CRACK PROPAGATION IN STEEL AND EPOXY MATERIAL USING FEA

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Abstract - *The interest of this paper is to research how a crack propagates and grows in Structural/Mild steel & Epoxy material plate. Edge & middle crack these two cases will be performed for both material to calculate stress intensity factor & J integral. FEA result will be cross checked with analytical result to validate results. Finite element method software (ANSYS16) is going to be wont to simulate failure criteria and to compute the stresses and the stress-intensity factor. A special designed part was taken and a central crack was scrutinized. This configuration was used since the engineers often detect this sort of crack in object. The Von-Misses stress nearby position the crack tip is compared against the yield strength of the material. So we have carryout FEA analysis for epoxy material as well as for Mild steel.*
So we can understand the propagation of crack & its growth in material plates.

Key Words: *Epoxy material, Mild steel, stress-intensity, crack, ANSYS16*

1. INTRODUCTION

Most of the structures are usually designed or taking loads to which they were subjected while in service. The care has to be taken in order to avoid large stress concentrations and suitable safety factor is considered so that their values closed to maximum permissible stress are not going to attained. But due to imperfections in materials that are arises during the production are unavoidable and must take in account.

The existence of crack and its propagation results in decreasing the material strength, on the other hand if flow is discovered in structure that doesn't hint that the structure is not safe.

The criterion actually applicable to those materials which are expensive or structures whose working is not economical to interrupt. Fracture analysis here plays a major role, as fracture mechanics approach has various concepts for structures analysis which contains the crack. Our aim is to analyse and predict in what manner failure is going to occur.

Engineers need to study and analyze the cracks which are present in the structure resulting from the manufacturing process or from fatigue. To eliminate the failure of structure before to its expected life in a easy way. Strength of material approach is used in traditional design to access structural integrity. Fracture mechanics approach is an important tool

Which include effect of flaws which becoming the practice in a most of the industries. Fracture mechanics can be explained using concept of applied mechanics & material science. Propagation of a crack in a structure is a function of stress and flaws, and is represented by fracture parameters.

- Stress intensity factors (K or SIFs): characterizes stress state near crack tip
- J-Integral (J or JINT): contour-integral around the crack tip that is equal to the Change in potential energy due to incremental crack advance
- Energy release rate (G): Energy required to create newly formed crack surfaces

1.1 MODEL GEOMETRY

Plate with dimension of 100*50*3 is created in Ansys design modular as below.

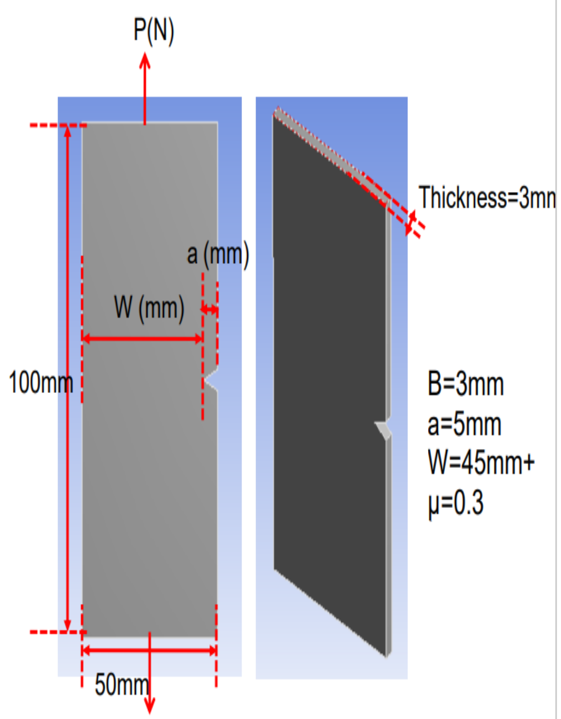

Fig. 1 Geometry detail

ANALYSIS IS PERFORMED FOR BELOW CASES,

Mild Steel/EPOXY Material			
Sr. No.	a(mm)	W(mm)	Load(P)(N)
1	5	45	4680
2	10	40	5360
3	15	35	7040
4	20	30	10320
E(MPa)		206000/85000	
μ		0.3/0.35	
B(mm)		3	

Table 1. Geometry details

1.2 MATERIAL PROPERTIES

	Mild steel	Epoxy Resin
Young's Modulus	206	85
Poisons Ratio	0.3	0.35
Density	7850 Kg/m3	40 Kg/m3

