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Three-dimensional J- and Interaction Integral Evaluations for Unstructured Finite Element Mesh around the Crack Front

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In this presentation, methods to compute the crack parameters such as the stress intensity factors and the J-integral in three-dimensional problems, based on the domain integral method for unstructured finite element mesh around the crack front consisting of the quadratic tetrahedral finite element, are presented. They are the interaction integral method for the computations of mixed-mode stress intensity factors for linear elastic material and ii) J-integral for elastic-plastic solid undergoing finite deformation. In both the cases, the straight forward methodologies loose the property of integral domain independence.

In the case of interaction integral method, the auxiliary solutions which are the asymptotic solutions of the crack do not rigorously satisfy the equilibrium in terms of the finite element method. The stress intensity factors computed by the straight forward approach sometimes contain a large amount of numerical error. Thus, the correction terms are introduced to recover the equilibrium of the auxiliary field in terms of the finite element mesh. Hence, it is applied to fatigue crack propagation problems.

For the problem of the finite deformation elastic-plastic solid, the stress measure in the J-integral computation is chosen to be the first Piola-Kirchhoff stress tensor and the integral is carried out for the initial configuration. Furthermore, the assumption of proportional loading which is often adopted in the infinitesimally small strain case is not valid any more in the case of finite deformation elastic-plastic problem. That is because the finite rotation associated with the large deformation changes the principal directions of stresses and strains. Therefore, the assumption of proportional loading does not hold any more. To overcome this problem, authors implemented a method to accurately evaluate the spatial derivatives of the stresses and the strain energy density by using the local least square method.

In the presentation ad APCOM 2012, we will present the methodologies of numerical evaluations for the crack parameters and some numerical results.

Keywords: J-integral, Stress intensity factors, Interaction integral method