Study of Fracture Parameter Using COMSOL-multiphysics For Curved Cracked Bimodular Flexural Specimen

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Introduction: Effect of bi-modularity on complex *J*-integral in curve cracked three point bend specimen has been presented here.

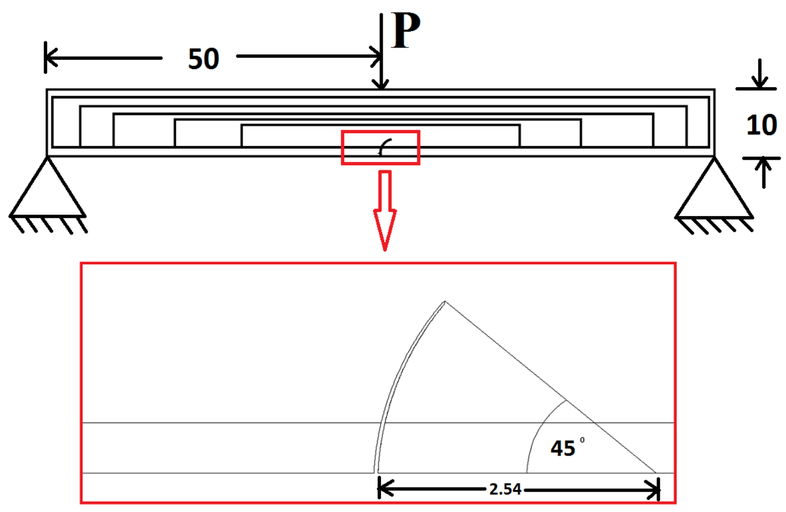


Figure1

Computational Methods: Using stress dependent elasticity considering different Young's modulus of elasticity in tension and compression shown in table 1. The complex *J*-integral for 2D semi-circular geometry has been evaluated, following equation in elastic bi-modular region derived by Khan. et. al, in 2010 [1]

$$\hat{J}_F = \int_{\Gamma_A} (W\hat{n}_\beta - \hat{T}_i \hat{u}_{i;\beta}) d\Gamma - \int_A \frac{1}{r} \hat{\sigma}_{i\beta} \hat{u}_{i;r} dA + [\int_A \hat{\sigma}_{ij} \hat{\varepsilon}^{th}_{ij;\beta} dA + \int_A \hat{\sigma}_{ij} \hat{\varepsilon}^{o}_{ij;\beta} dA + \int_A \rho \ddot{\hat{u}}_i \hat{u}_{i;\beta} dA - \int_A \hat{B}_i \hat{u}_{i;\beta} dA]$$

In elastic bi-modular stress field, the integrals due to material inertial, thermal stresses, initial strain and body forces vanishes and expression reduced to

$$\hat{J}_F = \int_{\Gamma_A} (W\hat{n}_\beta - \hat{T}_i \hat{u}_{i;\beta}) d\Gamma - \int_A \left(\frac{1}{r} \hat{\sigma}_{i\beta} \hat{u}_{i;r} \right) dA$$

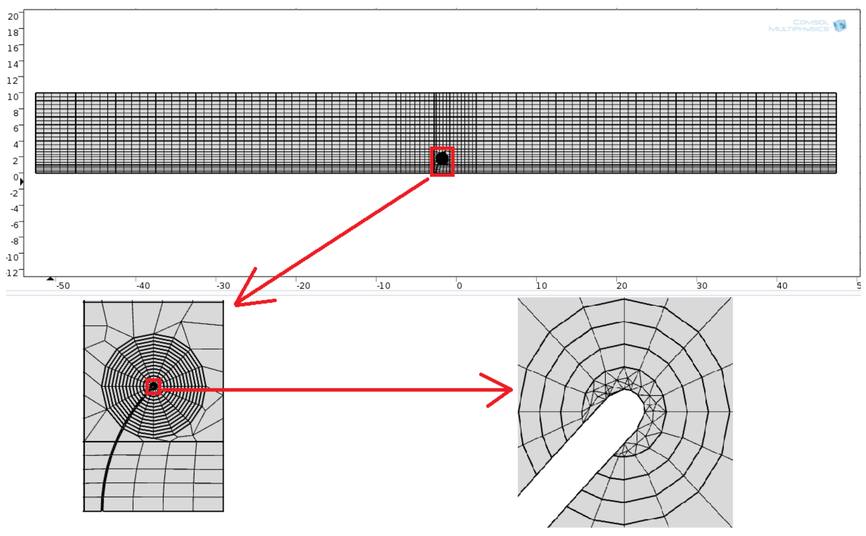
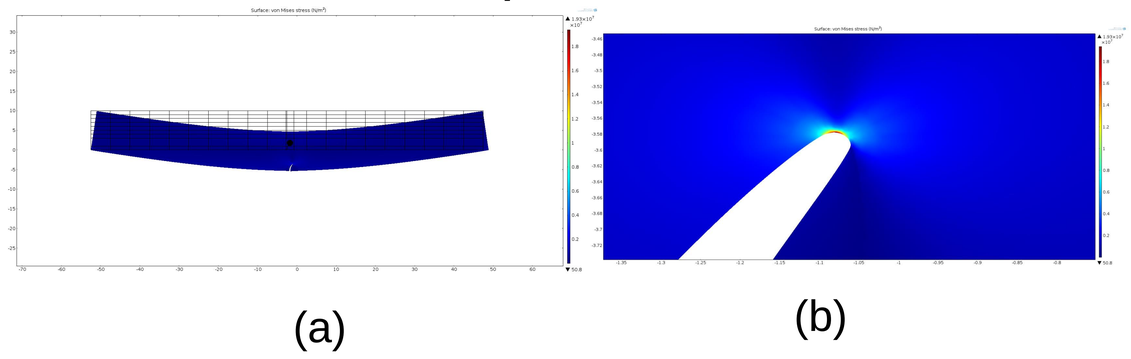


