ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Fracture Analysis of Cracks in Composite Cylindrical Panels

Lakpathi Naveen Kumar
M.Tech Student,
Ellenki College of Engineering and Technology.

Pawan Kumar Nagalgidde
Assistant Professor,
Dept of Mechanical Engineering,
Ellenki College of Engineering and Technology.

ABSTRACT:

In this thesis, the fracture mechanics analysis in ANSYS for cylindrical panels (boiler) with semi elliptical non-through surface cracks is investigated by determining the stress intensity factors, deformation and compared for different materials Stainless Steel, Aluminum Alloy 7075, composite materials Carbon Fiber and S - Glass. Theoretical calculations are done to compare the stress intensity factors, energy release rates and J - Integral. 3D modelling is done in Creo 2.0 and fracture analysis is done in Ansys.

FRACTURE MECHANICS:

Fracture mechanics is the field of mechanics concerned with the study of the propagation of cracks in materials. It uses methods of analytical solid mechanics to calculate the driving force on a crack and those of experimental solid mechanics to characterize the material's resistance to fracture. In modern materials science, fracture mechanics is an important tool in improving the mechanical performance of mechanical components. It applies the physics of stress and strain, in particular the theories of elasticity and plasticity, to the microscopic crystallographic defects found in real materials in order to predict the macroscopic mechanical failure of bodies. Fractography is widely used with fracture mechanics to understand the causes of failures and also verify the theoretical failure predictions with real life failures. The prediction of crack growth is at the heart of the damage tolerance discipline. There are three ways of applying a force to enable a crack to propagate:

Mode I Fracture:

Opening mode (a tensile stress normal to the plane of the crack),

Mode II Fracture:

Sliding mode (a shear stress acting parallel to the plane of the crack and perpendicular to the crack front), and

Mode III Fracture:

Tearing mode (a shear stress acting parallel to the plane of the crack and parallel to the crack front).

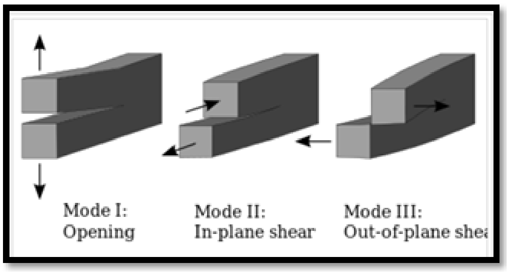
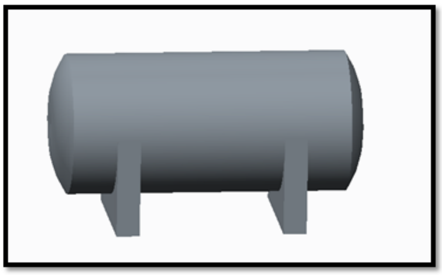


Fig – Modes of failure

MODELING OF COMPOSITE CYLINDRICAL PANEL OF BOILER IN CREO 2.0

For modeling of composite cylindrical panel of boiler, the reference is taken from Static Structural Analysis of Boiler Shell with Riveted Joints Using ANSYS by Gurpreet Singh

Diameter of the cylinder	1500 mm
Thickness of the cylinder	22 mm
Length of the cylinder	3000mm



Final model

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

THEORITICAL CALCULATIONS FOR STRESS INTENCITY FACTOR AND J - INTIGRAL CALCULATIONS FOR STRESS INTENSITY FACTORS

$K = F_0 \sigma_0 \sqrt{\pi a}$

$F_0 = [\,1+0.52\lambda +1.29\lambda^2 -0.074\lambda^3]^{1/2}$

$\lambda = \frac{a}{\sqrt{Rt}}$

σ_0 = Stress (considered from analysis results)

a = Crack length major radius

R = crack length counter radius

t = thickness of the boiler cylinder

CALCULATIONS FOR J – INTEGRAL

J – Integral = $K_{IC}^2\,(1-\nu^2/E)$

Where K_{IC} = Fracture Toughness

ANALYSIS OF COMPOSITE CYLINDRICAL PANEL OF BOILER

BOUNDARY CONDITIONS

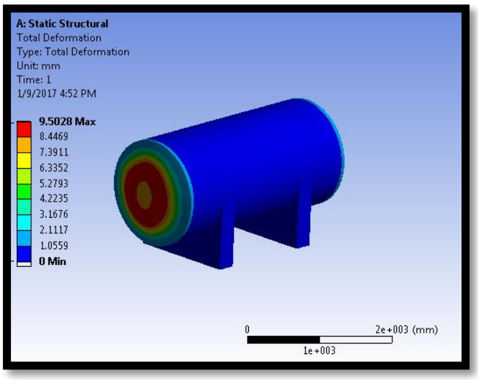
The is Composite Cylindrical Panel Of Boiler analyzed for an internal pressure of 2 MPa. The value is taken from the journal paper, Static Structural Analysis of Boiler Shell with Riveted Joints Using ANSYS by Gurpreet Singh.

