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Review

A Review of Dust Movement Laws and Numerical Simulation-Based Dust Suppression Methods in Coal Mines

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Abstract

Dust generated during coal mining and transportation poses serious threats to miners' health, operational safety, and the surrounding environment. However, comprehensive review studies on dust suppression in coal mines remain limited, particularly those integrating dust movement laws with numerical simulation approaches. This review presents a systematic and reproducible analysis of dust control methods in coal mines with a particular focus on numerical simulation. Current research progress and development trends are summarized from three aspects: structural optimization of dust suppression devices, optimization of operating conditions, and ventilation system design. Existing studies indicate that structural improvements mainly concentrate on nozzle geometry, diameter, installation position, and spraying distance, while operating condition optimization primarily involves pressure regulation. Due to the complexity and high cost of full-scale experimental platforms, ventilation system optimization is largely achieved through numerical simulation, supplemented by field measurements. Studies based purely on numerical simulations remain limited in addressing the chemical modification of dust removers; however, with the advancement of molecular dynamics techniques, this area may represent a promising direction for future research.

Keywords: coal mine dust; dust suppression; numerical simulation; nozzle optimization; pressure; ventilation system

1. Introduction

China possesses abundant coal resources, with proven reserves of 187.55 billion tons as of 2020, making it the largest coal storage country and producer worldwide. In the same year, national coal production reached 3.84 billion tons, accounting for nearly half of global output. Coal mining generates substantial dust, which severely degrades the working environment and contributes to occupational diseases, particularly pneumoconiosis [1,2]. In China, over 90% of the approximately one million occupational disease cases are pneumoconiosis, with 80% of affected individuals employed in coal mines. The annual number of newly reported occupational pneumoconiosis cases in China from 2017 to 2024 is presented in Figure 1 [3,4].

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