Table 2. Material properties

1.3 FORMULAE TO CALCULATE SIF (K1) AND J INTEGRAL (Jint)

$$f\left(\frac{a}{W}\right) = \frac{k_1 B\sqrt{W}}{P}$$

$$f\left(\frac{a}{W}\right) = \frac{2+\frac{a}{W}}{\left(1-\frac{a}{W}\right)^{\frac{3}{2}}}\left[0.866 + 4.64\left(\frac{a}{W}\right) - 13.32\left(\frac{a}{W}\right)^2 + 14.72\left(\frac{a}{W}\right)^3 - 5.60\left(\frac{a}{W}\right)^4\right]$$

$$J = \frac{K_1^{\,2}(1-v^2)}{E}$$

1.4 MESHING

Meshing is the process of dividing the structure into the number of small parts call as elements. This is done by meshing. In order to mesh a certain model element type has to be decided first. In this case element type is solid186.

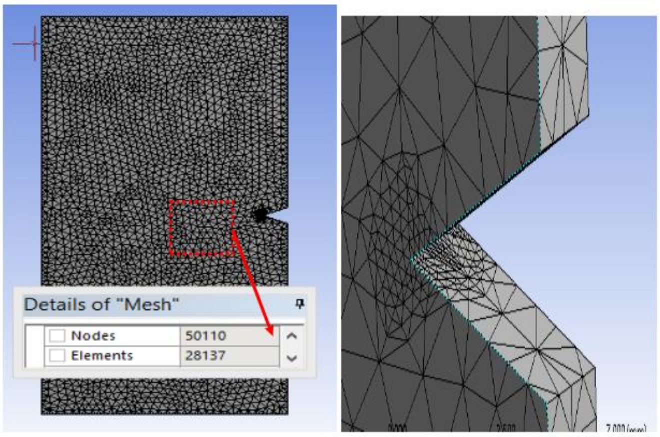

Fig. 2 Geometry detail

1.5 LOADS AND BOUNDARY CONDITIONS

One end of plate is constrained in all direction & force is applied in other end.

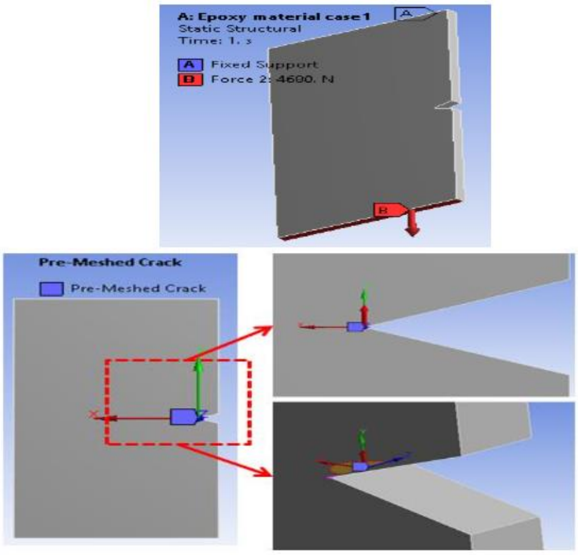

Fig. 3 Loads, boundary conditions and crack

2. STATIC ANALYSIS RESULT

Epoxy Material				Analytical		FEA	
Sr. No.	a	W	Load	SIFS K1	j-Int.	SIFS K1	j-Int.
1	5	45	4680	3371.8	86.9	3498	88.9
2	10	40	5360	5124.6	200.8	5747	216
3	15	35	7040	7156	391.6	7595	376
4	20	30	10320	9327.3	665.3	10447	711
E(MPa)				206000/85000			
μ				0.3/0.35			
B(mm)				3			

Table 3. Static Analysis of Epoxy

Mild steel				Analytical		FEA	
Sr. No.	a	W	Load	SIFS K1	j-Int.	SIFS K1	j-Int.
1	5	45	4680	3371.8	38.6	3497.6	35.2
2	10	40	5360	5124.6	89.2	5811.4	93.7
3	15	35	7040	7156	174	7594.6	160.3
4	20	30	10320	9327.3	295.6	10446	300.9
E(MPa)				206000/85000			
μ				0.3/0.35			
B(mm)				3			