STRUCTURAL ANALYSIS OF COMPOSITE CYLINDRICAL PANELS OF BOILER

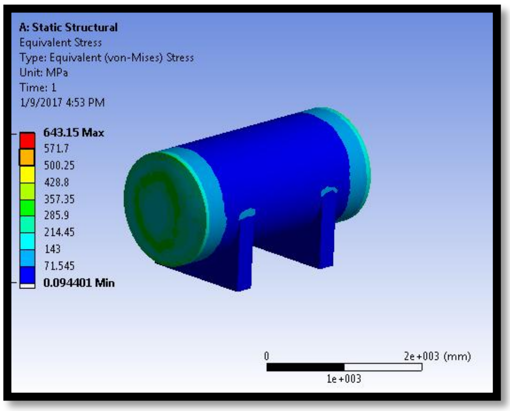
MATERIAL – CARBON FIBER

CONDITION 1 – FRACTURE CREATED AT THE MIDDLE OF THE BOILER

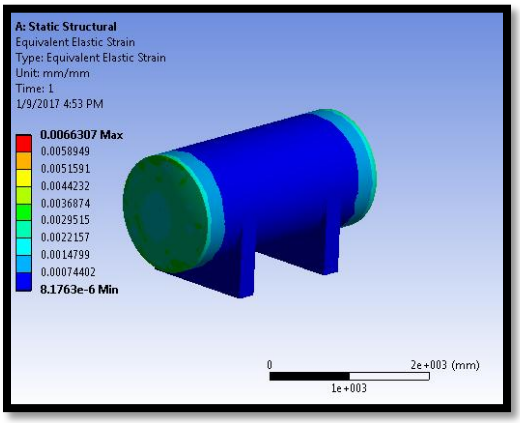
Deformation



Stress

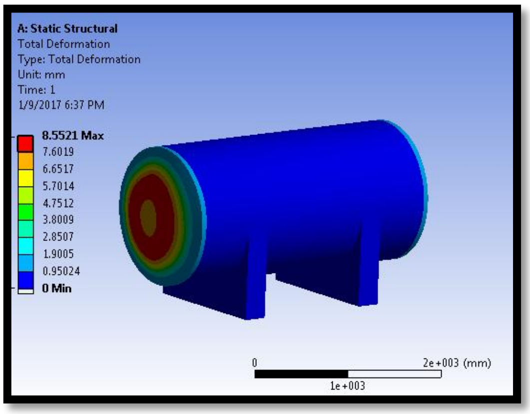


Strain



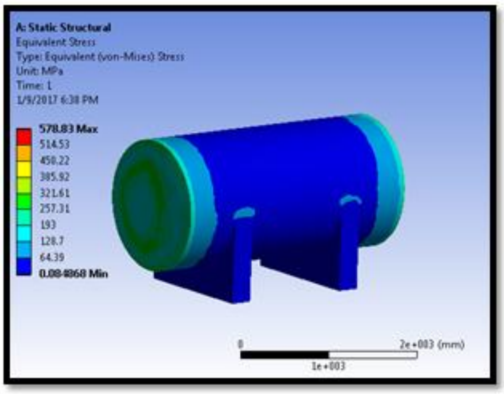
CONDITION 2 – FRACTURE CREATED AT THE END OF THE BOILER

