anti-reflection

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Abstract. For hydraulic fracturing in the deep geological conditions, crack closure, the present situation of the extraction effect is poor, developed including mixed bone bunker and together with bin, hydraulic fracturing and aggregate equipment, formed the construction technological process, in a typical low permeability coal seam pan three mine of huainan mining area for the practical application, has made significant technical effect: after fracturing of coal seam permeability coefficient increased by 13.31 times, anti-reflection regional standard extraction time is not anti-reflection reduce 26d.

1. Introduction
Increase the permeability of coal seam has become improve mine gas extraction of key technical problems, the hydraulic fracturing technology has proven to be coal and rock mass structure, increase the permeability of coal seam, improve the effect of coal seam gas extraction of effective technical way, it has a wider range of influence, the advantages of the anti-reflection effect is remarkable, is a kind of widely used in low permeability coal seam anti-reflection technology [1]. However, the fractures formed by conventional hydraulic fracturing technology will gradually close under the action of in-situ stress and rock mass, blocking the gas migration channel of borehole, shortening the duration of hydraulic fracturing construction effect and reducing the technical advantages of hydraulic fracturing. Adding proppant into fracturing fluid can effectively prevent fracture closure, ensure the effect of hydraulic fracturing and improve the efficiency of drilling gas extraction.

2. Technical principle
Hydraulic fracturing plus aggregate fracturing is a process in which high pressure pumps are used to inject fracturing fluid into the formation. When the injection pressure is greater than the formation fracture fracturing, the coal formation is forced open and fractures occur. At this point, the sand-carrying fluid with proppant will be injected into the fracture. After the sand-carrying fluid enters the fracture, on the one hand, it can make the fracture continue to extend [2], and on the other hand, it can support the cracked fracture without closing [3]. After the pump is stopped, the proppant plays a supporting role on the fracture, and one or more sand-filled fractures are left in the coal layer, which can increase the
permeability of the coal seam, so that the gas near the hole wall and even the far distance can be smoothly transported to the borehole, so as to improve the drilling gas extraction efficiency and shorten the extraction time. According to the characteristics of hydraulic sanding fracturing technology, the fracture propagation process of hydraulic sanding fracturing in underground coal mine usually includes the preparation stage, fracture generation stage, fracture propagation stage and fracture filling stage [4].

In the process of sanding fracturing, the fracturing fluid is divided into three parts according to the different functions played at different construction stages (Fig. 1): preposition fluid, sand-carrying fluid, and displacement fluid. The pre-fluid is the precondition to make the formation fracture and form a certain scale fracture for the subsequent sand-carrying fluid to enter, and it also plays the role of cooling and enhancing efficiency. The sand-carrying fluid is used to bring proppant into the established fracture. The displacement fluid is used to deliver the sand carrier fluid to a predetermined location. After the sand carrier fluid is injected, all the sand carrier fluid in the wellbore is replaced in the fracture. In hydraulic fracturing fracture have been placed by adding proppant can effectively delay fracture closure, provides the effective channel for the gas flow, mainly embodied in the following two aspects:

1. hydraulic fracturing and high pressure water forced the eme occurred damage fracture as the main gas flow, but due to the fracture surface is not smooth, as the accumulation of the pulverized coal easy to fracture channel congestion. The addition of proppant can polish the hydraulic fracturing fracture wall to form a smooth channel, which provides guarantee for the replacement fluid to deliver the sand-carrying fluid to the predetermined position in the later stage. Hydraulic fracturing plus proppant is also the main body of fracture diversion channel, and it also has the function of delaying fracture closure and providing reliable time guarantee for gas extraction.

2. Primary fractures in coal seams and the micro-fracture network formed by hydraulic fracturing pressure water are important components of gas flow channels. However, microcracks have the characteristics of "width" and "easy closure". In the process of hydraulic sanding fracturing, proppant can fully enter the micro-fracture network, which plays an important role in delaying the closure of micro-fracture. Therefore, it can be seen that hydraulic fracturing plus proppant plays an important role in delaying fracture network (micro fracture network and main fracture network), and hydraulic sanding fracturing for broken soft coal seam is a necessary process, which can also effectively reduce the cost and shorten the engineering cycle. Therefore, hydraulic sanding fracturing of broken soft coal seam has a good prospect of engineering application.

