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Determination of the fracture behaviour of MgO-refractories using multi-cycle wedge splitting test and digital image correlation

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Abstract

Refractories with reduced brittleness show a pronounced deviation from linear elastic behaviour and an enhanced thermal shock resistance. This paper aims to study the influence of microstructure on the fracture behaviour of magnesia refractories. The wedge splitting test(WST), which enables stable crack propagation for quasi-brittle materials, was used to identify the fracture behaviour and evaluate the energy dissipation. The evaluation of the crack lengths of the magnesia and magnesia spinel materials during the entire cyclic WST is based on the localized strain evaluated using the digital image correlation (DIC). A significant fracture process zone develops in the magnesia spinel material. The relationship between the dissipated energy and the actual crack length, which was used to characterize the crack growth resistance, was determined. The refractory materials that showed reduced brittleness consume a small amount of energy for fracture initiation but a large amount of energy for further crack propagation.

Key words: **Magnesia refractories, Fracture behaviour, Toughening, Cyclic wedge splitting test, Digital image correlation**

1. Introduction

The thermal shock resistance is a key factor for the safe and prolonged usage of refractory materials. Different thermal shock parameters were developed for the characterization of thermal shock resistance. For example, the thermal shock parameter R [1] developed by Kingery was used to evaluate the crack initiation resistance. The thermal shock parameter R'''' [2] developed by Hasselman was used to characterize the crack propagation resistance. For many industrial applications, refractories with reduced brittleness, which correspond to pronounced deviations from pure linear elastic fracture mechanics (LEFM) [3], are favourable. The characteristic length l_{ch} introduced by Hillerborg was used to describe the material brittleness [4]:

$$l_{ch} = \frac{G_F E}{{\sigma_t}^2} \qquad (1)$$

Here, G_F is the specific fracture energy for forming two fracture surfaces, σ_t is the tensile strength and E is the Young's modulus. Generally, refractory materials achieve reduced brittleness by decreasing the ratio σ_t^2/E while maintaining G_F [5]. The characteristic length is twice of the thermal shock parameter R'''' developed by Hasselman [2]. It confirms that a

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