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**PROCEEDINGS**

# Simulation of Temporary Plugging Agent Flow State in Fractures of Hot Dry Rock Considering Environmental Changes

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**ABSTRACT**

Geothermal energy is an important renewable energy source, where hot dry rock (HDR) constitutes the primary component, accounting for approximately 90% of the resource. Therefore, the establishment of an efficient HDR geothermal utilization system is a core issue in geothermal resource development. Hydraulic fracturing (HF) technology serves as a crucial means aimed at enhancing the complexity of underground fracture networks and increasing heat exchange efficiency, thus improving the performance of HDR geothermal utilization systems. However, the fracture structure formed by conventional HF techniques is relatively simple, resulting in limited heat exchange areas. Hence, the temporary plugging and diverting fracturing (TPDF) technology, which enhances fracture complexity, emerges as one of the most important techniques in hydraulic fracturing.

TPDF technology involves the injection of fracturing fluid containing temporary plugging agent particles into the fracture end, gradually sealing the fracture to alter its direction. The diversion effect of temporary plugging in fractures is closely related to the migration of plugging agents. However, existing studies often overlook the temperature changes in HDR during the migration of plugging agents. Based on the premise of considering HDR temperature variations, this study conducted a simulation investigation on the migration process of plugging agents under different conditions. The results indicate that as the migration speed of temporary plugging agents increases from 0.2m/s to 0.4m/s, the temperature rise at the fracture outlet decreases from 5.8% to 2.67%. Furthermore, under different inlet velocities, fracturing fluid viscosities, and fracture structures, varying characteristics are observed in the distribution of particle temperatures.

**KEYWORDS**

Temporary plugging and diverting fracturing; rock temperature decline; particle migration

Geothermal energy plays a crucial role in the global energy system. If fully developed, the geothermal energy within the upper 10 kilometers of the Earth's crust would be sufficient to meet human energy demands for approximately 200 million years. Among geothermal energy resources, hot dry rock (HDR) constitutes the predominant component, accounting for about 90% of the total. Therefore, the establishment of efficient HDR geothermal utilization systems is imperative for the development of geothermal resources. Hydraulic fracturing (HF) technology serves as a pivotal component in enhancing these systems.

Traditional HF techniques typically result in relatively simple fracture structures with fewer branching fractures, thereby limiting heat exchange areas. In contrast, the temporary plugging and diverting fracturing (TPDF) technology utilizes temporary plugging agents to temporarily seal fractures and alter their direction, thereby enhancing the complexity of underground fracture networks and increasing the heat exchange area within HDR formations. The flow state and transport processes of temporary plugging agents within fractures have a direct impact on the outcomes of TBADF. Hence, investigating the migration process of temporary plugging agents within fractures is of paramount importance for geothermal energy extraction.

Within fractures, the flow of temporary plugging agents primarily manifests as particle flow, involving particle migration, collisions, and aggregation. Traditional research methods include Euler-Euler and Euler-Lagrangian models. The Euler-Euler model treats particles as a continuous medium and is suitable for handling dense particle flows with lower computational demands. In contrast, the Euler-Lagrangian model treats the fluid phase of temporary plugging agents as a continuous medium, with each particle treated as an individual entity, resulting in higher computational costs but superior accuracy. With advancements in computer performance, more computational resources are available for research. Therefore, to achieve better computational efficiency, this study employs the Computational Fluid Dynamics-Discrete Element Method (CFD-DEM) based on the Euler-Lagrangian model to simulate particle flow within fractures.

This study, employing the CFD-DEM method and considering HDR thermal conduction, investigates the particle flow within fractures under different conditions, including inlet velocities, temporary plugging agent viscosities, and fracture structure characteristics. The study reveals variations in parameters such as fracture outlet temperature and particle temperature at different locations within fractures. For instance, under conditions of an inlet velocity of 0.2m/s, temporary plugging agent viscosity of 30mPa·s, and no branching fractures, the fracture outlet temperature decreases from 10.82% to 5.71% when thermal conduction of the rock is not considered. When considering rock thermal conduction, with a simulation time of 3 seconds, increasing the inlet velocity from 0.2m/s to 0.4m/s results in a decrease in the fracture outlet temperature from 5.8% to 2.67%. Similarly, an increase in temporary plugging agent viscosity from 30mPa·s to 90mPa·s leads to a change in the fracture outlet temperature from 5.7% to 5.46%. Furthermore, with two branching fractures at a 45° angle, the fracture outlet temperature is 10.5%, whereas with two branching fractures at a 90° angle, the fracture outlet temperature is 12.4%.

