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A Comparison Study of High-Water Base as Hydraulic Fluid for Hydraulic Support

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ABSTRACT

The water quality of each mine in the mining region was studied in light of the usage and existing difficulties of high water cut hydraulic fluid for hydraulic support in mining areas. We looked at how mine water quality affects hydraulic fluids, including the effects of hardness, contaminants, sulfate ions, chloride ions, pH value, conductivity, and more. We then compared different raw liquids and different hydraulic fluids to see what effect each had. Hydraulic fluid utilization and maintenance issues have been discussed in detail. Hydraulic fluid should be chosen and proportioned in accordance with the water quality in the mine. There should be a focus on hydraulic fluid monitoring in real time. Hydraulic fluid quality, concentration, pH, and microbiological condition should be evaluated on a day-to-day basis. In order to avoid equipment corrosion and maintain the hydraulic system's functioning stability, it is critical that maintenance and issue management be done on time and according to the condition. It may serve as a guide for the selection, proportioning, and ongoing maintenance of the mine hydraulic support's high water-cut hydraulic fluid, ensuring the working face's safety and efficiency.

Keywords: Mining Machinery; Hydraulic Support; High Water, Hydraulic Fluid, Mining Equipment

1. Introduction

The stability of the hydraulic support's performance is one of the primary criteria that determines the normal output of the fully automated coal mining face. Hydraulic support is the primary piece of equipment used in fully mechanized coal mining faces. Emulsion oil or liquid concentrate used in hydraulic support is most often employed in coal mines, and its performance will have a direct link with the proper functioning of the complete hydraulic system [1, 2]. When using hydraulic support, there is a possibility that the hydraulic system may have issues such as inadequate fluid return [3].

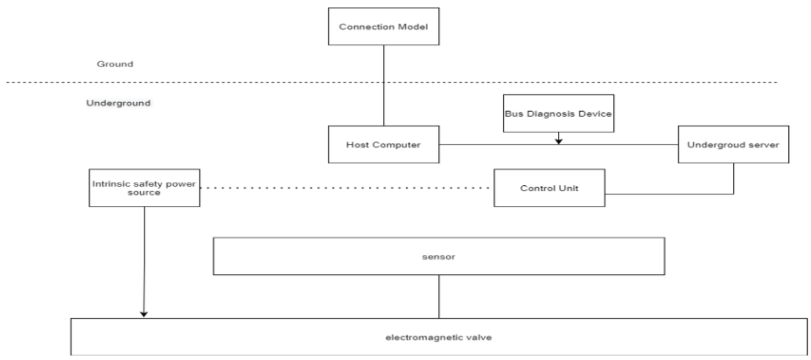

Figure 1. Proposed model for evolution

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During production, there will be a number of technical issues, including frequent disassembly and installation of cleaning filters, gate valve obstruction, a rise in costs, and contamination of the surrounding environment [4, 5]. The dependability of a hydraulic system may be improved by the examination of faults that occur within the system [6, 7]. Failures in the mechanical structure, the hydraulic system, and the electrical controls are the primary factors that contribute to the instability of the hydraulic support. The first problem is mechanical structure failure, the second failure is hydraulic system failure, and the third failure is electrical control failure. According to the data of the mining region, the incidence of failure of mechanical structures and electrical controls is around 35 percent, while the incidence of failure of hydraulic systems accounts for approximately 70 percent of all mining-related failures. As a result, the failure of the hydraulic system is the primary reason for the failure of the hydraulic support. The most common causes of failure in hydraulic systems are the blocking of valves and filters, leaks in hydraulic cylinders, and rust. It manifests itself via a poor liquid supply efficiency, a small liquid supply flow, and an inadequate support force of hydraulic support [8-10]. The inappropriate selection, ratio, and maintenance of hydraulic fluid in mining areas is the primary cause of hydraulic system failure. This may be traced back to the mining industry. The high water-cut hydraulic fluid with A emulsion, G emulsion, and C concentration ratio that is often used in mining is analyzed in this work, and a reference for the scientific ratio of hydraulic fluid is provided.

