Three-Dimensional J-Integral based on a Domain Integral Method for Welded Joints

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ABSTRACT

In this research, the three-dimensional J-integral for non-homogeneous material under the influence of weld residual stress, undergoing finite deformation is presented. Welding is applied to many structures, such as power plants, automobile, ships, bridges, etc., for their assemblies. Cracks often emanate from the welded joints or their vicinities. Welding induces residual stresses and material non-homogeneities, due to thermo-elasto-plastic deformation during the processes. Hence, to perform fracture mechanics analysis, we need to take the influences of the material non-homogeneities and the weld residual stresses into our considerations. The influences of finite deformation also need to be considered.

In this presentation, we discuss about a new three-dimensional J-integral based on the virtual crack extension and the domain integral method. It is the three-dimensional version of the T_{ε}^{*} (see, Atluri et al. [1] and Okada and Atluri [2]) which represents the energy dissipation into a small volume V_{ε}^{o} surrounding the crack front, per unit crack extension. Then, we discuss about the treatments on the weld residual stresses and the stain energy density W^{o}. To compute the strain energy density, the entire deformation history, including that during welding, is necessary. Some of the information of deformation history is often missing. The residual stresses may be measured by the experiment or are determined by some empirical formula. We do not have the complete information on the deformation histories of material for the computation of J-integral.

On the other hand, an engineering structure sometimes undergoes a large deformation prior to its failure. Koshima and Okada [3] pointed out that the so-called path independent property was lost due to the effect of finite rotation. To retain the path-independent property, an additional term must be included. Such formulation was presented as the T^{*} integral by Atluri, Nishioka and Nakagaki [1]. Arai, Okada and Yusa [4] recently proposed a three-dimensional J-integral formulation considering the virtual crack extension. They also included the additional term.

Finally, some numerical examples on the evaluation of J-integral are presented. They demonstrate that the proposed three-dimensional J-integral is unconditionally path-independent. Then, possible extension to the ΔJ are discussed as our future research plan.

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