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Comparative Analysis of unit Force Problems using I_P Theory and FEM (ANSYS)

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Abstract

The problem of crack initiation is of tremendous practical interest for is applications are varied and will make the difference of whether the component successfully operates or fails. An attempt is made to study the few basic and simple problems in fracture mechanics to investigate crack propagation using a fairly new concept of I_P Theory. Through the problem investigated here are fairly simple, they provide the working of the method and also and an insight as to how the same can be applied to complex mixed mode problems-which are intended to be presented in last stage along with FEM software analysis. Westergaard's method is used to obtain the complex functions and they are applied in conjunction to obtain stress field ahead of the crack. Since, I_P is a function of first and second stress invariants using the already available stress field. The same problem is solved using FEM i.e. ANSYS and the results found are compared with that obtained with analytical method.

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Keywords:Fracture Mechanics;IpTheory ;FEM; ANSYS;

1. Introduction

The concept of product design has changed drastically over the years we no longer rely on the use of high safety factors or the crude theories of solid mechanics. Many theories have been put forth for the purpose of crack propogation prediction, however many theories prove to be either prove to be either too difficulty to apply to the problem at hand or the result don't match with experimental observations for the case of complex loading. I_P theory

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deals with general crack propagation in a combined stress field where a crack grow in any direction, with reference to its original position. I_P theory is new fracture criterion that determines the critical radius and angular location of crack initaition in the case of ductile material. Morever, it determines critical stress of crack initation. It can be used for predicting the growth crack growth rate due to fatigue on similar grounds to thet of Paris Law. The result of I_P theory is in good agreement with experimental result.The Analytical method for Ip theory and its application to fractute mechanics is developed [1]. A simple criterion of crack initiation based on first and second stress invariants was proposed by Ukadgaonker and Awasare [2] which agrees with the results obtained previously by Theocaris and Andrianopoulos [3] for the case of uniaxial and shear loading at infinity . This criterion determines the critical radius and angle of crack initiation in the case of duuctile material. Some problems was solved by powar [4] using FEM i.e ANSYS and the results found are compared with that obtained with analytical method.

Nomenclature

Z_1, Z_{II}, Z_{III}	Westergaard function for Mode I, II and III respectively
P	Tensile force
Q	Shear force
r	Radius of core region
x,y	Cartesian co-ordinates
r, θ	Polar co-ordinates
K_1, K_{II}, K_{III}	Stress intensity factors for I, II, III respectively
σ_{xx}, σ_x	Normal stress in x-direction
σ_{yy}, σ_y	Normal stress in y-direction
σ_{zz}, σ_z	Normal stress in z-direction
τ_{xy}	Shear stress plane in xy plane
I_1	First stress invariant
I_2	Second stress invariant
A	Length of straight crack
Z	Complex variable
Y	Yield strength

2. Ip theory and its application

Dilatational strain energy of a material is proportional to Ip. Ip = $I_1^2 - 2I_2$ where Ip prominent stress invariant, I_1 and I_2 are first and second stress invariant. This Ip theory is valid for two dimensional and three dimensional cases. This theory is also useful in fatigue loading with temperant variation.

2.1 Infinite plate with central crack

Consider an infinite plate with central crack of length 2b as shown in Fig 1.

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