3. SIMULATION RESULTS

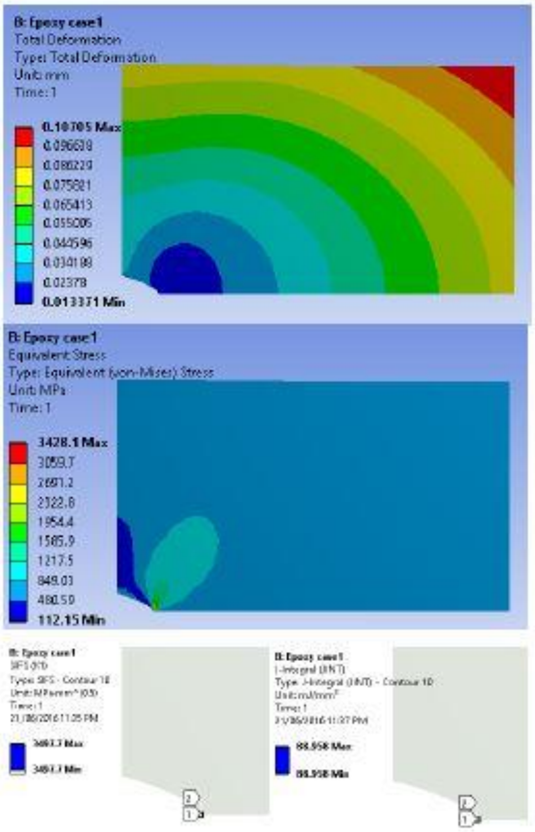

Fig. 3.1 Epoxy 5 mm

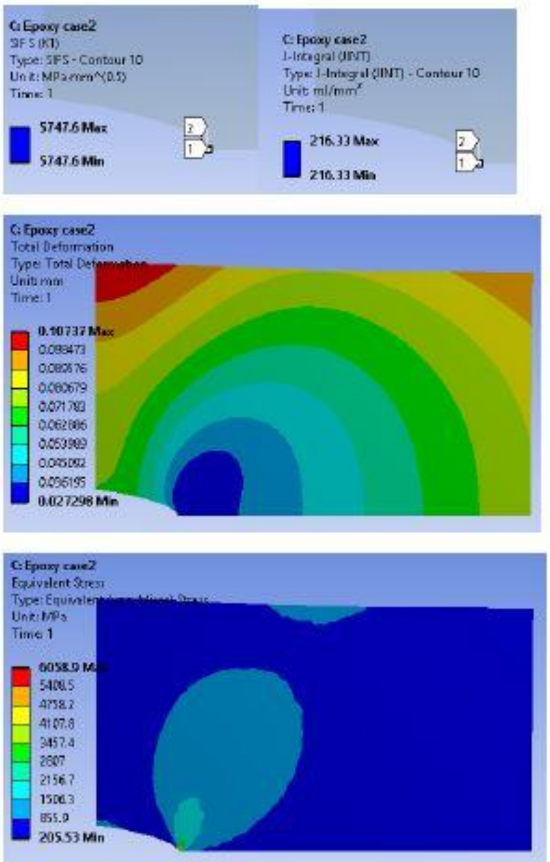

Fig. 3.2 Epoxy 10 mm

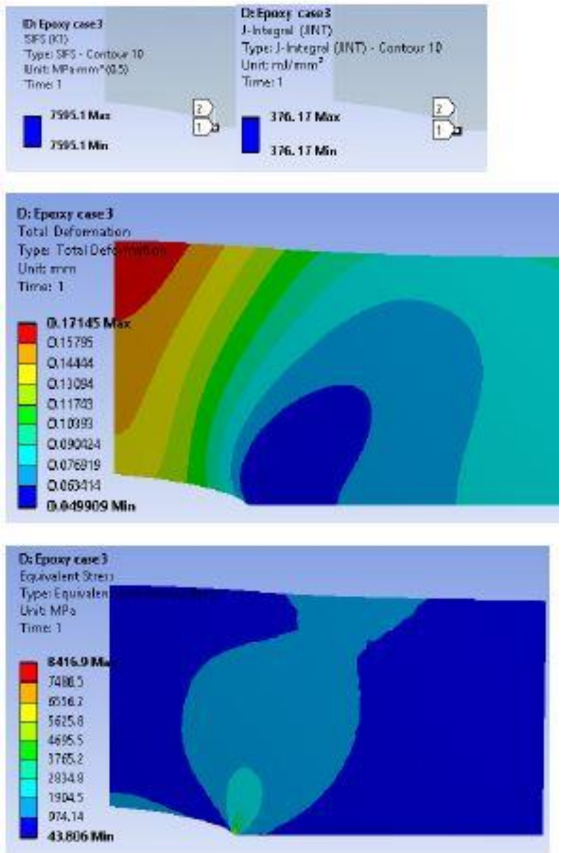

Fig. 3.3 Epoxy 15 mm

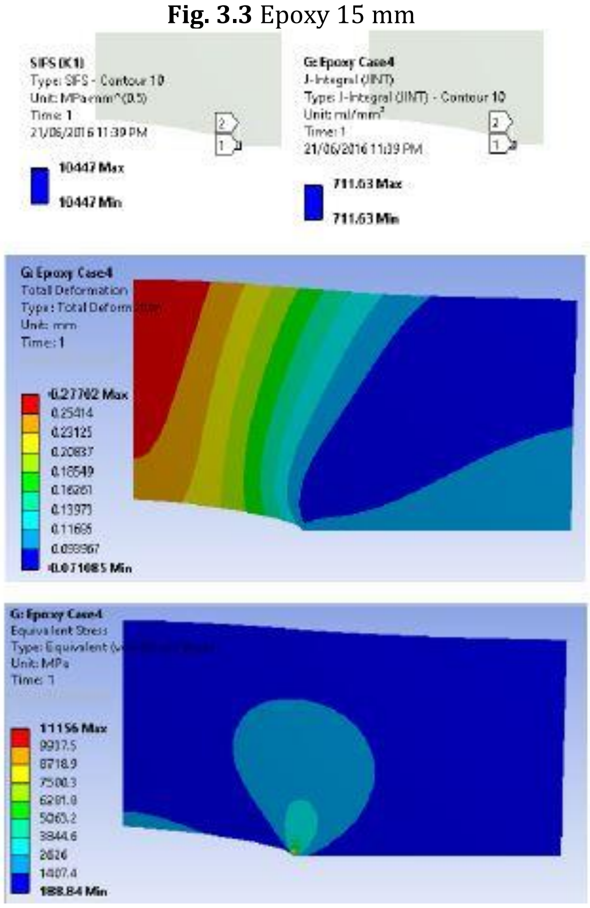

Fig. 3.4 Epoxy 20 mm

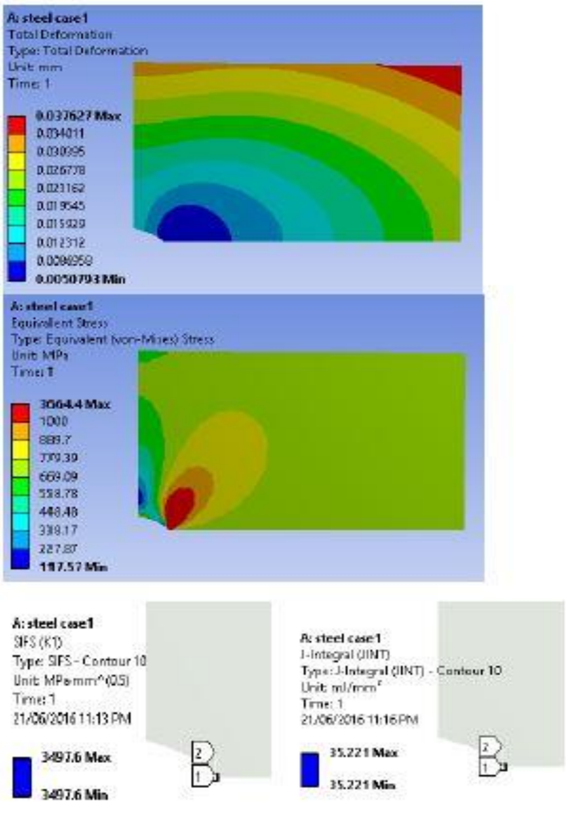

Fig. 3.5 Steel 5 mm

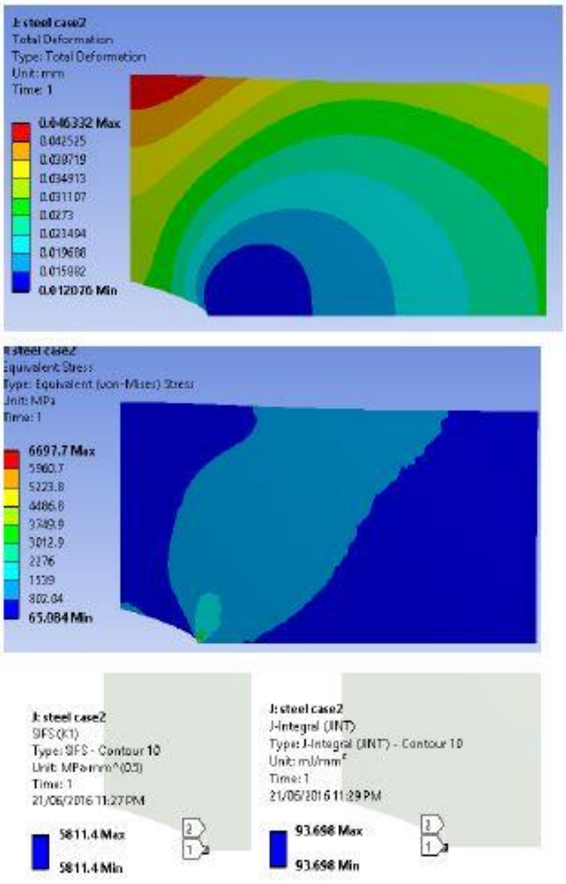

Fig. 3.6 Steel 10 mm

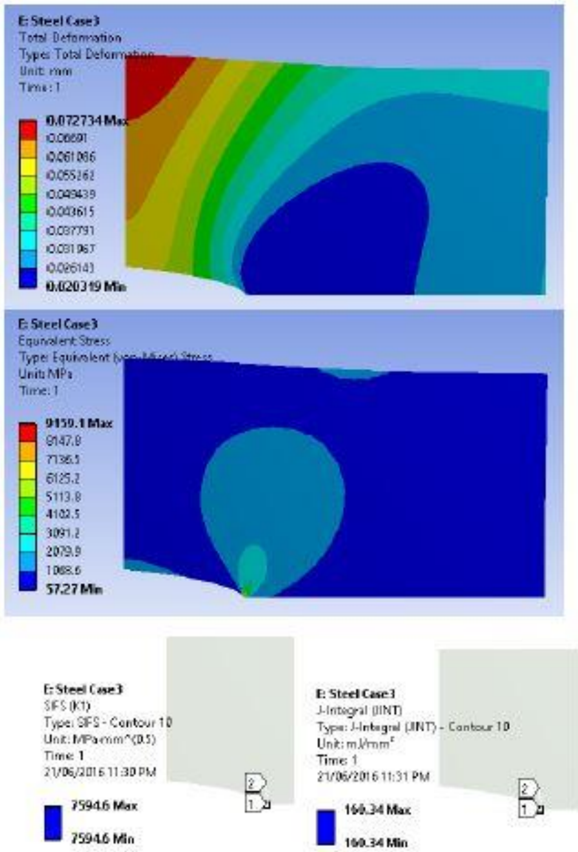

Fig. 3.7 Steel 15 mm

