An extended finite element method for modelling dislocation interactions with inclusions

abstract
A method for modelling the interactions of dislocations with inclusions has been developed to analyse toughening mechanisms in alloys. This method is different from existing methods in that infinite domain solutions are not superimposed. The method is based on the extended finite element method (XFEM) in which the dislocations are modelled according to the Volterra dislocation model. Interior discontinuities are introduced across dislocation glide planes using enrichment functions and the resulting boundary value problem is solved through the standard finite element variational approach. This method can be used to analyse complex geometries, interfaces with mismatch strains and materials with anisotropic properties. The level set method is used to describe the geometry of the dislocation glide planes without any explicit treatment of the interface geometry which provides a convenient and an appealing means for tracking moving interfaces. A method for estimating the Peach-Koehler force by the domain form of J-integral is considered. The convergence and accuracy of the method is studied for an edge dislocation interacting with a free surface where analytical solutions are readily available. The applicability of the method to dislocation interactions with inclusions is illustrated. A system of Aluminium matrix with Aluminium-Copper precipitates is chosen. The effect of size, shape and orientation of the inclusions on an edge dislocation for a difference in the stiffness and coefficient of thermal expansion of the inclusions and matrix is considered. The energy needed to move an edge dislocation through a domain containing an array of circular, square and diamond shaped inclusions is calculated. The extension of this method to other types of dislocations in addition to edge dislocation studied here is straightforward.