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Comparative Analysis of High Water Hydraulic Fluid for Hydraulic Support

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Abstract: In view of the use and existing problems of high water cut hydraulic fluid for hydraulic support in Shendong mining area, the water quality of each mine in Shendong mining area was analyzed. The influence of mine water quality on hydraulic fluid was analyzed, including the influence of water hardness, the influence of impurities in water, the influence of sulfate ions and chloride ions, the influence of pH value, the influence of conductivity, and the comparison of different raw liquids and different hydraulic fluids. The matters needing attention in daily use and maintenance of hydraulic fluids were put forward. The corresponding hydraulic fluid should be scientifically selected and reasonably proportioned according to the mine water quality. The real-time monitoring of the hydraulic fluid should be paid attention to. The changes in the water quality, concentration, pH value and microbial situation of the hydraulic fluid should be monitored daily. The maintenance and management of the problems should be carried out in time according to the situation, so as to prevent equipment corrosion and ensure the working stability of the hydraulic system. It can provide reference for the selection, proportioning and maintenance of the high water-cut hydraulic fluid of the mine hydraulic support and ensure the safe and efficient production of the working face.

Keywords: Hydraulic Support, Hydraulic Fluid, Water Quality, Hydraulic System

1. Introduction

Hydraulic support is the main equipment of fully mechanized coal mining face, and its performance stability is one of the main factors that determine the normal production of coal mining face. Emulsion oil or liquid concentrate used in hydraulic support is mainly used in coal mines, and its performance will have a direct connection with the normal operation of the entire hydraulic system [1, 2]. In the process of using hydraulic support, the hydraulic system may have problems such as poor fluid return [3]. Technical problems such as continuous disassembly and installation of cleaning filter, gate valve blockage, cost increase and environmental pollution will occur in production [4, 5]. The investigation of hydraulic system faults can improve the reliability of hydraulic system [6, 7]. The main problems affecting the stability of hydraulic support can be roughly divided into three aspects: one is mechanical structure failure, the second is hydraulic system failure, and the third is electrical control failure. According to the statistics of Shendong mining area, the incidence of mechanical structure failure and electrical control failure is about 30%, and the incidence of hydraulic system failure accounts for about 70%. Therefore, hydraulic system failure is the main cause of hydraulic support failure. Hydraulic system failure mainly includes valve and filter plugging, hydraulic cylinder leakage and corrosion. Its manifestations are low liquid supply efficiency, small liquid supply flow and insufficient support force of hydraulic support [8-10]. The main reason of hydraulic system failure is mainly caused by improper selection, ratio and maintenance of hydraulic fluid in Shendong mining area. This paper analyzes the high water-cut hydraulic fluid with A emulsion, G emulsion and C concentrate ratio commonly used in Shendong mining area, and provides reference for the scientific ratio of hydraulic fluid.

2. Influence of Mine Water Quality on Hydraulic System

2.1. Analysis of Mine Water Quality in Shendong Mining Area

There are some differences in the water quality of seven main mines in Shendong mining area due to geological, environmental and other factors. Different water quality in accordance with the same concentration and the proportion of the original liquid will produce different effects during use. According to the general requirements of MT76-2002 "«Emulsion oil for hydraulic support»" for the water quality of hydraulic fluid ratio, the water quality has no color, odor, suspended solids and mechanical impurities. The pH range is 6-9. The concentration of chloride ion in water is not more than 200 mg / L, and the sulfate ion content is not more than 400mg/L. According to the general requirements of MT76-2011 "«Emulsion oil, concentrate and high water hydraulic fluid for hydraulic support»" for the water quality of hydraulic fluid ratio, the water quality has no color, no odor, no suspended solids and mechanical impurities. The pH value range is 6-9. The concentration of chloride ion in water is not more than 200mg/L. The water quality hardness and sulfate ion content are not greater than the corresponding hardness and sulfate ion content of the selected model products [9]. According to the above standards, the appearance and PH value of water quality of seven mines in Shendong mining area meet the requirements. Among them, one mine exceeds the standard of chloride ion, four mines have high sulfate ion content, and three mines have high water hardness.

2.2. Influence of Water Quality on Hydraulic System

According to the statistical results of relevant literature, about 60% of the hydraulic system failure of coal mine hydraulic support is caused by water quality. According to the requirements of coal industry standard MT76 for water quality, compared with MT76-2002 «Emulsion oil for hydraulic support» and the latest version of MT76-2011 «Emulsion oil, concentrate and high water hydraulic fluid for hydraulic support» standard, the new standard puts forward that the hardness and sulfate ion content of water quality should meet the requirements of selected products. According to the hardness and sulfate ion content of water quality, the ratio of raw liquid can be scientifically selected. Under normal conditions, the content of sulfate ion in water is high, the mineral content is high, and the water quality is hard. In order to ensure the quality of liquid water and improve the stability of hydraulic fluid, water quality treatment is needed. Water quality treatment can be used by precipitation, filtration, softening and high-tech material reverse osmosis [11]. The influence of water quality on hydraulic system is analyzed as follows.

