Journal of Innovation and Development
ISSN: 2958-4752 | Vol. 9, No. 1, 2024

Research on Coal Transportation Under Low Temperature Environment

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Abstract: Coal is transported in cold regions at temperatures as low as -15℃ and 13% humidity, and due to the moisture carried by the mining process, the coal freezes with the train cars as it passes through the cold regions, making the process of opening the side panels to unload the coal problematic and making it difficult to unload all of it. Due to the hard texture of frozen coal, and coal carriages connected closely, so the unloading operation is very difficult, greatly affecting the play of railroad capacity and the normal production of the majority of coal enterprises.

Keywords: Cold environments; Coal transportation; Anti-Freeze; Antifreeze agent.

1. Introduction

Coal is an important basic energy source and industrial raw material in China, widely used in metallurgy, chemical industry, building materials, thermal power generation and other fields. Due to the uneven regional distribution of China's coal production capacity and use of coal, coal enterprises often need to use the source of coal transportation by rail, and the outdoor temperature in northern winter is generally -30 ℃ ~ -10 ℃, coal in the long-distance transportation process will inevitably produce freezing viscosity phenomenon, resulting in the formation of frozen coal (the thickness of the general about 400mm), and in severe cases, or even the whole car freezing[1]. Due to the hard texture of frozen coal, and coal carriages connected closely, so the unloading operation is very difficult, greatly affecting the play of railroad capacity and the normal production of the majority of coal enterprises[2].

2. Research Progress of Coal Antifreeze in Transportation

Coal is an important energy source for China's social and economic development, and a large amount of coal needs to be transported from the northwest to the southeast coastal areas by railroad. With the continuous improvement of coal washing rate, the moisture content of washed coal is generally 6.5%～20%[3]. During the storage or transportation of coal in winter, water will gradually penetrate to the bottom of the coal seam and freeze with the wagons, and the frozen coal will be difficult to be loaded and unloaded in the transportation process, resulting in the problems of pressure on the wagons and the port. Many methods have been used at home and abroad to solve the problem of coal freezing during unloading, such as vibration, heating, oiling and waxing, and adding chlorine salts to the coal, etc[4]. However, the cost of these methods is high and the effect is not good, and the carriages and the quality of coal will be affected. Therefore, the research and utilization of antifreeze has become a mainstream trend in the field of coal antifreeze in recent years . Antifreeze is easy to use, not subject to site constraints, low energy consumption and effective. At present, the majority of coal enterprises in China choose to use calcium chloride as the main component of antifreeze to solve the problem of frozen coal and frozen cars. However, calcium chloride coal antifreeze has low adhesion, and the antifreeze effect on coal is not good when the concentration is low, while the use of higher concentration of calcium chloride antifreeze will introduce a large amount of chlorine, which will corrode the storage, spraying equipment and train carriages, and chlorine will be converted into hydrogen chloride during the process of coal combustion, which will have an impact on the environment[5]. Non-chlorine coal antifreeze not only has the same or even lower freezing point than calcium chloride antifreeze, but also has moderate viscosity and good metal corrosion resistance[6].

3. Coal Antifreeze Principle of Use

3.1. Mechanism of action

The essence of antifreeze is to ensure that the aqueous solution does not freeze at negative temperatures, to maintain the fluidity of the solution, is a non-volatile solute dissolved in water when the solution is formed, in the process of dissolution, solute and solvent some of the properties of the solution will be changed, the overall changes in the nature of the solution can be divided into two categories[7]. One is determined by the physical properties of the solute, such as color, density, acidity and alkalinity, as well as electrical conductivity, etc.; The second is affected by the number of solutes, such as solution vapor pressure, boiling point, freezing point, as well as osmotic pressure of the four phenomena, these phenomena are known as “depending on the number of properties”. After the addition of antifreeze, the antifreeze solute destroys the orderly arrangement structure of water molecules inside the solution, so that the overall vapor pressure of the solution decreases[8]. In the solution, the vapor pressure of ice is higher than the vapor pressure of antifreeze, in order to solidify the antifreeze, it is necessary to reduce the vapor pressure of ice, so that the vapor pressure of antifreeze and antifreeze are equal, in order to achieve the effect of condensation and antifreeze.

3.2. Technical indicators

According to the indexes listed in the industry standard of antifreeze for coal transportation, it is quantitatively required for freezing point, boiling point, flash point, density, viscosity, pH value, metal corrosion rate and heavy metal content, and

the range of performance indexes is stipulated[9]. Freezing point and metal corrosion rate is to evaluate the antifreeze antifreeze performance of the main indicators, the requirements of the freezing point is less than or equal to 46 ℃, 45 # steel, T-3 copper and 5083 aluminum three metal corrosion rate of less than or equal to 0.05mm / a within 168h[10]. Qualified coal antifreeze needs to have excellent antifreeze effect on the transport vehicles and equipment corrosion is small, moderate viscosity, easy to spray and friendly to the environment[11].