Deformation

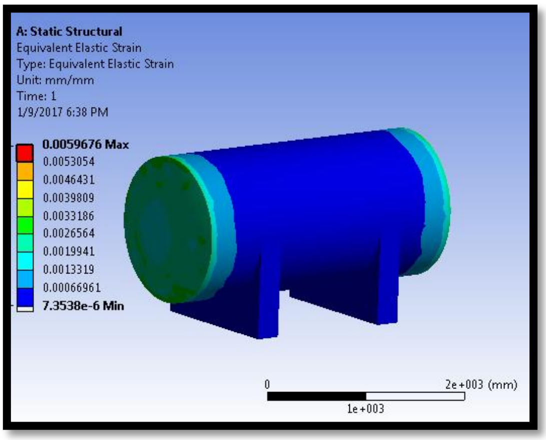


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Stress



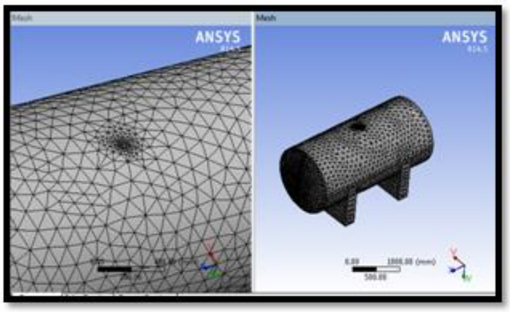
Strain



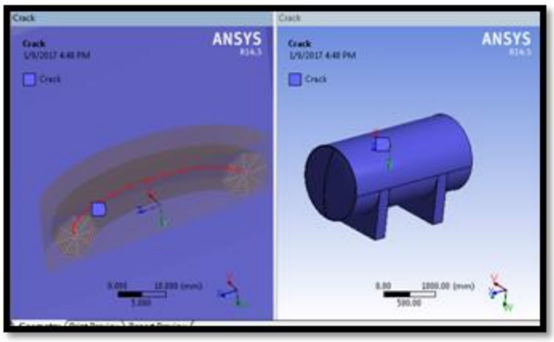
FRACTURE ANALYSIS

CONDITION 1 – FRACTURE CREATED AT THE MIDDLE OF THE BOILER

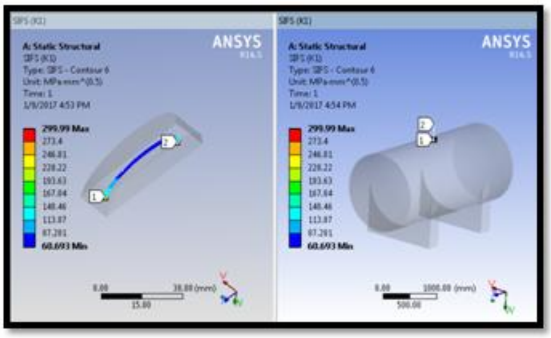
Meshed model



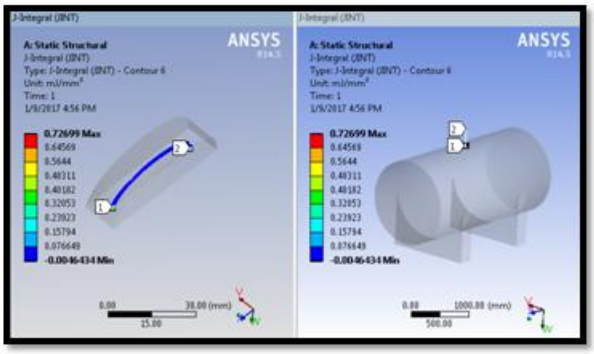
Crack on boiler



STRESS INTENSITY FACTOR



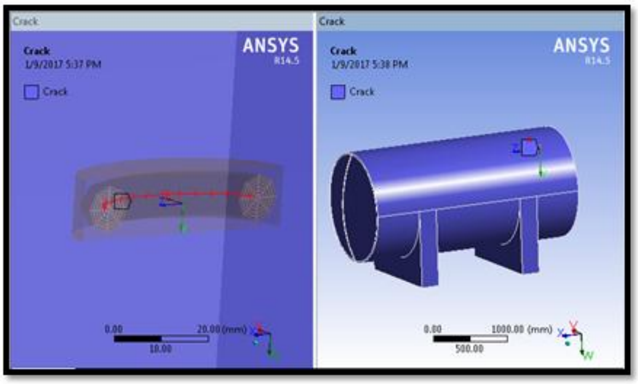
J-INTEGRAL



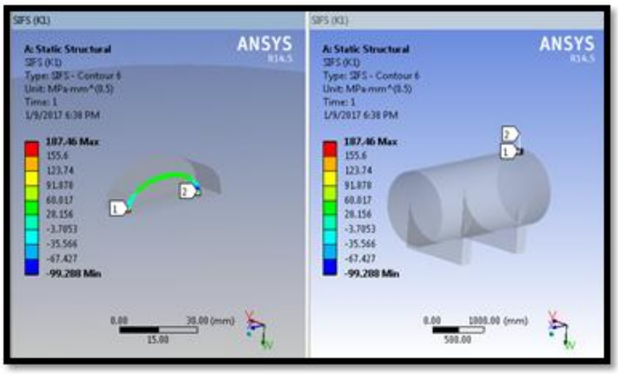
CONDITION 2 – FRACTURE CREATED AT THE END OF THE BOILER

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

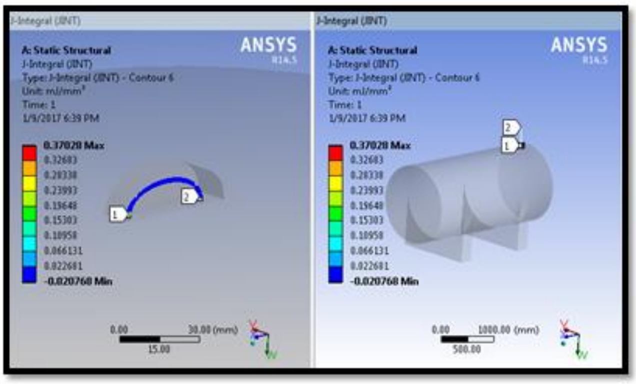
