Study of Fracture Parameter for Curved Cracked Bimodular Flexural Specimen Using COMSOL Multiphysics® Software

A. Bhushan[1], S. K. Panda[1]

[1]Indian Institute of Technology (BHU) Varanasi, Uttar Pradesh, India

Abstract

Even though disasters due to presence of crack or crack like defects has been observed both in huge structures like bridges, nuclear reactor or failure of the micron level structures like flip-chip and wire bond packages in electronics industry since the construction of the most primitive artificial structures, however, the formulations of various fracture theories and the understanding of this phenomenon expeditiously accelerated during the twentieth century. It should be understood clearly that rely on structures due to catastrophic failure is sometimes very difficult to avoid because the factors involve in predicting fracture became very complex. And the material unpredictive nature makes the situation more complicated. Here the effect of bimodularity (the phenomenon exhibited by some materials posses different elastic behavior in tension and compression which simultaneously acted in flexural condition named by [1]) on the complex J-integral value derived path-independent for curved crack material media has been discussed [2]. To the best of the authors' knowledge there have not been much work done complex J-integral for bimodular material media for curvature crack geometry.

In the present study, COMSOL Multiphysics® software has been used to investigate the complex J-integral for circular arc cracked flexural specimen for bi-modular nuclear grade graphite (grade 2020 [3]) shown in Fig.1. It is well known fact that the computation of path independent complex J-integral for curve crack geometry is a tedious task even for a unimodular case due to the presence of additional area integral term for curve geometry. The presence of stress dependent modulus of elasticity variable function in the formulation required for the constitutive equation for bimodularity implementation in COMSOL Multiphysics®, the authors are motivated here to investigate the complex J-integral for curved geometry for nuclear grade graphite. The complex J-integral with additional area integral is found to be path independent for bimodular graphite for specific ET/EC (ET is Youngs modulus of elasticity of Nuclear grade-2020 graphite up to proportional limit in tension whereas EC in the compression) ratio equal to 1.83 for all five contours and also compared with the Rice's J-integral as observed in Fig. 2 . The significant effect of bimodularity on the complex J-integral value has been estimated by the help of the results of various simulations, which is carried out by changing the ET/EC ratios from 0.5 to 2.0.

Reference

[1] Tabaddor F. “Constitutive equations for bimodu-lus elastic materials.” AIAA 1972;10(4):516-518,

[2] Khan D, Biswas K. “Circular arc crack under dynamic load: a generalized approach for energy release rate.” Int J Fract (2006) 141:27–35.

[3] General Atomics (1988) "Graphite design hand-book", , DOE-HTGR-88111

Figures used in the abstract

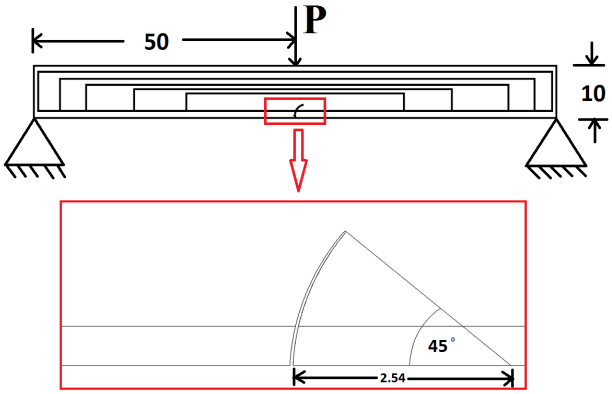

Figure 1: Circular arc cracked flexural specimen with five con-tours for which complex J-integral value evaluated and the arc lengh is 2 mm radius 2.54mm.

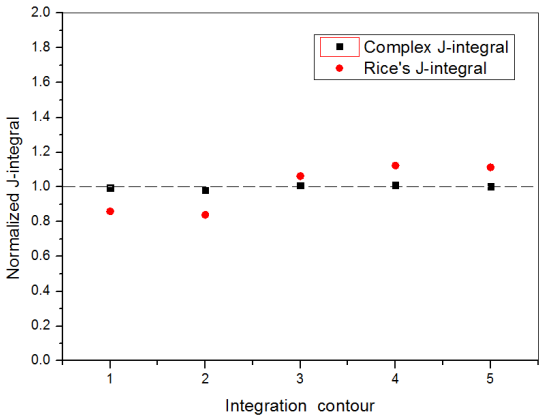

Figure 2: The path independent behaviour of complex J-integral in all the five contoures and comparing with Rice’s J-integral.