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Study on the influence of some ventilation parameters on dust dispersion in heading face coal mine using CFD numerical model

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Coal is crucial for energy in domestic economies, powering industries and plants. However, as shallow coal reserves deplete, mining operations delve deeper, raising concerns about labor safety and the microclimate in underground coal mines. In Quang Ninh, Vietnam, mines like Mong Duong Coal Mine's L7 longwall face soaring air temperatures, exceeding safety standards and risking workers' health and mining efficiency. Key contributors to the temperature rise include heat from rocks, electrical equipment, and coal oxidation. Previous studies have examined factors like soil, rock, and coal temperatures, as well as mine airflow. This study focuses on the L7 longwall area, aiming to identify heat sources and model temperature distribution, considering wind velocity and inlet wind temperature variations. The insights gained aim to guide strategies for managing and reducing air temperatures, enhancing worker safety and mining productivity in deep-level coal mining areas.

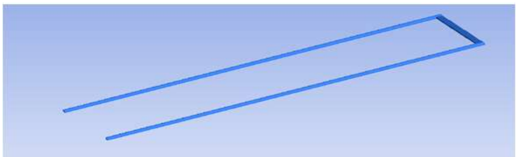

Fig.2. Model of the longwall area using ICEM – CFD

Table 1. Parameters in the model

Parameters of the longwall	Model parameters	Parameters of the longwall	Model parameters
velocity	1 m/s; 1,5 m/s; 2m/s; 2,5m/s; 3m/s; 3,5 m/s; 4m/s	Temperature of equipment	308,15K - 311,15K
outlet	outlet	roughness	2 cm
Temperature air of inlet	297,15K; 299,15K; 302,15K;	Thermal conductivity of rock	1,9 W/mk
Initial air of temperature	302,15K	Thermal conductivity of coal	0,35W/k
Temperature of rock	304,15K - 305,15K		

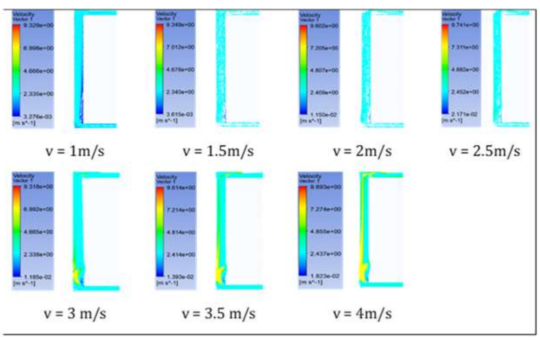

Fig.3. Velocity field at mining area

Effect of airflow rate

Fig. 3 displays the wind velocity pattern in the mining area. The wind speed is stable along the roadway horizontally but shows notable fluctuations at the top and bottom of the longwall, forming distinct vortex patterns with higher wind speeds. With increased inlet wind speed, the vortex area expands gradually, enhancing convective heat transfer between the wind and high-temperature zones. The wind speed near the wall is higher at the top and bottom of the longwall, influencing a broader area. Conversely, lower wind speed on the lower side leads to localized temperature rises. These insights into airflow dynamics, especially vortex presence and behavior with varying wind speeds, are critical for optimizing ventilation strategies and improving heat dissipation efficiency in the mining area. Accurate assessment of the velocity field helps miners manage potential risks tied to temperature variations, ensuring safer and more productive mining operations

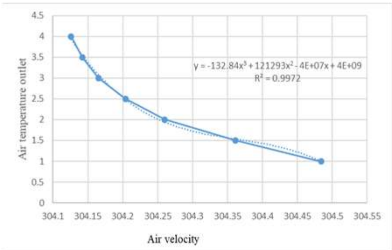

Fig.4. Relationship between wind speed and air temperature of longwall

Fig. 4 illustrates the link between wind speed and air temperature in the longwall. Airflow rate significantly influences the microclimate in the mining area, impacting heat distribution and working environment temperatures. The study employs numerical simulations and field measurements to investigate airflow rate effects on longwall temperature. Results indicate that higher airflow rates correlate with lower air temperatures in the longwall. This relationship follows a nonlinear pattern represented by a third-order nonlinear regression function. This emphasizes the need to carefully control airflow rates for an optimal working environment. Understanding airflow rate effects enables effective ventilation strategies, ensuring safety, comfort, and productivity for miners. Additionally, the findings aid in temperature forecasting and optimizing ventilation systems in modern mines.

Effects of inlet air temperature

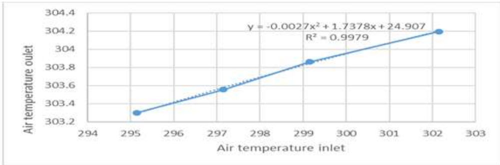

Fig.6. The relationship between input and output temperature in the longwall

Figure 6 illustrates the relationship between the input air temperature from the starting point of the transportation roadway and the output temperature of the longwall at the starting point of the longwall. This relationship is represented by a nonlinear regression function. The input temperature has a substantial impact on the temperature in the longwall area. It is crucial to implement solutions to reduce the temperature in the longwall area, ensuring the safety and well-being of the workers. Overall, these findings emphasize the importance of controlling and optimizing the microclimate conditions within the longwall mining area to ensure a safe and healthy working environment for the workers."

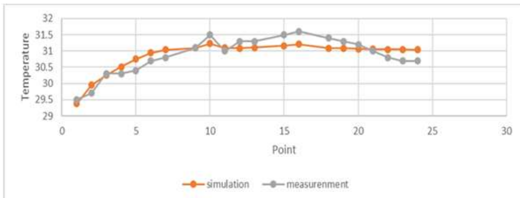

Fig. 7. Measurement and simulation results

Figure 7 presents the numerical simulation results of the model with a wind velocity of v = 2 m/s. A comparison with the field measurements indicates slight deviations between the two sets of data, but these differences do not significantly impact the accuracy of the numerical simulations. Hence, the results obtained from the numerical simulations remain reliable and hold substantial reference value.

Conclusion

In summary, the study focused on the L7 mechanized longwall in Mong Duong coal mine, emphasizing the influence of geothermal heat, mining equipment-generated heat, and inlet air temperature on the longwall's temperature. The research revealed a nonlinear relationship between input temperature, inlet wind speed, and longwall temperature under similar mining conditions. Simulation results indicated that increasing wind speed reduced the air temperature in the mining area; however, this effect diminished beyond a certain wind speed. To enhance worker conditions in high-temperature mine areas, strategies like increasing wind speed and reducing inlet air temperature are recommended. Temperature regulation of the inlet wind during deep mining is essential, and the use of air conditioners in mines is advised to maintain a comfortable environment for workers, aligning with regulations. Implementing these measures ensures worker safety, health, productivity, and fosters efficient mining activities. Optimizing ventilation and temperature control strategies is critical for sustainable mine operations.