Crack



STRESS INTENSITY FACTOR



J-INTEGRAL

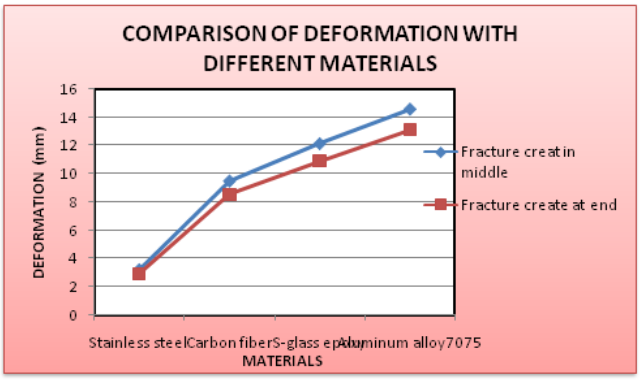


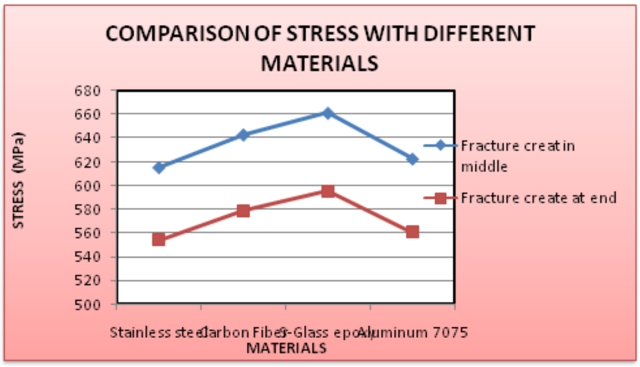
RESULT & DISCUSSIONS

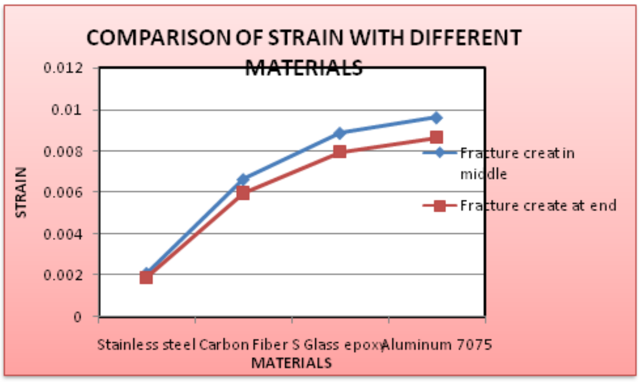
STRUCTURAL ANALYSIS

	Materials	Deformation (mm)	Stress (Mpa)	Strain
Fracture created at the middle of the boiler	Stainless steel	3.2503	615.66	0.0021056
	Carbon fiber	9.5028	643.15	0.0066307
	S-glass epoxy	12.13	661.35	0.0088622
	Aluminium alloy7075	14.566	622.86	0.0096126
Fracture created at the end of the boiler	Stainless steel	2.9252	554.09	0.0018908
	Carbon fiber	8.5521	578.85	0.0059676
	S-glass epoxy	10.916	595.21	0.0079759
	Aluminium alloy7075	13.108	560.57	0.0086512