2.3. The Influence of Water Quality Hardness

According to the experimental data, the hardness of water quality will lead to the decrease of the stability of the hydraulic fluid. The main reason is that the minerals with high content of hard water are easy to react with the relevant components in the original liquid to produce oil separation and soap floating on the water surface. The flocculent formed by the flocculent will affect the stability of the hydraulic fluid, and cause blockage of the valves and filters of the hydraulic system, resulting in the decrease of the concentration of the hydraulic fluid, the increase of the pipeline pressure, the explosion of the pipe, the corrosion of the operating valve and the cylinder body. Therefore, the proportion concentration of the hydraulic fluid needs to be improved when the water quality hardness is high [12]. The selection of the original liquid should be based on the water quality hardness to select the appropriate emulsion products.

2.4. The Influence of Impurities in Water

The impurities in water mainly include mechanical impurities and suspended solids, and its source is mainly dust pollution in the production process and metal particles entered in the pipeline transportation process. Mechanical impurities and suspended solids will cause wear on the metal surface and sealing part of the cylinder body. Part of the particles will even react with some components in the matching liquid to affect the stability of the hydraulic fluid, which leads to the damage of the support seal and the wear and corrosion of the cylinder body. In serious cases, it will cause the blockage of the valve, the filter and other key pathways.

2.5. The Influence of Sulfate ion and Chloride Ion

When the mixture water with high sulfate ion and chloride ion is mixed with the original liquid, it is easy to react with the hydrogen ion in the water to generate destructive acids, which will cause different degrees of corrosion to the cylinder and valve parts. Sulfate ion will react with the minerals in the water to generate flocs of calcium sulfate, magnesium sulfate and other substances, which will cause blockage of the hydraulic system. The higher the content of sulfate ion and chloride ion, the stronger the corrosion of the cylinder, and the hydraulic system is constantly damaged in the process of hydraulic fluid recycling [13].

2.6. The Influence of pH Value

The pH value of the liquid mixture water will have different effects on the hydraulic fluid. The hydraulic fluid with obvious acidity will be corroded on the cylinder block of the hydraulic system through the ionization chemical reaction. The lower the pH value is, the stronger the acid corrosion is. The hydraulic fluid with obvious alkaline will lead to the combination of alkaline ions in the hydraulic fluid with minerals and metal ions to form precipitates, resulting in the formation of scale in the hydraulic fluid. In severe cases, it will lead to the blockage of key pathways such as valves and filters.

2.7. The Influence of Electrical Conductivity

The electrical conductivity of the liquid mixture is related to the content of sulfate ions, chloride ions, calcium and magnesium ions in the water. The higher the content of various charged ions is, the higher the electrical conductivity is. In particular, the electrical conductivity of hard water is usually high. It can be seen that the higher the electrical conductivity is, the higher the content of various ions in the water is, and the higher the content of ions is, it is easy to cause related chemical reactions, and the results may lead to blockage of pathways or corrosion of equipment.

3. Analysis of Proportioning Liquid

At present, the hydraulic fluid used in coal mine is mainly divided into emulsion ratio type hydraulic fluid and concentrate dilution type hydraulic fluid, the specific situation analysis is as follows:

Emulsion matching type hydraulic fluid: This kind of hydraulic fluid is made up of emulsified oil and 90% of the mixed liquid water. Its preparation is uniform and dispersed, but it cannot be dissolved in water. Therefore, its thermodynamic properties are unstable, and the hardness of the mixed liquid water is not high. Otherwise, it will produce mineral oil and soap out precipitate, resulting in valve block, seal wear and even leakage. Blocking the filter will also lead to the effective components of emulsified oil are filtered, resulting in a decrease in the proportioning concentration, affecting the performance of the hydraulic fluid and affecting the normal use of the hydraulic support. In addition, due to the poor biodegradability of emulsion hydraulic fluid, leakage or abandoned emulsion hydraulic fluid as wastewater into mine water will pollute water quality.

Concentrate dilution type hydraulic fluid: This kind of hydraulic fluid is a solution type diluent which is made up of concentrated liquid and 90% of the mixed liquid water. It is dissolved in water, so it is called solution type. Because it is soluble in water, it has stable thermodynamic properties, good lubrication performance, and has a certain protective effect on metal rust and corrosion resistance. It has less damage to sealing components, high biodegradability of the solution, safe and environmental protection, and avoids oil and soaping caused by water quality problems, so as to avoid the blockage of valve group and pipeline path. It has wide application [10].

4. Comparative Analysis of Different Hydraulic Fluids

In view of the above two types of hydraulic fluid, combined with the Shendong mining area used A emulsion, G emulsion, C concentration ratio of high water-cut hydraulic fluid, through the test of three different types of hydraulic fluid with 30 water samples in each mine, the appearance, dispersion, thermal stability, corrosion resistance, pH value and shock stability of high water-cut hydraulic fluid were observed. The test results are shown in table 1.

