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ANALYSIS OF CRACK IN DUCTILE MATERIAL

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Abstract: The reliability of structural components is now commonly accessed by fracture mechanics procedures. Fracture mechanics is an engineering discipline that quantifies conditions under which a load bearing body can fail due to the enlargement of dominant crack. The central difficulty in designing against fracture in high strength materials is that the presence of a crack can modify the local stresses to such an extent that elastic stress analysis plays an important role. When a crack reaches a certain critical value, it can propagate through the structure to cause failure in a tensile specimen. Stress intensity factor is important fracture parameters in understanding and predicting dynamic fracture behavior of a cracked body. In the present work an isotropic elastic solid with crack is taken and load is applied. The stress intensity factor and j integral at the crack tip is calculated. The analysis at the crack tip is done with the help of ANSYS software. The results obtained are in good agreement with those found in the literature.

Keywords: Fracture, ANSYS, stress intensity factor, j integral.

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INTRODUCTION

An important problem in the constitutive description of solids is the behavior when subjected to compressive loads. Ductile materials such as steel contain a large number of different in homogeneities like soft and hard inclusions, pores and micro cracks. These micro defects are responsible for the inelastic behavior and they finally lead to a macroscopic failure under both compressive and tensile loads. Evaluation of the probability of failure is useful in design of components. Consideration of fracture from a mixed mode crack is essential. Several criteria were proposed with respect to ductile fracture. These involves the Tresca or maximum shear stress criterion, the von Mises yield criterion or distortional strain energy density criterion.

In this study, the nucleation or initiation stage is not considered and a fully-formed crack is assumed. Its size will be such that the surrounding material is assumed to be homogeneous and isotropic.

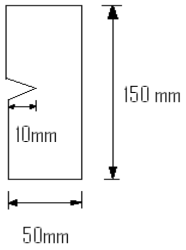
Stress intensity factor

It is used in fracture mechanics to more accurately predict the stress state near the tip of a crack caused by a load or residual stresses. It is a theoretical construct applicable to a homogeneous elastic material and is useful for providing a failure criterion for brittle materials. The magnitude of K (stress intensity factor) depends on sample geometry, the size and location of the crack, and the magnitude and the modal distribution of loads on the material. Stress intensity factor, K, is a parameter that amplifies the magnitude of the applied stress that includes the geometrical parameter. These load types are categorized as Mode I, II, or III. Stress intensity in any mode situation is directly proportional to the applied load on the material. If a very sharp crack can be made in a material, the minimum value of KI can be empirically determined, which is the critical value of stress intensity required to propagate the crack. This critical value determined for mode I loading in plane strain is referred to as the critical fracture toughness (KIc) of the material. The units of KIc infer that the fracture stress of the material must be reached over some critical distance in order for KIc to be reached and crack propagation to occur. The Mode I critical stress intensity factor, KIc, is the most often used engineering design parameter in fracture mechanics and hence must be understood if we are to design fracture tolerant materials used in bridges, buildings, aircraft, or even bells. Typically for most materials if a crack can be seen it is very close to the critical stress state predicted by the stress intensity factor.

