ABSTRACT

This Thesis focuses on the influence of bimodularity on the strength and the fracture behaviour of nuclear grade graphite. A new analytical hypothesis includes bimodular effect to characterize the strength and the fracture parameters have been proved with the help of experimental and numerical analogy. Weibull statistical approach has been used to evaluate the effective volume and effective surface area. The effective volume and effective area are the key step in estimating reliability of ceramic component life cycle. The most common tests performed to assess the strength and reliability of components made from nuclear grade graphite is flexural tests on rectangular and cylindrical cross-sectioned beam, and C-ring specimen under diametrical compressive and tensile loads. The ASTM closed form solutions for the effective volume and area exists for these specimen geometries has been improved for more general bimodular field, which are based on classical theories with underlying assumptions. In general the closed form expressions are valid for limited specimen geometry bounds. But, the alternative numerical approach based on finite element has been utilized to calculate the effective volume and area for any type of ceramic test specimens. The results obtained through the use of the numerical approach are compared with the analytical closed form solutions and these comparisons leads to the conclusion that the effect of bimodularity has been significant.

The influence of bimodularity on fracture behaviour of graphite specimens has been studied with the help of fracture toughness (K_{Ic}), critical J-integral (J_{Ic}) and critical strain energy release rate (G_{Ic}). The crack characterizing parameters critical stress intensity factor and critical strain energy release rate have been estimated with the help of Weibull distribution plot between peak loads versus cumulative probability of failure. Experimental and Computational fracture parameters have been compared qualitatively to describe the significance of bimodularity.

A universal path independent integral J^u that represents the energy release rate or flux during crack extension in a homogeneous and isotropic material, has been derived for straight and curved crack subjected to multiple loads including magnetostriction. These integrals are widely applicable in the interacting thermo-magneto-elastic problems for aerospace, avionics and nuclear reactor components.

Keywords: Weibull Effective volume, Effective area, Size effect, Bimodularity, Bimodular 3D J-integral, Contour integral, Fracture toughness, Graphite, Strain energy release rate, Bimodular FE analysis, Reliability analysis.