Graphs



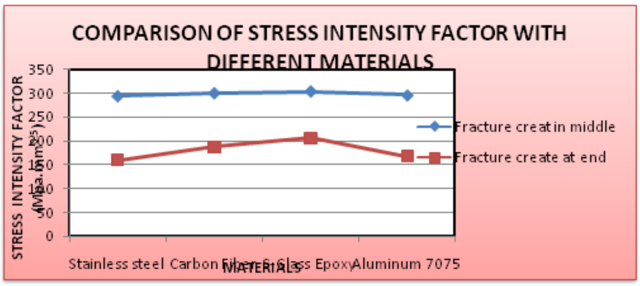


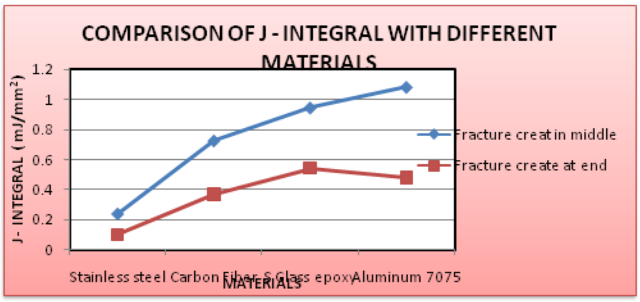


FRACTURE ANALYSIS

	Materials	Stress intensity factor(Mpa.mm$^{0.5}$)	J-Integral (mJ/mm^2)
Fracture created at the middle of the boiler	Stainless steel	293.5	0.23941
	Carbon fiber	299.99	0.72699
	S-glass epoxy	303.75	0.94657
	Aluminium alloy7075	295.26	1.0843
Fracture created at the end of the boiler	Stainless steel	159.41	0.10078
	Carbon fiber	187.46	0.37028
	S-glass epoxy	205.77	0.54319
	Aluminium alloy7075	166.67	0.47998

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal





CONCLUSION:

By observing above results, the displacement and stress values are more when fracture is created at the middle than when created at the end. The stress value for all materials is less than their respective allowable stress values. The stress value is less for Steel. Now according to stress intensity factor and J-integral are more when fracture is created at the middle than when created at the end. The values are less for steel. Since the composite materials Carbon Fiber and S-Glass epoxy have more strength to weight ratio, their life will be more after crack initiation.

REFERENCES:

[1] X.P. Shu, A generalised model of laminated composite plates with interfacial damage. Compos. Struct., 74, 237-246, 2006.

[2] A. Boutaous, B. Peseux, L. Gornet, A. Bélaidi. A new modeling of plasticity coupled with the damage and identification for carbon fibre composite laminates. Compos.Struct., 74, 1.9, 2006.

[3] Lord-Rayleigh, On the Free Vibrations of an Infinite Plate of Homogeneous Isotropic Matter. Proc. of the London Mathematical Society, 20, 225-234, 1889.

[4] H. Lamb, On Waves in an Elastic Plate. Proc. of the Royal Society, London, 93, 114. 128, 1917.

[5] I. Mirsky, Axisymmetric vibrations of orthotropic cylinders. J. Acoust. Soc. Am., 36, 2106, 1964.

[6] J.L. Nowinski, Propagation of longitudinal waves in circular cylindrical orthotropic bars. J. Engng. Ind., 89, 408, 1967.

[7] F.H. Chou, J.D. Achenbach, Three-dimensional vibrations of orthotropic cylinders. ASCE J. Engng. Mech., 98, 813, 1981.

[8] A.H. Nayfeh, Wave propagation in layered anisotropic media with applications to composites. Elsevier, Amsterdam, 1995.

[9] F.G. Yuan, C.C. Hsieh, Three-dimensional wale propagation in composite cylindrical shells, Compos. Str., 42, 153, 1998.

[10] M.N. Ichchou. J.L. Mencik, W. Zhou, Wave finite elements for low and mid-frequency description of coupled structures with damage. Comput. Methods Appl. Mech. Engrg., 198, 1311, 2009.