INVESTIGATIONS ON STRESS TRIAXIALITY FOR UNIFIED STRENGTH THEORY AND ANISOTROPY FOR MIXED MODE FRACTURE

ABSTRACT

Structural parts used in boilers, turbines, ships, and many household purposes are manufactured through sheet metal forming processes. During manufacturing, the micro structure of the material is deformed and micro cracks along with anisotropic properties get induced. The first part of the work deals with analytical study of a thin sheet metal plate containing a central crack subjected to mixed mode (*I+II*) loading. Anisotropic triaxiality, at the yield loci of the crack tip has been modelled. According to the well-known *M*-criterion, the crack of any orientation from the loading axis, initiate at a polar angle at which criticality of triaxiality occurred. Thus, the critical values of triaxiality have been obtained by numerically evaluating the proposed model for various crack inclinations. The modelling involves five different anisotropic yield conditions. The combination of six anisotropic constants classifies these conditions. These find wide applicability in metals, polymers, and certain composites and extracted from Hill's generalized anisotropic yield equation. The assumption of limited plastic deformation at the crack tip has been the basis of analysis. In particular, the principles of Linear Elastic Fracture Mechanics hold well i.e. the yielding considered have been up to the small scale. Plastic zone shapes at the crack tip for various crack inclinations are plotted to supplement the results obtained from critical values of triaxiality. For both plane stress and strain conditions, the analysis reveals the regions of the degree of anisotropy for particular Lankford's coefficient and vice versa where the crack initiation angles show variations. In the later part of the work an old model of stress triaxiality at the yield loci of the crack tip, subjected to both plane stress and strain condition under mixed mode (*I+II*) loading has been generalized using Unified Strength Theory to incorporate various convex and non-convex failure criteria, including single shear, twin shear, etc. The new triaxiality model also reveals about the effect of intermediate principal stress at the crack tip for materials with and without strength difference. The crack initiation angles at the crack tip, obtained through the proposed model have been found to be in good agreement with those obtained through other fracture criteria. Lastly an endeavour has been made to combine both energy criteria (strain energy density) and stress criteria (unified triaxiality) to study the variation in SED with respect to triaxiality.

Keywords: Anisotropic triaxiality; Hill's generalized anisotropic yielding; Linear Elastic Fracture Mechanics; Plane stress and strain conditions; ANSYS, FEM