Risk Analysis and Prevention Strategies for Dust Explosion during Coal Washing Process

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Abstract: Coal washing is an important process to improve the quality and utilization rate of coal. For example, through washing, harmful substances such as ash and sulfur in coal can be removed, and the calorific value and quality of coal can be improved. However, there is a potential risk of dust explosion during the coal washing process. Once a dust explosion occurs, it will cause equipment damage, personnel injury, environmental pollution, and other problems. This article analyzes the causes and hazards of the risk of appeal, and proposes targeted prevention and control strategies to provide reference and guidance for relevant factories and personnel to prevent and control dust explosion risks in coal washing activities.

1. Introduction

Coal itself is a combustible substance, and during the coal washing process, block shaped coal will peel off a large amount of coal powder, resulting in a significant increase in the contact area between coal and air, and an increase in the degree of oxidation. If the environment is dry and hot, oxidation will significantly increase, ultimately leading to dust explosions [1]. Dust explosions pose great hazards, therefore relevant engineering and personnel should strengthen risk prevention and control to prevent equipment damage, personnel injury, environmental pollution, and other issues caused by dust explosions.

2. Dust Explosion during Coal Washing Process

Dust can release a large amount of flammable gases into the air at lower temperatures (300-400 ℃). Among them, when 1000g of dust comes into contact with air and undergoes oxidation, it can release 200-300L of combustible gas. Once these gases encounter high temperatures or open flames, they will quickly burn and transfer the heat generated by the combustion to the surrounding dust. If the coal washing and processing plant does not take corresponding prevention and control measures in a timely manner and allows it to continue to expand, the oxidation reaction will become more and more obvious, and to a certain extent, it will cause dust explosions. During the process of coal washing, dust explosion is similar to gas explosion, which produces a large amount of impact and carbon monoxide. The concentration of carbon monoxide can reach 2% to 3%, with the highest reaching 8%.

In fact, the dust generated during the coal washing process cannot be directly ignited, but needs to be heated to become combustible and fully mixed with air before it can burn. Carbon particles are an important medium for igniting coal powder dust after it is fully evaporated. Therefore, the volatilization of coal has a huge impact on the generation and development of dust explosions. The higher the volatilization content, the easier it is to cause dust explosions during the coal washing process [2]. The parameters of dust explosion caused by different types of coal are shown in Table 1.

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Table 1 Explosion parameters of different types of coal dust

Explosion index %	explosive	Coal type	Metamorphic degree	Rock fraction usage %
<10	Not explosive	Anthracite	high	no
10~15	Flammable and weakly explosive	Lean coal	medium	20~40
15~28	Explosiveness and short flame	Coking coal, fat coal	low	50~80
>28	Strong explosiveness and long flame	Lignite	low	85

According to Table 1, the smaller the degree of coal metamorphism, the higher the dust explosion index during the coal washing process, and the stronger the harm caused by the explosion. In general, the lower explosive limit concentration of lignite is 45-55g/m^3, and the lower explosive limit concentration of bituminous coal is 110-2000g/m^3. The maximum explosive power is 112g/m^3.

3. Risk of Dust Explosion during Coal Washing Process

Dust explosion during coal washing is a major safety hazard, and once an explosion occurs, it will bring many risks, as follows.

3.1 Risk of Equipment Damage

Once a dust explosion occurs during the coal washing process, the risk of equipment damage is extremely high. After coal comes into extensive contact with air in the form of dust, it will become combustible due to the influence of surrounding heat. When the dust explodes, it will release a large amount of energy, producing high temperature and high pressure [3]. This strong explosive force will cause serious equipment damage problems. For example, the shock wave generated by a dust explosion can have a direct physical impact on surrounding equipment, causing deformation, rupture, and complete damage to the equipment after being impacted. The high temperature generated by dust explosions can ignite or even dissolve equipment or components, posing a risk of equipment damage. After a dust explosion, many deposited dust particles will be greatly lifted up by shock waves, forming new dust clouds and triggering secondary dust explosions. Multiple explosions will further exacerbate the damage to various equipment in the coal washing plant. The dust explosion during the coal washing process poses a risk of equipment damage, which not only affects normal production activities and causes economic losses, but also poses a serious threat to the safety of production workers. To reduce the risk of equipment damage caused by dust explosions during the coal washing process, factory management personnel should take relevant protective measures.

3.2 Risk of Personnel Injury or Death

The dust explosion generated during the coal washing process can also pose a risk to the safety of factory personnel. Dust explosions release a large amount of heat and energy, generating high temperatures, high pressures, and strong shock waves, which can cause serious injuries to personnel and even lead to death.

Firstly, high-temperature burning. The high temperature generated by dust explosion during coal washing is sufficient to ignite and melt nearby objects, causing serious burns to personnel. Secondly, shock wave damage. The shock wave generated by dust explosion during coal washing can also cause direct physical harm to the human body, such as visceral rupture, fractures, etc. Thirdly, toxic gases. During the coal washing process, dust explosions can also release a large amount of toxic gases, such as carbon monoxide, which can cause poisoning and suffocation of personnel. For example, a food ingredient factory in Qingdao experienced a dust explosion during production activities. Due to the friction and impact of metal debris falling from the raw material warehouse and mixing machine, mechanical cremation occurred, causing the dust explosion and resulting in 5 deaths. This accident indicates that dust explosion poses a great threat to the safety of personnel's lives.