2. Principle and design

To analysis the finding we proposed a hypothetical model as shown in the figure 1. In the following section we have also discussed about finding and design principles.

$f(x,t) = \int\ g(X,t)\delta(\mathrm{x}-\mathrm{X})\mathrm{ds}\ \ldots\ldots\ (1)$

To validate we used the lattice is the LBM-based discretization calculation as given in equation (*1*). Furthermore, analysis can be done to improve the test efficacy.

2.1 Analysis of Mine Water Quality in Mining Area

There are significant geological, environmental, and other elements that contribute to the variances in the water quality of the seven major mines in the mining region. If the concentration and the percentage of the original liquid remain the same, but the water being used is of a different quality, the results of using the water will be different. 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, or mechanical impurities. This is one of the general requirements for the water quality of hydraulic fluid ratio. The pH scale runs from 6 to 9. There is not more than 200 mg/L of chloride ion in the water, and there is not more than 400 mg/L of sulfate ion in the water. Both of these levels are acceptable. 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 must have no color, no odor, no suspended solids, and no mechanical impurities. Additionally, the water quality must be free of any mechanical impurities. Six to nine is the pH value range. The amount of chloride ion that is present in water does not exceed 200 mg/L in concentration. The water quality hardness and sulfate ion content are not larger than the equivalent hardness and sulfate ion content of the chosen model products [9]. [This is to ensure that] the water quality hardness and sulfate ion content are comparable. According to the criteria presented above, seven of the mines in the mining region have water quality that, in terms of its look and its PH value, satisfies the requirements. One of these mines has a chloride ion concentration that is higher than the norm, four of these mines have a high sulfate ion content, and three of these mines have a high-water hardness.

2.2 Influence of Water Quality on Hydraulic System

According to the statistical findings of the relevant body of research, the quality of the water accounts for around sixty percent of the failures that occur in the hydraulic systems that provide support for coal mines. According to the requirements of coal industry standard MT76 for water quality, the new standard puts forward that the hardness and sulfate ion content of water quality should meet the requirements of selected products. This is in comparison to the standard MT76-2002, which was titled "Emulsion oil for hydraulic support," and the most recent version of the standard MT76-2011, which was titled "Emulsion oil, concentrate, and high-water hydraulic fluid for hydraulic support." The ratio of the raw liquid may be scientifically chosen based on the hardness and sulfate ion content of the water quality. Under typical circumstances, the amount of sulfate ion in water is high, as is the amount of mineral content, and the water's overall quality is said to be hard. Treatment of the water's quality is required in order to maintain the integrity of the liquid water supply and to enhance the consistency of the hydraulic fluid. The processes of precipitation, filtration, softening, and high-tech material reverse osmosis may all be used in the treatment of water quality [11]. The following analysis demonstrates how the quality of the water influences the hydraulic system.

2.3 The Influence of Water Quality Hardness

According to the findings of the experiments, the hardness of the water quality will result in a drop in the hydraulic fluid's stability, which will cause it to become less stable. The primary reason for this is that the minerals that are present in large concentrations in hard water are more likely to react readily with the relevant components of the initial liquid, which results in the production of oil separation and soap that floats on the water's surface. The flocculent that is formed by the flocculent will have an effect on the stability of the hydraulic fluid, and it will cause blockage of the valves and filters of the hydraulic system. This will lead to a reduction in the concentration of the hydraulic fluid, an increase in the pressure within the pipeline, an explosion of the pipe, and corrosion of the operating valve and the cylinder body. Because of this, the percentage concentration of the hydraulic fluid has to be adjusted in order to accommodate the increased hardness of the water quality [12]. When choosing the initial liquid, consideration should be given to the hardness of the water in order to ensure that the proper emulsion products are chosen.

