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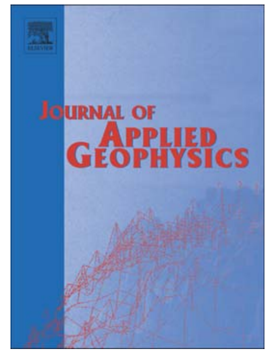

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Analytical and numerical solutions for heat transfer and effective thermal conductivity of cracked media

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Abstract

This paper presents analytical solutions to heat transfer problems around a crack and derive an adaptive model for effective thermal conductivity of cracked materials based on singular integral equation approach. Potential solution of heat diffusion through two-dimensional cracked media, where crack filled by air behaves as insulator to heat flow, is obtained in a singular integral equation form. It is demonstrated that the temperature field can be described as a function of temperature and rate of heat flow on the boundary and the temperature jump across the cracks. Numerical resolution of this boundary integral equation allows determining heat conduction and effective thermal conductivity of cracked media. Moreover, writing this boundary integral equation for an infinite medium embedding a single crack under a far-field condition allows deriving the closed-form solution of temperature discontinuity on the crack and particularly the closed-form solution of temperature field around the crack. These formulas are then used to establish analytical effective medium estimates. Finally, the comparison between the developed numerical and analytical solutions allows developing an adaptive model for effective thermal conductivity of cracked media. This model takes into account both the interaction between cracks and the percolation threshold.

Keywords: Effective thermal conductivity; cracked media; adaptive scheme, BEM.

1 Introduction

In most practical situations, the cracked media have three-dimensional characteristics. However, two-dimensional modelling of heat transfer in solid media is usually required when considering the heat transfer from a linear heat source and the fractures are perpendicular to the considered 2D plane and sufficiently long in the normal direction to this plane. That are the cases of widely applications in geomechanical fields such as