Numerical study of the effect of acidizing on the permeability of rock joints during shear displacement

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(Received: July 2021, Accepted: February 2022)

Keywords

Permeability
Acidizing
Shear displacement
Numerical modeling
Cubic law

English Extended Abstract

Summary

A numerical code based on the finite element method in MATLAB software has been developed to investigate the effect of joint shear rate on the hydraulic behavior of joints in pre/post-acidizing conditions.

Introduction

Evaluation of permeability and fluid flow behavior in rock joints is one of the most critical and fundamental issues in many rock engineering projects. In recent years, changes in the permeability of rock joints and mechanical deformations of the rock mass with the effects of chemical reaction have been studied by H-M-C process. Shear-flow coupling tests are generally performed under conditions where the flow direction is either parallel to the cutting direction or radially from the center of the joint sample due to the limitations of difficult laboratory conditions. One of these difficulties is the complete insulation of the sample to create a one-dimensional linear flow in the direction of the shearing. Numerical simulations can eliminate laboratory difficulties with flow sealing conditions. In this paper, the influence of chemical agents on fluid flow while the shearing process is applied. Due to the difficulties of implementing this issue, modeling has been done by developing a computational code using the finite element method.

Methodology and Approaches

Designing a coupling process with simultaneous effect of hydro-mechanical-chemical phenomena, numerical modeling based on the finite element method has been used to study the effect of shear displacement on fluid flow rate when fracture surfaces are degraded. The hydraulic head pressure (equal to one meter of water) is applied to the flow's input, and zero pressure is applied to the flow's outflow to simulate and quantify the flow rate from the fracture's left to right. The upper and lower boundaries of the fracture are also sealed. In the next step, because the fluid flow is to be examined separately in the X and Y directions, then, in each step, the flow in the conduct of outlets must be opened in the desired direction and closed in the other directions. To apply the effect of shear displacement on the flow rate, a secondary code based on the changes in the elements due to shear displacement was used and added it to the computational process of the developed primary code. The aperture values in each step are calculated and returned to the original code to calculate the flow rate step by step.

Results and Conclusions

The results show that with increasing the shearing rate in both conditions before and after acidizing, the flow rate has an increasing trend. Also, the fluid flow pattern goes channelized with an increasing shear rate. After acidizing the joint surface, the difference between the roughness coefficient and the linear roughness of the two fracture surfaces increases, which increases the initial hydraulic conductivity of the fracture, and flow changes shows a lower trend compared with the conditions in the pre-acid state. In some cases, the trend of discharge rates in the conditions after acidizing does not follow the general pattern of discharge rates. It seems it’s caused by closures which are created by shear displacement in the fluid flow path, forcing the fluid to change direction and find a new path to pass through the joint.