3. Hydraulic fracturing and aggregate equipment
The hydraulic fracturing aggregate device mainly includes two parts: the mixed bone silo and the bone-carrying silo, which are controlled by the valve group. The working principle of the device is controlled by pneumatic valve group, forming the directional rapid flow of fracturing fluid, impact the mixed bone silo chamber, forming turbulent flow, so as to realize sand mix. The high-pressure waterway is divided into two ways, one into the bone mixing silo and the other into the bone carrying silo. The high-pressure water flow into the bone-carrying silo is used for sand mixing, and then the high-pressure water carries the proppant into the bone-carrying silo for further mixing and evenly entering the fracturing pipeline.
and injecting into the fracturing borehole. The device design is shown in Fig 2. See Fig 3 for the actual device.

![Fig. 2 Design of liquid flow impact type sand mixing device](image)

![Fig. 3 Physical drawing of aggregate adding device](image)

4. Technology

4.1. Overall process technology

High pressure hydraulic fracturing fluid is provided by fracturing pump. After the aggregate is evenly mixed in the aggregate tank, it enters the drilling hole through the high pressure manifold and fracturing pipe for fracturing with proppant. After the single aggregate fracturing is completed, the orifice valve group is closed to maintain pressure through the remote control device of the high pressure gate valve. Open the pressure relief valve of the aggregate tank. After pressure relief, add the designed aggregate amount, open it through the remote valve control switch, and open the pump set for circulating proppant fracturing. Through the high pressure solenoid valve and the remote pump operating system, the remote, controllable and quantitative aggregate injection fracturing construction can be realized to ensure the construction safety, ensure the ratio of fracturing fluid and aggregate injection, and improve the anti-reflection effect of fracturing. The specific technological process is shown in Fig 4.

The specific construction process includes the following steps:

(a) firstly determines the underground aggregate fracturing construction location, completes the design of drilling trajectory, and carries out drilling construction through downhole field investigation,
design of fracturing site structure development, coal reservoir characteristics and other factors analysis, combined with the production demand of mining replacement.

(b) The secondary hole sealing technology of "one plug and two injection" cement mortar is used to seal the fracturing hole (Fig.5), and the overall fracturing design is carried out according to the actual size of the drilling hole and other parameters.

(c) connected downhole and aggregate fracturing equipment system, and tested the pump group, in the process of running monitoring fracturing construction drilling and coal wall, anchor rope, roadway and adjacent drilling field whether there is leakage happens, if not present leaking water, such as drilling pump injection pressure continues to rise, show that drilling hole sealing qualified, next fracturing operation can be performed.

Fig. 4 Hydraulic fracturing and aggregate construction process flow

(d) Perform pre-fluid (clear water) fracturing. During the fracturing process, monitor the pressure change at all times, identify the moment of coal seam rupture and record it.

(e) When the fracture pressure of the borehole is regular (the pressure is significantly reduced), the construction of aggregate is started. During the construction process, the pressure is monitored and the construction borehole is near the coal wall and whether there is water in the borehole, etc.

(f) When the fracturing fluid and proppant meet the design requirements and the pressure does not fluctuate significantly, the fracturing with aggregate shall be stopped and the replacement fluid shall be added for construction. When the replacement fluid meets the design requirements, the construction shall be stopped.
4.2. The holding technology
After the end of the crack, if the drainage is direct, because of the high water pressure and large gas accidents are easy to occur, at the same time, when the drainage is under high pressure in the hole, it is easy to cause hole collapse, hole plugging and other problems, affecting the effect of gas extraction. The pressure holding process in the hole is also the process of restoring the balance between the injected pressure and the ground stress, and the injected water diffuses continuously to displace the gas. Fractures have a comprehensive process of extension, expansion and partial closure. Therefore, pressure retaining measures should be taken after the end of fracturing. Generally, pressure retaining measures should be taken for 7d. The specific period should be determined according to the change of orifice pressure. When the pressure in the hole is reduced to or close to the gas pressure, the holding pressure is stopped.

4.3. Drainage technology
After the pressure holding work, drainage shall be carried out through the orifice valve group, and the blowout preventer shall be installed and the drainage volume shall be controlled.