2.4 The Influence of Impurities in Water

The Impact that Impure Substances Have on Water The major types of impurities found in water are called mechanical impurities and suspended solids, and the primary causes of these impurities are dust pollution during the manufacturing process and metal particles that enter the water supply via pipeline transmission. Wear will occur on the metal surface of the sealing section of the cylinder body and the inside of the cylinder if mechanical impurities and suspended particles are present. The instability of the hydraulic fluid is what causes the damage to the support seal as well as the wear and corrosion of the cylinder body, which is caused by some of the particles reacting with some of the components in the matched liquid. In more severe instances, it will result in the obstruction of the valve, the filter, and several other important channels.

2.5 The Influence of Sulfate ion and Chloride Ion

When the water containing a high concentration of sulfate ions and chloride ions is combined with the original liquid, it is simple for the original liquid to generate destructive acids by reacting with the hydrogen ions that are present in the water. These acids will cause varying degrees of corrosion to the cylinder and valve parts. Because of the reaction between sulfate ion and the minerals in the water, flocs of calcium sulfate, magnesium sulfate, and other substances will be produced, which will result in the hydraulic system being clogged. In the process of recycling hydraulic fluid, the hydraulic system is continuously subjected to damage [13], and the severity of the corrosion of the cylinder is directly proportional to the amount of sulfate and chloride ions present in the fluid.

2.6 The Influence of pH Value

It is possible that the hydraulic fluid will respond differently depending on the pH value of the liquid mixing water. Because of the ionization chemical reaction, the corrosive effects of the hydraulic fluid, which has a noticeable amount of acidity, will be seen on the cylinder block of the hydraulic system. The pH value must be lowered in order for the acid corrosion to become more severe. The presence of an obviously alkaline hydraulic fluid will result in the formation of scale in the hydraulic fluid due to the combination of alkaline ions in the hydraulic fluid with minerals and metal ions to form precipitates. This will cause the alkaline ions to combine with one another to form precipitates. In extreme circumstances, this might result in the obstruction of vital passageways, such as valves and filters.

2.7 The Influence of Electrical Conductivity

There is a correlation between the number of ions in the water, namely sulfate ions, chloride ions, calcium ions, and magnesium ions, and the electrical conductivity of the liquid combination. The electrical conductivity of a substance increases in direct proportion to the number of different types of charged ions that it contains. In particular, the electrical conductivity of hard water is often high. [Case in point:] [Case in point:] It is clear that the water contains a greater number of different ions when the electrical conductivity of the water is higher. When the water contains a greater number of ions, it is simpler to trigger chemical reactions that are connected to those ions. The end result of these reactions may result in the obstruction of pathways or the corrosion of equipment.

3. Research status

At the moment, the hydraulic fluid that is used in coal mines is primarily classified as either an emulsion ratio types hydraulic fluid or a concentrate dilution type hydraulic fluid. The following is an analysis of the particular situation: Emulsion-matching hydraulic fluid of the following types: This kind of hydraulic fluid is composed of oil that has been emulsified and water that has had 90 percent of its volume replaced by mixed liquid. It cannot be dissolved in water despite the fact that its preparation is homogenous and distributed. Because of this, the thermodynamic characteristics of the combined liquid water are unstable, and it does not have a particularly high hardness. In the event that this does not occur, mineral oil and soap out precipitate will be produced, which will lead to valve blockage, seal wear, and even leakage. Blocking the filter will also result in the effective components of the emulsified oil being filtered, which will lead to a decrease in the proportioning concentration. This will have an effect on the performance of the hydraulic fluid, as well as the results, which show that there are more samples of A and G emulsions that have precipitated, but only two samples of C concentrate have flocs produced. According to the findings of the tests, the most stable form of concentrated liquid is the one that has been diluted. The Daliuta Coal Mine has been using emulsion type matching hydraulic fluid prior to the year 2015. During the manufacturing process, the hydraulic system often became clogged, rusted, and required replacement of valve components. As a result, the support force of the hydraulic support dropped, which had a significant

