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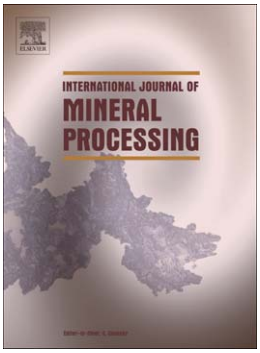

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Thermal Stress FEM Analysis of Rock with Microwave Energy

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Abstract

This paper presents a study of a thermal breakage process used to analyse the thermal stress and crack development that occurs when rock is exposed to short-pulse microwave energy. A two-dimensional circular plate, containing two-phase minerals, was used in finite element simulation to calculate thermal stress for the purpose of better understanding thermal fracture behaviour in comminution. It is found that the thermal mismatch between a microwave-absorbing inclusion and a low-absorbing matrix mineral can generate large localized thermal stresses around the inclusion. Fracture initially occurs, not around the grain boundaries between the two minerals, but some distance away, as a result of thermal expansion stress on the matrix mineral. The results also indicate that though grain size is one of the factors causing cracks during heating of granular materials, it is not the only reason. The size and the thermal properties of the matrix mineral can also affect the results of thermal stresses.

Introduction

Breakage is essential in most mineral processing operations to liberate valuable minerals. The comminution process in the mineral processing industry is extremely energy-intensive, accounting for the majority of energy consumption in the mineral recovery process (Schwechten and Milburn, 1990)

Heating to facilitate comminution has been applied in the mineral industry for nearly a century (Yates, 1918 and Holman, 1926). In 1984 the microwave absorption properties of minerals were reported by Chen et al. (1984). Their research indicated that certain groups of minerals, such as chalcopyrite, pyrite, galena and magnetite, are good heaters (microwave-absorbing); while others, such as silicate and carbonate gangue minerals, are poor heaters (microwave low-absorbing). Significantly, different thermal properties between different mineralogical species in the same rock result in the generation of thermal stresses and, consequently, cracks within the rock sample. Many studies on this subject have been published in the past two decades (Wills et al., 1987, Raddatz et al., 1989, Rowson and Rice, 1990, Uslu et al., 2003). Fitzgibbon and Veasey (1990) suggested that these thermal cracks may lead to a significant reduction in grinding

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