Estimation of Stress Intensity Factor for Natural Rubber with Toughened GFRP

Divyabarathi P*, Adikeshavan P, Syedhaleem M
Department of Aeronautical Engineering, Bharath University, Chennai – 600073
***Corresponding author: E-Mail: divyabarathi.aero@bharathuniv.ac.in**

ABSTRACT

The Glass fiber reinforced polymer composite strengths has been estimated. The glass fiber Tensile strength and Stress intensity factor has been estimated an investigation with different ply orientation. To find the fracture parameter K with the help of crack mouth opening displacement method (CMOD). Initially a six layered unidirectional stitched oven mat is cast into a laminate. A six layered cross ply is also cast into a laminate and the CTOD is fabricated according to ASTM D3039 and ASTM D 5045 standard. To determine Tensile Test and the K, it is proposed to use clip gauge to measure the crack mouth opening displacement and K will be estimated from the plot of load against displacement. From these results we known strength of cross ply laminates are lower than the unidirectional laminate.

KEY WORDS: Stress Intensity factor, strength, natural rubber, glass fiber, GFRP

1. INREODUCTION

In the technologically advanced era that we currently live in, there is a rising demand for low cost and more durable materials for a wide variety of applications. Conventionally, metals and metal alloys are used to manufacture almost everything. Then the invention of plastics brought a revolution where plastics started replacing metal components. It is easy to mould plastics into any complex form and also they are light weight and durable. The initial expensiveness of plastics has reduced considerably after the demand for plastics grew and simple low cost manufacturing processes were invented. However, plastics cannot be used for applications that require high strength like in the case of aerospace and automobile industries. Hence, a material with high strength to weight ratio was required and as a consequence, composite materials were developed and this field is now the attractive area of Research both for Engineers as well as academicians.

A composite material is formed by the combination of two or more materials that have different properties. The different constituents of the composite material when bonded together as a composite exhibit enhanced properties better than that in their separate form. A common misconception is the assumption of a composite material as an alloy. This is not true because the constituents of an alloy are completely dissolved at the microscopic level whereas in case of a composite material, they are bonded only at a macroscopic level. A composite material is made up of two basic constituents, namely, a matrix and the reinforcement. The reinforcement is usually the constituent that provides the composite with its strength. It can be either in particulate form or fibers. The matrix is the constituent that surrounds and binds the reinforcement as well as serves the protection against damage. It also aids in the distribution of the applied load to the reinforcement.

2. FABRICATION OF MATERIAL

It is made using the following constituents,

- Glass Fiber
- Natural Rubber
- Resin (LY556)
- Hardener (HY951)

Fabrication of Laminate: The required ingredients of resin, hardener and glass fiber and natural rubber were mixed thoroughly. Compression molding provides higher performance when compared to other molding process. So the fabrication of the polymer matrix composite was done by compression molding process. A pressure of 22 psi is used during the compression molding process. Taking away the excess resin leads to a composite material with higher fiber content and as a result, it has good mechanical properties.

Six layers of dimension 30x30 cm^2 are taken. Combined materials are kept on compression molding machine by covering with milor sheet. Sheet is fabricated by taking resin and Hardener in 10:1 ratio. Load applied on the sheet by switching on the compression molding machine. The sheet is left for curing. Curing was done at room temperature.

Laminate Measurements:

Tensile Test Measurements: The laminate measurements according to ASTM (D 3039) standard are as follows:

Table.1. Tensile test measurements

Specimen type	Length (mm)	Width (mm)	Thickness (mm)
Uni – directional	295	12.4	7.5
Cross ply	295	12.4	6.7
1% rubber unidirectional	295	12.4	8.5
1% rubber cross ply	295	12.4	9.0

Stress Intensity Factor Test Measurements: The laminate measurements according to ASTM (D 5045) standard are as follows:

Table.2. Stress intensity factor test measurements

Specimen type	Length (mm)	Width (mm)	Thickness (mm)
Uni directional	70	50	7.5
Cross ply	70	50	6.7
1% rubber unidirectional	70	50	8.5
1% rubber cross ply	70	50	9.0

Material strength tests: Material strength experiment for Glass fiber reinforced polymer composite was conducted as per ASTM standards. The test was done at thrice. All the details of specimen, experimental procedure, and formulae used for computation are with respect to the ASTM standards.