4.4. Fracturing fluid injection technology
Fracturing fluid injection is the key to the success or failure of the anti-reflection technology of hydraulic fracturing. It is the premise to ensure the development of coal seam fractures and the passage, transportation and delivery of proppant along the fractures. Its fracturemaking ability and proppant carrying performance are the guarantee of anti-reflection effect of fracturing. In the process of fracturing, the fracturing fluid is divided into three parts according to the role of different construction stages: preposition fluid, sand-carrying fluid and displacement fluid. The prefluid is the premise of fracturing the formation and creating a certain scale of fractures for the subsequent entry of sand fluid, which has the effect of cooling and enhancing efficiency. The sand-carrying fluid carries the proppant into the established fracture and into a predetermined location. The displacement fluid is used to deliver the sand carrier fluid to the predetermined location. After the sand carrier fluid is injected, all the sand carrier fluid is replaced in the fracture.

5. Application effect
Pan-san coal mine of Huainan Mining Group is a typical coal and gas outburst type mine. The main coal seams are 13-1 and 11-2 coal seams of Shangshihezi formation, which are both coal and gas outburst seams. According to the existing data collection and investigation, there have been 14 coal and gas outburst accidents in the mining area since the construction of the mine, and 13 of them occurred in the 13-1 coal seam. According to the mine gas, coal seam in the 13-1 gas permeability coefficient is 0.013~0.022(m²/MPa²•d), 600 m deep area of coal seam gas content is 5.90~10.51m³/t, the gas pressure is 1.05~3.80MPa, the f value was 0.52 on average, the lowest 0.26, belong to typical soft, low permeability, gas coal seams, difficult to drainage [5]. In order to solve the existing drainage technical problems of 13-1 coal seam in Pan-san coal mine area, Pan-san coal mine
has carried out engineering test research on perforating borehole hydraulic fracturing and aggregate anti-reflection technology in 17102 (3) working face.

The drilling hydraulic fracturing and aggregate anti-reflection technology of soft and low permeability coal seam is implemented in the -817m east wing track roadway, which is located in the 13-1 coal floor, 35~42m away from the 13-1 coal seam method, and 55m (horizontal distance) of 17102(3) transport lane. The horizontal section of borehole layout is shown in Fig. 6.

In 17102(3) working face, a total of 25 drilling holes in the -817m east wing track roadway were hydraulic fracturing and aggregate anti-reflection. The average single hole was pressed into 230m³, among which the largest single hole was Y1 pressed into 312m³ in drilling site # 41. The aggregate size is 60~80 mesh, 20~40 mesh and 10~20 mesh. The maximum single hole is 35# drilling field Y7 and 20~40 mesh quartz sand 240kg, and the average single hole is 135kg.

![Borehole layout drawing of hydraulic fracturing and aggregate reflection improvement through bed drilling](image)

**Fig. 6** Borehole layout drawing of hydraulic fracturing and aggregate reflection improvement through bed drilling

The permeability coefficient of coal seam in the affected area affected by hydraulic fracturing and aggregate anti-reflection is up to 0.173m²/(MPa²·d), the permeability coefficient of original coal is 0.013m²/(MPa²·d), and the permeability coefficient of coal seam is increased by 13.31 times after fracturing. According to the investigation of hundred-hole pumping pure volume in the fractured area and unfractured area, the average hundred-hole pumping pure volume in the unfractured area is 1m³/min and the average hundred-hole pumping pure volume in the fractured area is 2.3m³/min one month after the completion of drilling operation, and the hundred-hole pumping pure volume in the fractured area has good stability (Fig. 7). The extraction time to reach the standard in the anti-reflection area is 26d less than that in the non-anti-reflection area.
6. Conclusion
(1) A hydraulic fracturing and aggregate device was developed to realize continuous and stable proppant filling, which optimized the sanding fracturing process, simplified the construction process and improved the construction efficiency.
(2) The hydraulic fracturing and aggregate process, including hole sealing technology, drainage technology, pressure holding technology and fracturing fluid injection technology, has been formed.
(3) It has been applied in Pan-san Mine of Huainan mining area and achieved remarkable technical results: after fracturing, the permeability coefficient of coal seam is increased by 13.31 times, and the time of extraction reaching the standard in the anti-reflection area is reduced by 26 days compared with that in the non-anti-reflection area.

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