Figure 2. Comsol modular mesh around the crack tip for

Reference [3]	Value	Units
E_T	7.14	GPa
E_C	3.89	GPa

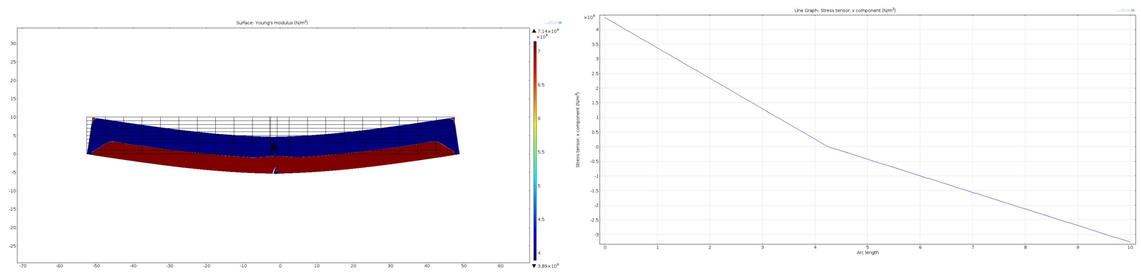
Table 1. Mechanical property of Nuclear grade graphite (grade 2020)

Results: Analysis of Von-Mises Stress around the crack-tip



(a) (b)

Figure 3. Von-Mises stress distribution (a) for whole geometry (b) around the Crack tip



(a) (b)

Figure 4. Young's Modulus plot (a) Representing the region of tension and compression and (b) Normal stress variation in the vertical cut line at quarter length from the left end of the beam

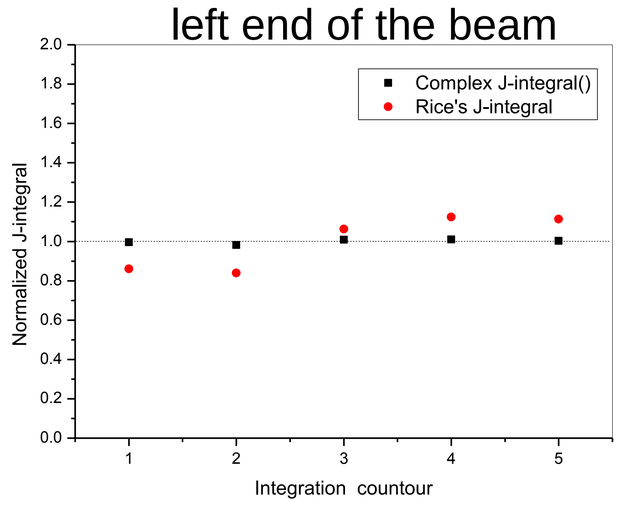


Figure 5.Comaparision of Normalized complex *J*-integral vs Rice's J-integral (for E_T/E_C ratio =1.83) at all contours

Conclusions: The degree of path independency for complex J-integral $\hat{J}_F$ in the comparison of Rice's J-integral [2] is found to very good. The E_T/E_C ratio influences the value of the complex *J*-integral significantly as observed by the simulation of nuclear grade graphite grade (2020). Therefore, it is concluded that the effect of the bi-modularity on the computation of complex *J*-integral $\hat{J}_F$ values cannot be neglected.

References:

1. Khan, D., Biswas, K., "Circular arc crack under dynamic load: a generalized approach for energy release rate." Int. J. Fract. 141, 27–35, (2006).
2. Rice, J.R., "A path independent integral and the approximate analysis of strain concentration by notches and cracks." Trans. ASME, J. Appl. Mech., vol. 35, pp. 379-386, (1968).
3. General Atomics "Graphite design handbook", , DOE-HTGR-88111, (1988).