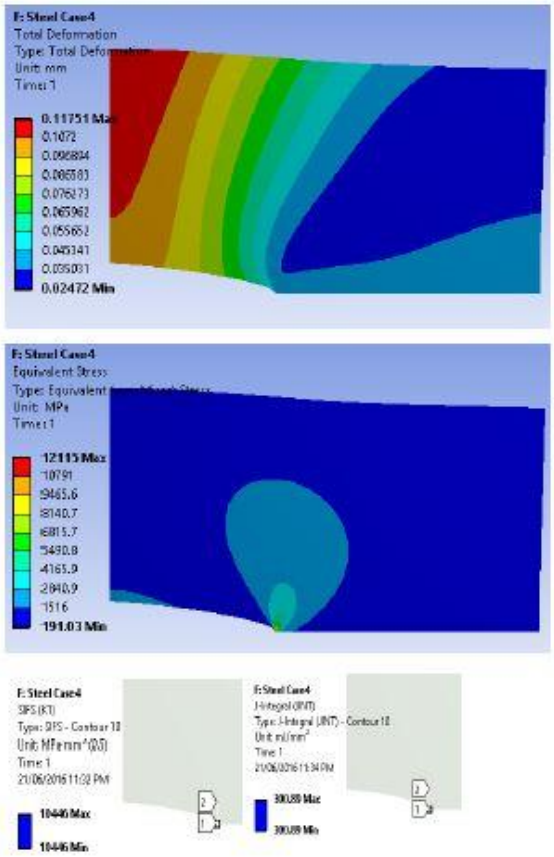

Fig. 3.8 Steel 20 mm

4. CONCLUSIONS

This project investigates how the crack grows and propagates in two different materials and their resulting stress distribution.

- For same loads epoxy resin material is observed having higher J-integral value, hence epoxy material is better than steel. Crack will not propagate more in case of epoxy material.
- This study helps us in design of composite materials as we can use epoxy adhesives along with steels to improve their toughness.
- Even we can use epoxy plates in the field that using steel plates of equal strength and failure comes due to cracks. This catastrophic failure or complete shutdown of unit resulted due to single part failure due to crack in mechanical systems is often. This can be eliminated by changing steel with epoxy in such cases as per requirement.

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