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Numerical Simulation on the Forced Convective Heat-extraction Method in Coal Fire Zone

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Coal fires are a worldwide hazard which is especially severe in China, USA, India and South Africa. Merely in Xinjiang, China, there are 47 coal fire zones which altogether take up 7 million square meters. These coal fires also release a lot of energy while burning up much coal resources, also. However, with widely-used coal-fire control techniques, such as grouting and water injection, the heat energy in the coal fire zone has always been treated as a kind of disaster resource and therefore were abandoned without being exploited and utilized, which results in a huge loss of energy. If coal fire control and heat extraction should be combined, that is, cooling high-temperature coal and rock by extracting the heat in the coal fire zone, organic unity would be realized among fire prevention and extinguishing, resources utilization and environmental protection. Therefore, based on the analysis of the geological conditions of coal fire zones, the method of forced convective heat extraction is designed. With the three-dimensional numerical simulation technique (Fluent), the effects of different borehole arrangement and the injection rate of heat transfer medium (HTM) on the temperature of the coal fire zone and the heat extraction rate during the heat extraction process are analyzed. The results show that the inert-gas-as-HTM and its multi-hole press-in and oriented method prove to be more suitable for coal fire zone than its single-hole press-in and single-hole extraction method. Besides, the temperature of coal fire zone can be reduced effectively by adopting the multi-hole press-in and oriented heat-extraction method, with the maximum temperature (T_1), the average temperature(T_2) of coal fire zone and the heat extraction time(t) in a quadratic function relationship which can be represented by the formula $T_1(T_2)=at^2+bt+c$. Moreover, the temperature of the extracted HTM, the rate of heat extraction and their rates of change decrease as the time of heat extraction increases. Within the same period of heat extraction time, the temperature of extracted HTM can be increased by reducing the amount of HTM injected. The rate of heat extraction is more stable when the amount of HTM injection is relatively small. This research provides a reference for the combination of fire control and energy utilization in coal fire zone.