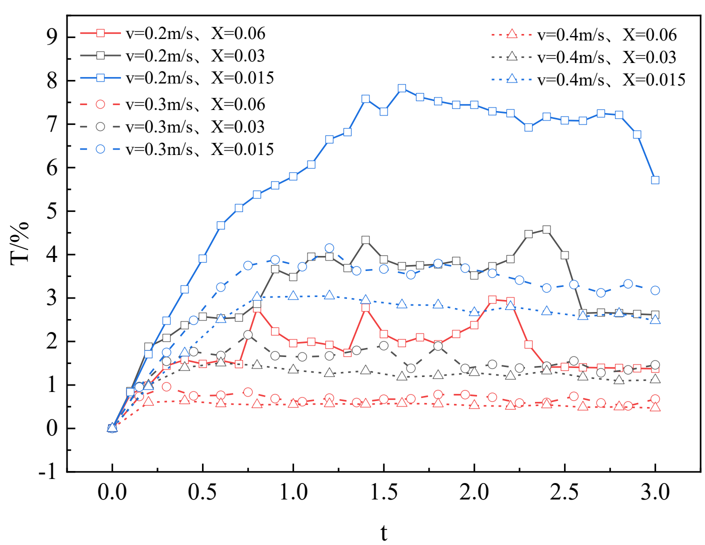


**Fig. 1.** Influence of temporary plugging agent inlet velocity on the flow temperature of temporary plugging agents within fractures

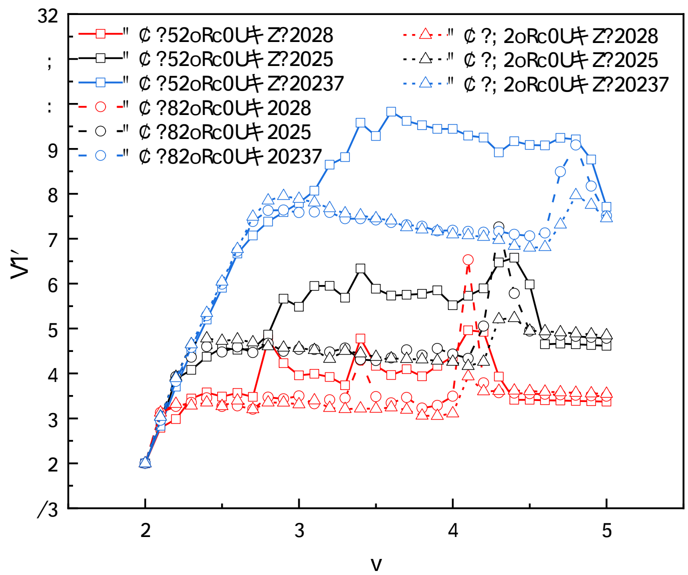

**Fig. 2.** Influence of temporary plugging agent viscosity on the flow temperature of temporary plugging agents within fractures

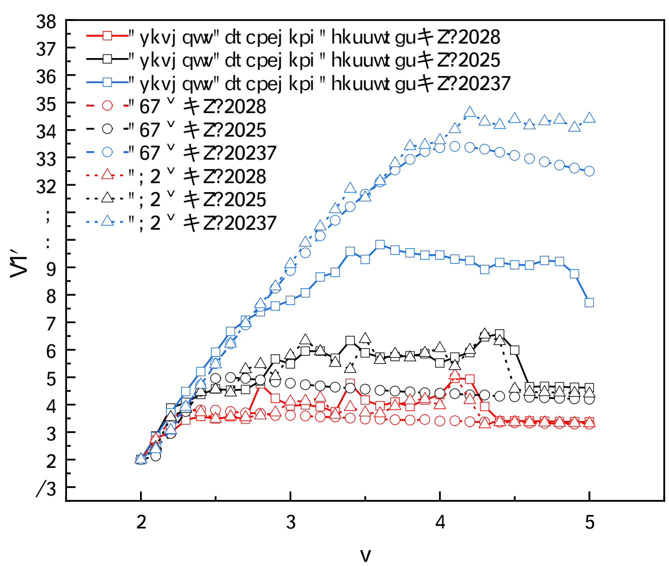

**Fig. 3.** Influence of fracture structure on the flow temperature of temporary plugging agents within fractures

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**Conflicts of Interest:** The authors declare that they have no conflicts of interest to report regarding the present study.