MULTISCALE ANALYSIS OF PIEZOELECTIRC CERMICS BY USING BOUNDARY ELEMENT METHOD

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1. Introduction

The barium titanate ($BaTiO_3$) compound is the most intensively studied perovskite material due to its wide use in the ceramics industry [1, 2]. Barium titanate is also a useful and technologically important material owing to its ferroelectric behaviour at and above room temperature [1]. Barium titanate is widely used in electronic devices, such as multilayer ceramic capacitors, tunable filters and piezoelectric sensors due to its high chemical and mechanical stability [3].

Over the past decades numerical simulation of fracture in piezoelectric ceramics has primarily been based on linear elastic fracture mechanics models [4, 5]. The use of either impermeable or permeable boundary conditions has been studied extensively [6]. A partition of unity-based multiscale approach for modeling fracture in piezoelectric ceramics.

Boundary element method (BEM) is a general numerical method for solving boundary-value or initial-value problems formulated by using of the Boundary Integral Equation (BIE) [7]. The dimension reduction in BIE formulations makes the BEM mesh much easier to generate for three dimensional problems or infinite domain problems. The boundary element method has a number of advantages relative to finite difference method and finite element method, such as requiring only surface discretizations and exactly treating boundary conditions at infinity [8]. However, it suffers from well-known drawbacks with regard to the computational efficiency, since the conventional BEM leads to a linear system of equations with dense coefficient matrix [7, 9]. Besides, the BEM is a semi-analytical method and thus is more accurate, especially for stress concentration problems such as fracture of structures and can be applied along with the other domain-based methods to verify the solutions to a problem for which no analytical solution is available [7].

2. Methods

The paper presents an effective implementation of boundary element multiscale method in analyzing of piezoelectric ceramics. The method is applied based on constitutive equations and numerical modeling. This method can be easily used to get a better understanding of damage mechanism in the ceramic materials in order to improve the constitutive models and to support the future design of those materials.

In this equation the relation of boundary element method for obtaining traction is presented. This equation must be integrated over segments of boundary (Fig. 1).

$$n_m(z_0)\int_S D_{jlm}(z,z_0)t_j(z)ds(z) - n_m(z_0)\int_S W_{jlm}(z,z_0)\frac{\partial u_j(z)}{\partial s(z)}ds(z) + n_m(z_0)\int_\Gamma D_{jlm}(z,z_0)\Sigma t_j(z)ds(z)$$

$$-n_m(z_0)\int_\Gamma W_{jlm}(z,z_0)\frac{\partial \Delta u_j(z)}{\partial s(z)}ds(z) = \frac{1}{2}(t_l(z_0) \quad z_0 \in S$$

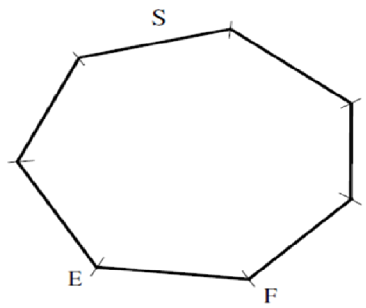

Fig 1. Discritized boundary on the element and crack surface.

3. Results

In this study, a multiscale method via boundary element method was introduced. Then bridges meso-scale to macro-scale by a damage parameter was performed. This method was applied on piezoelectric ceramics.

4. References

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