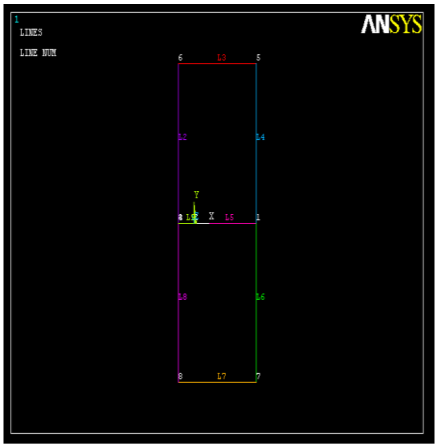
j integral

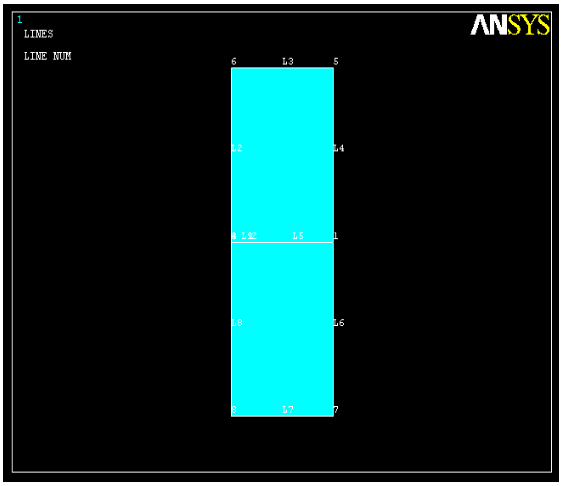
For a crack in an elastic body subject to a load, the elastic energy stored in the body is a function of two independent variables: the displacement of the load, and the area of the crack. The energy release rate is defined by the partial derivative of the elastic energy of the body with respect to the area of the crack. This definition of the energy release rate assumes that the body is elastic, but invokes no field theory. Indeed, the energy release rate can be determined experimentally by measuring the load-displacement curves of identically loaded bodies with different areas of the cracks. No field need be measured. Many materials, however, can be modeled with a field theory of elasticity. When a material is modeled by such a field theory, the energy release rate can be represented in terms of field variables by an integral, the J integral.

Cracked model



In this cracked model is made up of steel material and a load of 40 N is applied at width of the specimen, the following pictures shows the analysis of this specimen in ANSYS software.

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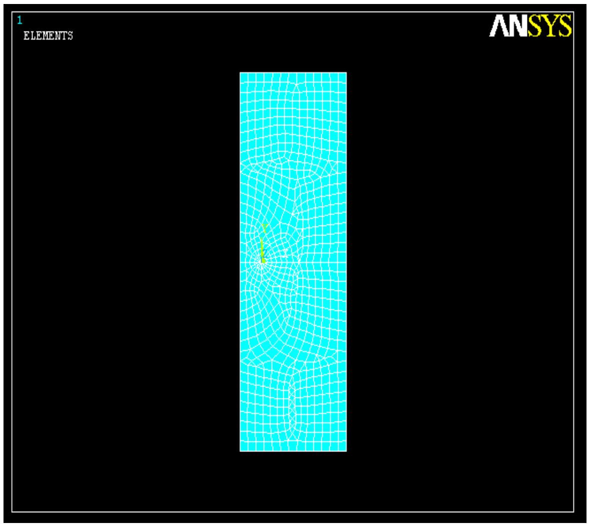
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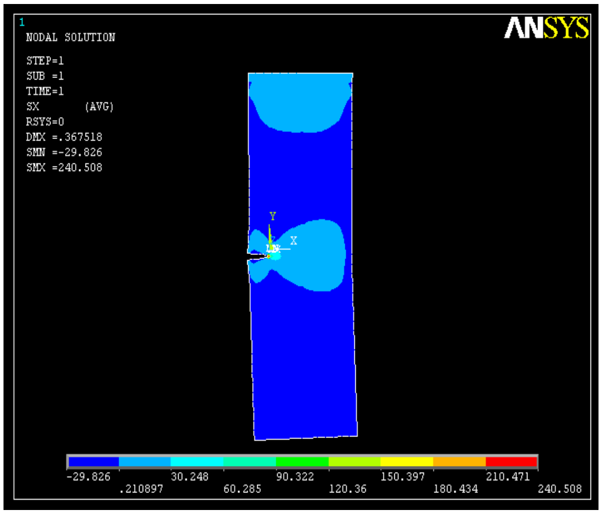
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120.36
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RESULTS

Analyzed Parameter	ANSYS	Hand calculation	Error (%)
Stress intensity factor ($N/mm^{3/2}$)	303.37	290.6	0.04
J integral (N/mm)	4.04	3.8	0.06

CONCLUSION

The cracked ductile material modeled in ANSYS showed values closer to the theoretical calculations. The agreement between the software values of stress intensity factor & j integral and the actual one is excellent. It can also be extended to cover plane problems involving general anisotropic material. From this study we can conclude that the methodology followed for crack analysis is well suited for the selected material.

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