



Fracture analysis of thin Aluminum Sheet by J integer and C T O D technique using FEA

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Abstract

A J integer and CTOD test are usually done on materials undergoes plastic deformation prior to failure. The testing material more or less resembles the original one, although dimensions can be reduced proportionally. More than 3 tests are done to minimize any experimental deviations. The specimen is placed on the work table and a notch is created exactly at the center. The crack should be generated such that the defect length is about half the depth. The load applied on the specimen is generally a three point bending load. A strain gauge is used to measure the crack opening. Crack tip plastically deforms until a critical point after which a crack is initiated that may lead to either partial or complete failure.

Keywords- J integer Method, Crack tip opening displacement (CTOD)

I. INTRODUCTION

Fracture is a problem that society has faced for as long as there have been man-made structures. The problem may actually be worse today than in previous centuries, because more can go wrong in our complex technological society. Major airline crashes, for instance, would not be possible without modern aerospace technology. Fortunately, advances in the field of fracture mechanics have helped to offset some of the potential dangers posed by increasing technological complexity. Our understandings of how materials fail and our ability to prevent such failures have increased considerably since World War II. Much remains to be learned, however, and existing knowledge of fracture mechanics is not always applied when appropriate. While catastrophic failures provide income for attorneys and consulting engineers, such events are detrimental to the economy as a whole. An economic study estimated the annual cost of fracture in the U.S. in 1978 at \$119 billion (in 1982 dollars), about 4% of the gross national product. Furthermore, this study estimated that the annual cost could be reduced by \$35 billion if current technology were applied, and that further fracture mechanics research could reduce this figure by an additional \$28 billion.

The finite element method (FEM) has been widely used in various problems of fracture mechanics. FEM was originally used as a simple analytical tool for obtaining the continuum based displacement and stress fields. Sophisticated singular elements were proposed by Barsoum and Henshell and Shaw and efficiently implemented by Fawkes and Owen and Fawkes to simulate the singularity condition at crack tips. Then, it was extensively adopted as a major improvement to already available numerical techniques in LEFM.\

II. LITERATURE REVIEW

The insufficient attention on studies related to fracture behavior of sheet metals originates from the fact that engineering materials with thinner sections are not considered as load bearing structural parts. Only Liu and his co-workers have suggested some guidelines to assess fracture criteria for thin and tough plates of structural materials D M kulkarni et al 2004 has found the experimental technique for fracture criteria of sheet metals and he has examined the effect of the variation of thickness of such steel sheets on their fracture criteria. A new approach is suggested in his research for determining fracture criterion of thin sheets using load drop technique, which assists in detecting the physical event of crack initiation. [1] García et al gives experimental analysis of two structural steels, one with a ductile behavior and the other one with brittle behavior, this paper compares the results obtained by means of small punch test (SPT) performed on notched samples with those obtained in standard fracture toughness tests, in order to obtain a relationship between them and to analyze the suitability of the SPT for estimating the fracture toughness. [2] S Yoshizu et al has to explain this scatter, by using Beremin proposed model called Weibull stress or Beremin model. These models cannot completely describe experiments, nor did they calculate the scatter of fracture initiation points. S Yoshizu et al of the present paper is to propose a new model which more precisely predict fracture toughness as well as fracture initiation points.[3]

The elastic-plastic process requires continuous assessment of stress and plastic strain at all points of the structure, as the applied load increases. Hence the load is applied in a sequence of relatively small increments, and within each step a check on stress and equilibrium is made. As loading starts, the program starts to iterate the stress above the yield stress to consider the plastic effects. The whole nonlinear curve is considered to consist of a number of straight lines, each being designated as a load step.

