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Simulation and performance characteristics of rock with borehole using Visual Finite Element Analysis

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Abstract

Purpose. This study aims to investigate fluid flow and heat transfer within rocks containing boreholes, focusing on the complex mechanisms within hot reservoirs. Non-commercial finite element (FE) software is used to visualize and present the results.

Methods. The study involved the use of FE method with Visual Finite Element Analysis (VisualFEA) software to analyze the coupled phenomena of fluid flow and heat transfer in a rock sample. Special attention was given to incorporating material structure and geotechnical analysis in the software, as well as the treatment of cracked elements. In addition, the validation was done by comparing the current numerical solution using VisualFEA with the numerical solution using ANSYS Software.

Findings. The study findings highlight the capabilities of VisualFEA software to accurately represent fluid flow, stress, and heat transfer in borehole-containing rocks. The results include insights into flow direction within the borehole, temperature distribution, and the validation of the software performance against expected system behavior. The study demonstrates the effectiveness of VisualFEA in handling complex loading and its ability to visualize multiple flow directions within a 2D model. The results are presented in the form of contours and curves.

Originality. This study contributes to the field demonstrating the application of VisualFEA software in analyzing fluid flow and heat transfer in rocks with boreholes. The focus on incorporating material structure, geotechnical analysis, and treatment of cracked elements adds originality to the study, providing a comprehensive understanding of the coupled phenomena in hot reservoirs.

Practical implications. The practical significance of this study is in the validation and benchmarking of VisualFEA software for studying fluid flow and heat transfer in geotechnical application. The findings can be utilized by geotechnical engineers and researchers to better understand the behavior of borehole-containing rocks under specific pressure and thermal loading conditions. The insights gained from this study can be used in decision-making processes related to resource mining, reservoir engineering, and geothermal energy use.

Keywords: *coupled simulation, fracture, rock mechanics, transient analysis, VisualFEA*

1. Introduction

Deep beneath the surface, in the heart of the Earth, there is a hidden world of intense heat and pressure. Geothermal regions are places of constant movement and change, where molten rock and superheated water surge and swirl, carving out channels and pathways that stretch for miles. The hydrodynamic behavior of a fractured reservoir needs to be studied in detail. Therefore, the distribution of pressure and flow in the cracked rock has been presented and simulated using different models and codes. The fracture and fluid models have been presented separately [1]-[6]. However, the thermocouple study was obscure. On the other hand, the modeling of complex coupled transient and dynamic processes in geosystems is being extended to provide more precise and realistic evaluation.

Until now, only a few publications have dealt with the coupling of thermal, fluid, and structural analyses of the rock. However, most of the work is based on commercial software and codes. These are either difficult to use or expensive, and the relevant codes are either not applicable or incomplete.

Stresses, strains, and temperatures are examples of scalar data obtained from FEA. Contouring is the most widely used method for visualizing scalar data. Therefore, VisualFEA [7] provides easier steps for initiating the geometry and different options for the meshing process. The main objective of VisualFEA is to overcome such barriers between the user and the software [7]. VisualFEA/CBT, which is used in this work, is

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