SPACING AND WIDTH OF COOLING CRACKS IN ROCK

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Summary

One important question in the hot dry rock geothermal energy scheme is the spacing and opening widths of secondary cracks that are induced by cooling in the walls of the main crack and propagate into the hot rock mass. To achieve a significant heat extraction rate after longer periods of operation, it would be necessary to have widely opened secondary cracks, which in turn requires a large spacing of these cracks.

The problem may be treated as a cooled halfspace. When a system of equidistant cooling crack propagates into a halfspace, it reaches at a certain depth a critical state at which the growth of every other crack is arrested. Later these cracks reach a second critical state at which they close. The intermediate cracks, at doubled spacing, open about twice as wide and advance further as cooling penetrates deeper. Determination of the critical states requires calculation of the derivatives of the stress intensity factors with regard to crack lengths, which is accomplished by the finite element method.

It is found that the crack depth-to-spacing ratio at which the critical state is reached is extremely sensitive to the temperature profile. It greatly increases as the cooling front becomes steeper, which is not favorable for maintaining a high heat extraction rate. The effect of transverse isotropy of the material upon the location of critical states is found to be relatively small. Approximate formulas for crack spacing as a function of temperature profile, to be used in conjunction with the analysis of water flow and heat transfer in the cracks, are developed.

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