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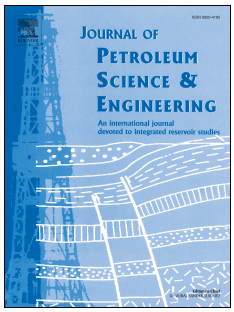

Numerical and experimental analysis of hot dry rock fracturing stimulation with high-pressure abrasive liquid nitrogen jet

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Numerical and experimental analysis of hot dry rock fracturing stimulation with high-pressure abrasive liquid nitrogen jet

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Abstract

Abrasive liquid nitrogen (L-nitrogen) jet fracturing is a novel technology, which is expected to be suitable for hot dry rock (HDR) fracturing. In this paper, numerical simulation has been presented to analyze the fluid flow, heat transfer and thermal stresses distribution in HRD fracturing with abrasive L-nitrogen jet. The simulation is carried out with a three-dimensional model in transient state. The low Reynolds number κ-ε model is employed to accurately predict the near wall flow. The heat transfer between L-nitrogen and hot rock on solid-liquid interface is computed by an inverse method of conjugate heat transfer. The thermo-elastic model is used to calculate the thermal stresses distribution in rock. Numerical results indicate that abrasive L-nitrogen jet has a better performance in perforation than abrasive water and supercritical CO_2 jet. Great tensile stress distributes in the region near interface, however, its affected depth is limited. This tensile is expected to be favor for fractures generation and growth along perforation direction. Short perforation length can promote the heat transfer on interface. The initial rock temperature has an important influence on values of thermal stresses. Experiments, in which the hot granite specimens with a small hole in center were impacted by L-nitrogen jet, have been conducted to validate the effect of thermal stresses on fracturing. The fractal method is adopt to quantitatively describe the flow and transport capability in rock masses. Experimental results show that numerous thermal cracks were generated on the interface. Rising rock temperature can significantly increase the number and size of thermal cracks and improve the connectivity of fractured rock, which are benefit to fracture initiation during L-nitrogen jet fracturing. The results in this paper would shed light on L-nitrogen jet fracturing for HDR as well as some high-temperature oil reservoirs.

Keywords: HDR fracturing; Abrasive liquid nitrogen jet; Flow field; Heat transfer; Thermal stress; Fractal;

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