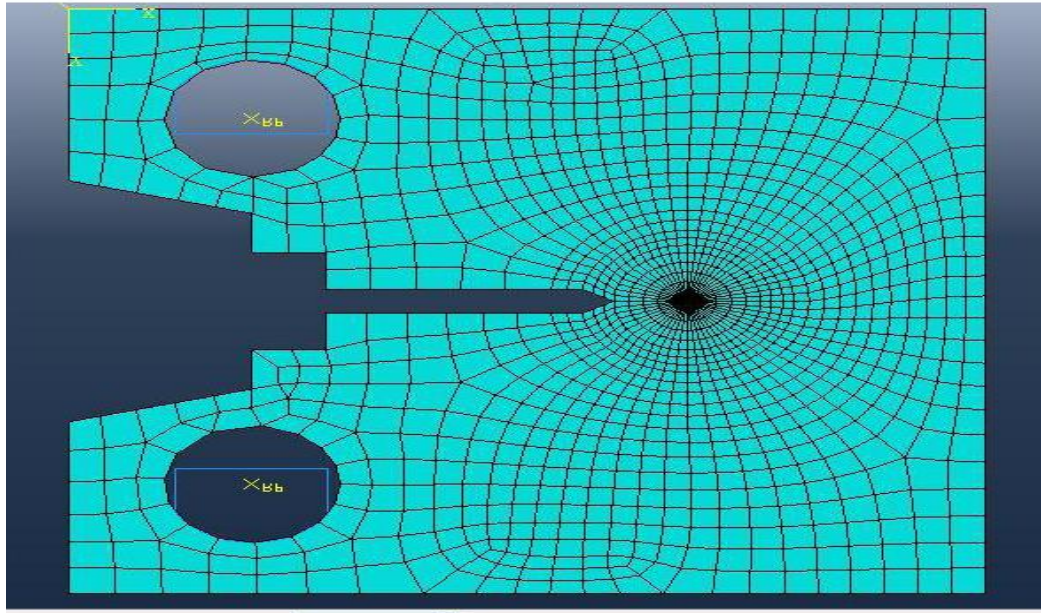


Fig.2.Meshing of CT Specimen

With the help of this analysis, the value of plastic CTOD_{pl} and crack tip necking is determined at the same node considered in linear analysis. The results of plastic CTOD and crack tip necking are shown in Fig respectively for S1 specimen. The values of elastic CTOD and plastic CTOD are used to find equivalent fracture toughness similar to experimental method

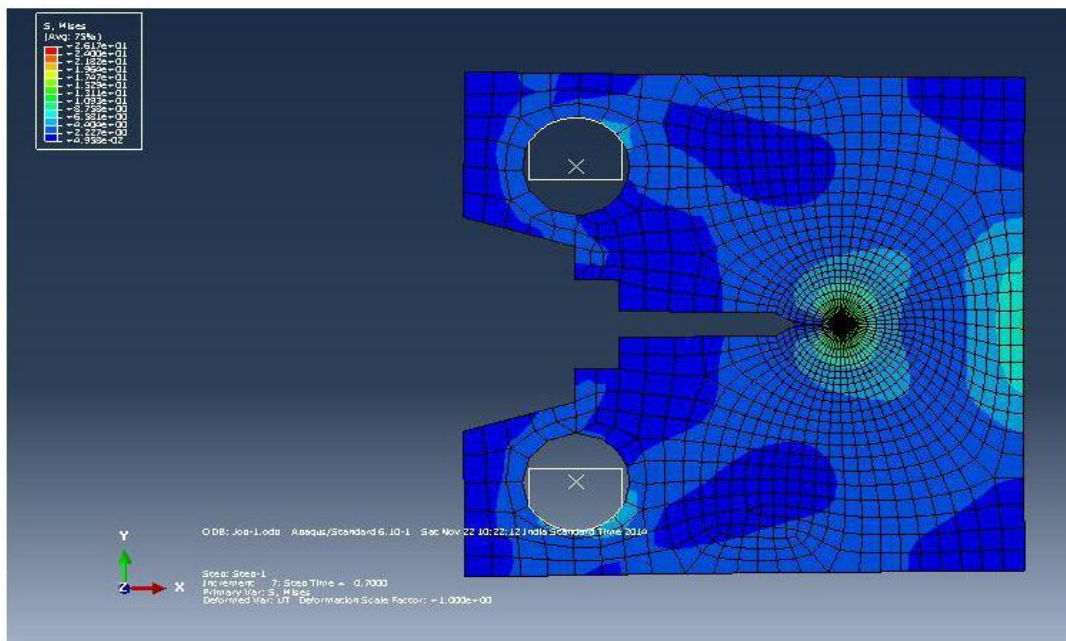


Fig.3.Distribution of Von Mises Stress in A CT Specimen

FEA analysis gives the results of J –integral for different 3 no of contours .The average J integral for a particular time steps is calculated. The relationship between J integral and CTOD Values are as follows.

$$CTOD = \frac{J}{\sigma_{ys}}$$

V. RESULTS

Length [m]	SIFS (K1) Contour 1 [Pa·m ^{0.5}]	SIFS (K1) Contour 2 [Pa·m ^{0.5}]	SIFS (K1) Contour 3 [Pa·m ^{0.5}]
0.	2.3945e+007	2.4899e+007	1.9983e+007
2.5e-004	2.4321e+007	2.8895e+007	3.0373e+007
5.e-004	2.4797e+007	1.9044e+007	1.8753e+007
7.5e-004	2.2707e+007	2.511e+007	2.8019e+007
1.e-003	2.748e+007	3.4055e+007	3.5984e+007

Table1. Stress intensity factors obtained by FEA

Length [m]	J-Integral (JINT) Contour 1 [J/m ²]	J-Integral (JINT) Contour 2 [J/m ²]	J-Integral (JINT) Contour 3 [J/m ²]
0.	6440.7	7735.	7932.9
2.5e-004	9364.6	8219.3	9461.1
5.e-004	10200	11559	11552
7.5e-004	7900.9	10363	11415
1.e-003	7589.2	8404.1	8502.1

Table2. J-Integer values by FEA

VI. CONCLUSION

1. One of the key observations in this study is the detection of the crack initiation in thin Sheets from the phenomenon of load-drop. The detection of this event eliminates the elaborate effort required.
2. The plastic zone size for all the tested sheets extends up to the ligament boundary of the specimens.
3. The amount of crack-tip necking could be determined by FE analysis, which otherwise a difficult task to measure.

VII. REFERENCES

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