3.3 Environmental Pollution Risk

Dust explosions during coal washing can also pose environmental pollution risks. Firstly, the risk of air pollution. During the coal washing process, dust explosions will generate a large amount of dust particles and harmful substances, which will be released into the air, causing serious air pollution. These pollutants may contain harmful gases, particulate matter, etc., which have adverse effects on the surrounding ecological environment and people's health. Secondly, water pollution. If the location of dust explosion during coal washing is close to a water source, the pollutants generated by the explosion may enter the water body through channels such as rainwater flushing and surface runoff, causing water pollution. Not only does it affect water quality, but it also has adverse effects on aquatic organisms, surrounding ecosystems, and so on. Thirdly, soil pollution. The dust and fragments generated by dust explosions during coal washing will scatter in the soil, and long-term accumulation will cause pollution to the soil. It will affect soil fertility, damages soil structure, and thus affecting subsequent crop planting activities. Fourthly, ecological destruction. Dust explosions during coal washing can also cause damage to the local ecosystem. For example, various pollutants generated by dust explosions may be transmitted through the food chain, affecting local species diversity and disrupting ecological balance.

4. Prevention and Control Methods for Dust Explosion Risk during Coal Washing Process

4.1 Methods for Preventing and Controlling Equipment Damage Risks

Firstly, control and eliminate ignition sources. Improve safety production management regulations in coal processing plants and strictly prohibit the use of electric heating appliances in explosive hazardous areas and their vicinity. For example, electric heating castings, stainless steel electric heating plates, etc., should be avoided from becoming potential sources of fire and causing dust explosions. In addition, it is necessary to strengthen the electrical safety management of the production workshop to ensure that all electrical equipment used in the coal washing process meets explosion-proof standards. Safety inspections on various electrical equipment should be regularly conducted to prevent mechanical sparks and dust explosions caused by equipment aging during use. Secondly, optimize production processes and equipment. Coal washing activities inherently pose significant safety risks, therefore, production processes that do not generate or generate less dust should be chosen. For example, the wet production process reduces the amount of dust generated. Sealed measures can also be taken, such as using sealed pipelines, equipment, etc. for transportation and processing during the coal washing process, to reduce large-scale contact between dust and air.

4.2 Methods for Preventing and Controlling Personnel Injury Risks

Firstly, strengthen the safety monitoring and management of production workshops. The coal washing and processing workshop should establish and strictly implement safety management regulations, including dust explosion prevention safety management system, equipment operation specifications, etc., to ensure that all personnel in the workshop understand and comply with relevant safety regulations. It is necessary to install explosion warning systems in the workshop, develop dust explosion evacuation plans, etc., utilize the explosion warning system to monitor the operation of the workshop in real time. Once the dust content in the air exceeds the standard or a fire source is detected, an alarm will be sounded in the workshop in a timely manner to ensure that workshop employees evacuate the scene quickly. A detailed emergency evacuation plan should be made to regularly organize drill activities, improve the safety awareness and emergency response capabilities of workshop employees, and prevent and control the risk of casualties caused by coal washing dust explosions. Secondly, enhance employees' safety awareness and strengthen safety education and training. It is significant to raise employees' awareness of dust explosions in coal washing and assist them in understanding how to properly use and maintain relevant equipment, as well as self rescue skills in emergency situations. At the same time, employees should be encouraged to participate in the design of workshop safety regulations, report potential safety hazards during coal washing activities, and jointly maintain workshop safety to avoid dust

explosions causing casualties.

4.3 Methods for Preventing and controlling environmental pollution risks

Firstly, control the amount and concentration of combustible dust generated. In the production and processing activities of coal washing, relevant personnel should control the amount and concentration of combustible dust generated, timely repair equipment with material leakage, ensure good sealing of various production equipment, prevent dust explosion caused by dust release, optimize the dust removal system in the workshop and use efficient dust collectors to promptly remove leaked dust. At the same time, attention should be paid to avoiding the sedimentation and accumulation of dust in the suction duct, and reducing the adverse effects of dust explosions on the surrounding ecological environment. Secondly, regularly clean and maintain. Workshop personnel should regularly clean the work site and related equipment to avoid dust accumulation and reduce the risk of ecological pollution caused by explosions.

5. Conclusion

In summary, the potential risk of dust explosion during coal washing poses a threat to equipment safety, personnel safety, and ecological environment. In this regard, relevant factories and personnel should focus on the prevention and control of dust explosions and various risks associated with coal washing activities. By regularly cleaning the workshop, strengthening safety management, optimizing production processes, repairing equipment, and other methods, the probability of coal washing dust explosions can be reduced, and the adverse effects caused by equipment damage, personnel injury, environmental pollution, and other risks can be controlled.

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