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negative impact on the regular manufacturing process. In 2015, both the water quality of the mine and the hydraulic fluid that is normally used for the hydraulic support were evaluated. In addition, since emulsion hydraulic fluid has a low rate of biodegradability, the water quality in mines may become contaminated if any of it leaks out or is left behind as waste and is then washed into the water supply. Hydraulic fluid of the concentrate dilution type: This form of hydraulic fluid is a solution type diluent that is made up of concentrated liquid and water that makes up 90 percent of the combined liquid. Because it can be dissolved in water, it is referred to as a solution type. It is water soluble, which means that it has stable thermodynamic characteristics, high lubricating performance, and a certain protective impact on metals that are resistant to rust and corrosion. It causes less damage to the components that are responsible for sealing, the solution has a high biodegradability, it is safe and it protects the environment, and it prevents oil and soaping from forming as a result of water quality issues, which helps to prevent the blockage of the valve group and the pipeline path. It may be used in a variety of contexts [10].

Fluids In light of the two different kinds of hydraulic fluid described above, together with the mining region that was the appearance, dispersion, thermal stability, corrosion resistance, pH value, and shock stability of high water-cut hydraulic fluid were observed through the testing of three distinct types of hydraulic fluid with 35 water samples in each mine. The emulsions A, G, and C have a concentration ratio of high water-cut hydraulic fluid. The findings of the tests 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[14].

Description of sample	**Appearance (transparent uniform fludid)**	**Dispersion (uniform dispersion)**	**pH value (6-9)**	**Corrosion resistance (rustless)**	**Thermal stability (No stratification, no precipitation)**	**Oscillation stability (no oil soap released)**
A emulsion	35 qualified	35 qualified	35 qualified	35 qualified	24 qualified, 6 sedimented	35 qualified
G emulsion	35 qualified	35 qualified	35 qualified	35 qualified	23 qualified, 7 sedimented and turbidity	35 qualified
C emulsion	35 qualified	35 qualified	35 qualified	35 qualified	28 qualified, 2 flocs	35 qualified

Whenever the coal mine hydraulic support is being used, the hydraulic fluid must be carefully checked and maintained on a regular basis. Monitoring the variations in water quality, concentration, pH value, and any other elements of the hydraulic fluid is mostly required because of how important it is. The issues need to be addressed as soon as possible in light of the current circumstances. When selecting hydraulic fluid for use in a mine, the appropriate raw fluid should be chosen in accordance with the quality of the mine's water. The fluid should then be produced and used in accordance with the standard concentration. If the concentration of the emulsion matching hydraulic fluid is too low, the hard water resistance and rust resistance will be diminished, and the stability of the hydraulic fluid will be damaged. This occurs throughout the process of selecting an emulsion matching hydraulic fluid. In the event that the concentration is too high, the components that do the sealing will suffer damage. Because of the hard water quality, the proportioning concentration needs to be increased appropriately in order to meet the hard water resistance of hydraulic fluid and to ensure that hydraulic fluid remains stable, as determined by an analysis of the water quality of each mine and the use of emulsion proportioning hydraulic fluid in mining areas. In addition to this, the pH level of the hydraulic fluid as well as the microbiological condition must be monitored constantly at all times. To avoid corrosion of the equipment, the development of microorganisms, and to guarantee the transmission performance of the hydraulic fluid, the pH value of the new emulsion-type hydraulic fluid should be adjusted to be between 8 and 10. This range should be maintained in order to achieve these goals. It is in your best interest to replace the concentrated liquid dilution hydraulic fluid whenever the circumstances are favorable.

4. Summary

The choice of hydraulic fluid for use in coal mine hydraulic support should be made in a manner that is both reasonable and scientific, taking into account the quality of the water used in the mine. The water quality of the liquid distribution water, as well as the proportion and pollution of the hydraulic fluid, should be identified in a timely manner in order to prevent the failure of the hydraulic system that is caused by issues with the hydraulic fluid. It is vital to pick the right raw liquid and proportion concentration for the mine that has excessive hardness and poor water quality of the liquid distribution water in order to function properly. The concentrated liquid dilution hydraulic fluid with stable performance, good lubrication effect, safe and environmental protection should be preferentially selected under the condition that the conditions are satisfied. This will ensure the stable performance of the hydraulic system and ensure the safe and efficient production of the working face.

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