4. Types of Coal Antifreeze

4.1. Antifreeze classification

Antifreeze can be divided into chlorine salt antifreeze and non-chlorine antifreeze according to whether the chlorine content is more than 1%; it can be divided into solid broadcasting antifreeze powder and liquid spraying antifreeze according to the form of the substance and the method of field use. In addition, antifreeze can also be divided into organic, non-organic and composite three types according to the composition. Organic type composition to carbon, oxygen elements, including polyols, amides, and ethers; inorganic type, including a variety of alkali metals, alkaline earth metal chlorides and other compounds composed of acid roots, etc.; composite type by the organic type and inorganic type compound composition.

4.2. Antifreeze Ingredients

Antifreeze usually consists of a coagulant reducer, a corrosion inhibitor and a buffering agent, and in some formulations a thickening agent is also added. According to the use of site conditions, according to the proportion of water mixed with the transportation of goods and vehicles to play the effect of anti-freezing. The main role of the coagulant is to reduce the freezing point, at present, the main domestic use of calcium chloride, magnesium chloride, ethylene glycol and propylene glycol. When the content of calcium chloride in 40% to 45%, reduce the freezing point of the best results and lower prices, the disadvantage is that the introduction of foreign chloride ions, corrosion of metals; magnesium chloride cost is higher, generally used with calcium chloride; ethylene glycol content of about 70% of the antifreeze formulated to stabilize, reduce the freezing point of the best results, corrosion performance is better than inorganic salts, but the cost is higher; propylene glycol is higher than in the price of Ethylene glycol, so it is not used much. Chlorine salt antifreeze, a single component of the coagulant reducing agent, adding corrosion inhibitors or thickening agents may cause crystal precipitation and other problems. Non-chlorine antifreeze not only can be compounded and synergized to meet the freezing point requirements, but also by adding different types of metal corrosion inhibitors to achieve synergistic corrosion inhibition, thickening agent can strengthen the wall performance of antifreeze, so that it can play a better antifreeze role in coal railway transportation, non-chlorine antifreeze is also gradually replacing the chlorine salt antifreeze.

5. Coal Freeze Test

5.1. Test Methods

Temperature and humidity were controlled using a large test silo, setting the ambient temperature to -15°C and humidity to 43%, freezing for 8 h, and unloading and recording the weight of the coal in the molds when the freezing was complete. This process was recorded as conducting a test procedure.

5.2. Experimental process

First set of tests: The moisture content of the coal is 15%, Option 1 is the original state with 36.7kg of filled coal; 2.54kg of water, and the unloaded mass is 6.69kg, which calculates the unloading rate to be 17.7%; Option 2 is the use of a water barrier with 27.5kg of filled coal; 1.8kg of water, and the unloaded mass is 5.29kg, which calculates the unloading rate to be 18%.

Second set of tests: The moisture content of the coal is 12%, Option 1 is to use release agent and antifreeze (top), fill 37kg of coal; 1.1kg of water, 4kg of antifreeze, and unloaded mass is 7.5kg, which calculates the unloading rate to be 17.8%; Option 2 is to use release agent and antifreeze (layered), fill 37kg of coal; 1.1kg of water, 4kg of antifreeze, and 36.6kg of unloaded mass, which calculates the yielded an unloading rate of 86.9%.

Third set of tests: The moisture content of coal is 12%, the first time is using release agent and antifreeze (layered), filling coal 37kg; water 1.1kg, antifreeze 4kg, unloaded mass is 36.6kg, calculated unloading rate is 86.9%; the second time is using antifreeze (layered), filling coal 37kg; water 1.1kg, antifreeze 4kg, unloaded mass is 34.2kg, calculated unloading The unloading rate is 80.0%.

6. Conclude

Cold environments pose a challenge to coal transportation as coal carries moisture from mining and therefore freezes with the train cars as it passes through cold regions, making the process of opening the side panels to unload the coal problematic and making it difficult to unload all of the coal. Innovative approaches should be taken to deal with this.Based on the above three sets of tests, the unloading rate of the test program release agent and antifreeze (layered) was 86.9% and the subsequent addition of antifreeze (layered) resulted in an unloading rate of 80.0%, making this program the most effective.

Acknowledgement

This work was supported by the Project Fund: China Railway Lanzhou Bureau Group Co., Ltd. scientific and technological research and development program topics under Grant No. 2024011-1. We are grateful for their financial support, which made this research possible.

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