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Interaction of an edge dislocation with a coated elliptic inclusion

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ABSTRACT

This paper presents an analytical solution for plane elasticity problems of an elliptically cylindrical layered media subject to an arbitrary edge dislocation. Based on the technique of conformal mapping and the method of analytical continuation in conjunction with the alternating technique, the general expressions of the displacements and stresses, where an edge dislocation is located in matrix, coating layer and inclusion are obtained. The numerical results of image forces exerted on a generalized edge dislocation are carried out by using the generalized Peach–Koehler equation. As a numerical illustration, both the image forces and equilibrium positions are presented for different material combinations and relative thickness of a coating layer. The result shows that the thickness and the shear modulus of the coating layer have a strong influence on the stability of dislocation.

1. Introduction

The interaction between an edge dislocation and multiple-phase materials is an important topic for understanding the physical behavior of engineering materials. This is because the dislocation mobility plays an important role in analyzing the mechanical and physical behavior of composite materials, and the mobility or stability is dependent upon the internal forces acting on the dislocation. Such investigations may be useful for determining the optimal cross section of composite materials and providing some insight into how the interaction of shape and material property affects the response of the materials.

Head (1953a,b) first derived the force on the dislocation which is near the straight interface between two dissimilar media. He found that the dislocation is either repelled or attracted by the interface, depending on the combination of two material constants. For the interaction problem of a dislocation near a circular inclusion, Dundurs and Mura (1964) indicated that an edge dislocation may have stable equilibrium positions near the inclusion. However, a screw dislocation is either attracted or repelled by the inclusion (Dundurs, 1967). The interaction between an edge dislocation with an elliptical inhomogeneity was studied by Smith (1968), Stagni (1982), Stagni and Lizzio (1983), Santare and Keer (1986), Tsuchida et al. (1991) and Stagni (1993). They solved the interaction of an edge dislocation outside the elliptical inhomogeneity, where the properties of the elliptical inhomogeneity range from a void to a rigid inclusion. The solution to the problem of an edge dislocation inside an adhering elliptical inclusion was obtained by Warren (1983). A screw dislocation interacting with an elastic elliptical inhomogeneity was studied by Gong and Meguid (1994) based on the Laurent series expansion. Some solutions for the problems of the dislocation (or a point force) inside the inhomogeneity have been also obtained and used to discuss the mobility and the equilibrium position of the dislocation by Chen (1995), Stagni (1999) and Fang et al. (2009).

The above works on interaction between inhomogeneities and dislocations involve an isolated inhomogeneity only. For multiphase materials, the dislocations interact not only with the nearest inclusion but also with the surrounding ones. Christensen and Lo (1979) introduced a three-phase composite cylinder model consisting of three concentric regions. Luo and Chen (1991) studied the problem of an edge dislocation located in the intermediate matrix phase based on the three-phase composite cylinder model by using the Laurent series expansion. Based on the Muskhelishvili's complex variable method of elasticity theory, Xiao and Chen (2000, 2001, 2002) considered a screw or an edge dislocation embedded in the three-phase composite cylinder model to analyze the strengthening and hardening mechanisms of heterogeneous materials. Liu et al. (2003) investigated the interaction between a screw dislocation and a three-phase composite cylinder by using Cauchy integral and Laurent series expansion techniques. Chao et al. (2006) solved the elastic fields of the three-phase composite cylinder media subjected to an arbitrarily located point force (singularity) by using the method of analytical continuation in

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