Table 1. *Statistical table of test results of water samples mixed with different ratios of raw solution in Shendong mining area.*

Description of sample	Appearance (transparent uniform fluid)	Dispersion (uniform dispersion)	pH value (6-9)	Corrosion resistance (rustless)	Thermal stability (No stratification, no precipitation)	Oscillation stability (no oil soap released)
A emulsion	30 qualified	30 qualified	30 qualified	30 qualified	24 qualified, 6 sedimented	30 qualified
G emulsion	30 qualified	30 qualified	30 qualified	30 qualified	23 qualified, 7 sedimented and turbidity	30 qualified
C emulsion	30 qualified	30 qualified	30 qualified	30 qualified	28 qualified, 2 flocs	30 qualified

The results show that there are more samples of A emulsion and G emulsion precipitation, while only two samples of C concentrate are produced: flocs. The test results show that the dilution type of concentrated liquid is more stable.

Before 2015, Daliuta Coal Mine adopted emulsion type matching hydraulic fluid. In the production process, the hydraulic system was often blocked, corroded and replaced valve parts, and the support force of hydraulic support decreased, which seriously affected the normal production. In 2015, the mine water quality and hydraulic fluid were tested and analyzed, and the water quality test results are shown in Table 2. The results show that the mine water quality has high hardness, high sulfate ion value and poor water quality. The test results of hydraulic fluid are shown in table 3. The comparison results show that the emulsion type hydraulic fluid has oil soap, precipitation and turbidity, and then the concentrated liquid dilution hydraulic fluid is selected as the power transmission medium of the hydraulic support. The test results show that there is no oil soap, precipitation and other conditions, and the effect is good in practical application.

Table 2. *Statistical table of water quality test results in Daliuta Coal Mine.*

Inspection Item	Limit Required	Test Result	Test Method	Remark
Appearance	colorless, uniform, transparent	A small amount of gray sediments	visual observation	
Odour	No peculiar smell	No peculiar smell	———	
pH value	6~9	7.83	pH meter	
Total hardness/(mg/L)	———	1445	EDTA titration	Calculation by CaCO2
SO42 -/(mg/L)	≤400	1263	EDTA titration	
Cl - / (mg/L)	≤200	135	AgNO3 titration	

Table 3. *Statistical table of test results of 30 water samples and different raw liquid ratio in Daliuta Coal Mine.*

Water sample	Description of sample	Ratio	Appearance (transparent uniform fluid)	Dispersion (uniform dispersion)	pH value (6-9)	Anti-rust (rustless)
liquid water	G emulsion	95: 5	transparent uniform fluid	uniform dispersion	8.6	rustless
liquid water	A emulsion	95: 5	transparent uniform fluid	uniform dispersion	8.3	rustless
liquid water	C emulsion	95: 5	transparent uniform fluid	uniform dispersion	7.9	rustless

Table 3. *Continued.*

Water sample	Thermal stability (no stratification, no precipitation)	Room-temperature stability (no stratification, no precipitation)	Oscillation stability (no oil soap released)
liquid water	have oil soap, no stratification, no precipitation	have oil soap, stratification, sedimented	no oil soap released
liquid water	no stratification, no precipitation, but turbidity	no stratification, no precipitation, but turbidity	no oil soap released
liquid water	no oil soap, no stratification, no precipitation	no oil soap, no stratification, no precipitation	no oil soap released

5. Use and Maintenance of Hydraulic Fluid

During the use of coal mine hydraulic support, the hydraulic fluid should be monitored and maintained regularly. It is mainly necessary to monitor the changes in water quality, concentration, pH value and other aspects of the hydraulic fluid. The problems should be dealt with in time according to the situation. During the selection of hydraulic fluid in mine, the suitable raw fluid should be selected according to the mine water quality and prepared and used according to the standard concentration. During the selection of emulsion matching hydraulic fluid, if the concentration is too low, the hard water resistance and rust resistance will be reduced, and the stability of hydraulic fluid will be affected. If the concentration is too high, the sealing parts will be damaged [14, 15]. According to the analysis of the water quality of each mine and the use of emulsion proportioning hydraulic fluid in Shendong mining area, due to the hard water quality, the proportioning concentration should be appropriately increased to meet the hard water resistance of hydraulic fluid and ensure the stability of hydraulic fluid. In addition, it is necessary to monitor the pH value and microbial situation of the hydraulic fluid at any time. The pH value of the new emulsion type hydraulic fluid should be controlled at 8 ~ 10, so as to prevent the corrosion of the equipment and the growth of microorganisms, and ensure the transmission performance of the hydraulic fluid. Under suitable conditions, it is better to replace the concentrated liquid dilution hydraulic fluid.

6. Conclusion

The selection of hydraulic fluid in coal mine hydraulic support should be scientifically and reasonably selected according to the water quality of the mine. For the hydraulic system failure caused by hydraulic fluid problems, the water quality of the liquid distribution water and the proportion and pollution of the hydraulic fluid should be detected in time. For the mine with high hardness and poor water quality of the liquid distribution water, it is necessary to select the appropriate raw liquid and proportion concentration. Under the condition of satisfying the conditions, the concentrated liquid dilution hydraulic fluid with stable performance, good lubrication effect and safe and environmental protection should be preferentially selected to ensure the stable performance of the hydraulic system and ensure the safe and efficient production of the working face.

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