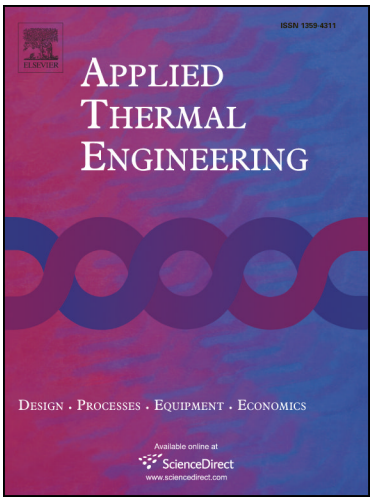

Research Paper

Numerical Investigation on Heat Extraction Performance of a Downhole Heat Exchanger Geothermal System

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Numerical Investigation on Heat Extraction Performance of a Downhole Heat Exchanger Geothermal System

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Abstract

The downhole heat exchanger (DHE) geothermal system is commonly used to exploit geothermal energy for space heating. In this paper, a 3D unsteady state numerical model is established to couple fluid flow and heat transfer processes of DHE system. The model is validated by field experimental data. Temperature and velocity fields are analyzed to understand thermal process of DHE system. Heat extraction performances of three different DHE structures, including single U-tube, double U-tube and spiral tube, are compared. Subsequently, cases are studied to investigate how key parameters affect DHE performance. Simulation results depict that spiral-tube has the best heat extraction performance. As working fluid mass flow rate rises, outlet temperature declines and thermal power increases. When inlet temperature ascends, outlet temperature rises while thermal power decreases. Effects of reservoir porosity and tube wall heat conductivity on DHE performance are minor. Higher subsurface water velocity and larger rock heat conductivity can improve DHE performance, but the former has a more significant influence. Besides, subsurface water flow direction has neglected influence on performances of single and double U-tube, but appreciable impact on that of spiral tube. Key findings of this work are beneficial for optimal design and optimization of DHE geothermal system.

Key words: geothermal energy; downhole heat exchanger; heat extraction performance; influencing factors; flow and temperature fields

1. Introduction

The rapid growth of energy demand desires renewable and clean energy sources alternative to conventional fossil fuels, which could cause severe environmental pollution [1, 2]. Geothermal resource is one of the most competitive renewable and clean energies. The heat stored within subsurface of 5 km depths is around 140×10^6 EJ. If only 1% of the total heat energy is exploited, it is sufficient for approximately 2000 years energy supplement to the whole world [3]. Thus, geothermal resource has advantages of abundance, environmentally friendly and easy exploitation, which has attracted global attention.

Over the past decades, the DHE geothermal system has been widely used to

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