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An Investigation of the Fracture Behavior of Model MgO-C Refractories Using the Discrete Element Method

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Abstract : Refractory composite materials employed in steel casting applications are prone to cracking and material damage because of the very high operating temperature (thermal shock) and mismatched properties of the constituent phases. The fracture behavior of a model MgO-C composite refractory is investigated to quantify and characterize its thermal shock resistance, employing a cold crushing test and Brazilian test with fractographic analysis. The discrete element method (DEM) is used to generate numerical refractory composites. The composite in DEM is represented by an assembly of bonded particle clusters forming perfectly spherical aggregates and single spherical particles. For the stresses to converge with a low standard deviation and a minimum number of particles to allow reasonable CPU calculation time, representative volume element (RVE) numerical packings are created with various numbers of particles. Key microscopic properties are calibrated sequentially by comparing stress-strain curves from crushing experimental data. Comparing simulations with experiments also allows for the evaluation of crack propagation, fracture energy, and strength. The crack propagation during Brazilian experimental tests is monitored with digital image correlation (DIC). Simulations and experiments reveal three distinct types of fracture. The crack may spread throughout the aggregate, at the aggregate-matrix interface, or throughout the matrix.

Keywords : refractory composite, fracture mechanics, crack propagation, DEM
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