Test for Tensile Strength: Three experiments each are conducted for both uni – directional and cross ply laminate. Before starting the test all the specimen dimensions are measured and noted down, then the specimen is fixed in between the two fixtures and pins are inserted to hold specimen firmly into the fixture as shown in figure.

Figure.1. Universal Testing Machine

Figure.2. Specimen after tensile test

Table.3. Tensile Test Values

Material	Layer	Stress (MPA)	Strain	Young's modulus (GPA)
Uni directional	6	637.4	0.032	19.621
Cross ply	6	275.2	0.020	13.216
1%rubber unidirectional	6	469	0.034	13.99
1%rubber crossply	6	261.5	0.018	14.34

Test for Stress Intensity Factor: Similar to the stress intensity factor test was also carried out for four specimens each condition. The final result is estimated in terms of strength.

Figure.3. CTOD Testing Machine

Stress Intensity Factor Calculation:

K1c = Y ((3PS √(a/w))/2TW2)

Y=1.9-3.07(a/w)+14.53(a/w)2- 25.11(a/w)3+25.80(a/w)4

p- critical load for crack propagation

s - length of the span

a -crack length

t -thickness

w -width
y -Non dimensional shape factor
Fiber unidirectional: T=7.5mm, P=1.925KN, W=25mm, '(a/w) = 0.5, S=70mm, Y=2.47, K1c =106.5Mpa√m.

Figure.4. Specimen after CTOD test

Table.4.Stress intensity test results

Sl. No.	Material	K_{IC} (MPA) √m
1	Unidirectional	106.5
2	Cross ply	43
3	1% rubber unidirectional	146
4	1% rubber cross ply	28

3. CONCLUSION

The experiment was done by using natural rubber with fiber and resin with different directions. The project is mainly compared to natural rubber and fiber, resin the stress intensity factor and tensile test was made by these laminates. The natural rubber gets more toughness compared to fiber resin.

REFERENCES

Alvarez VA, Valdez ME, Vazquez A, Dynamic mechanical properties and interphase fiber/matrix evalution of unidirectional glass fiber/epoxy composites, Polymer Testing, 22, 2003, 611-615.

Gopalakrishnan K, Sundar Raj M, Saravanan T, Multilevel inverter topologies for high-power applications, Middle - East Journal of Scientific Research, 20 (12), 2014, 1950-1956.

Hosseini-Toudeshky H, Sadeghi G, Daghyani HR, Experimental fatigue crack growth and crack-front shape analysis of asymmetric repaired aluminium panels with glass/epoxy composite patches, Composite Structures, 71, 2005, 401-406

Jasmin M, Vigneshwaran T, Beulah Hemalatha S, Design of power aware on chip embedded memory based FSM encoding in FPGA, International Journal of Applied Engineering Research, 10 (2), 2015, 4487-4496.

Kanniga E, Selvaramarathnam K, Sundararajan M, Kandigital bike operating system, Middle - East Journal of Scientific Research, 20 (6), 2014, 685-688.

Kanniga E, Sundararajan M, Modelling and characterization of DCO using pass transistors, Lecture Notes in Electrical Engineering, 86 (1), 2011, 451-457.

Karthik B, Arulselvi, Noise removal using mixtures of projected gaussian scale mixtures, Middle - East Journal of Scientific Research, 20 (12), 2014, 2335-2340.

Karthik B, Arulselvi, Selvaraj A, Test data compression architecture for lowpower vlsi testing, Middle - East Journal of Scientific Research, 20 (12), 2014, 2331-2334

Karthik B, Kiran Kuma, TVU, EMI developed test methodologies for short duration noises, Indian Journal of Science and Technology, 6 (5), 2013, 4615-4619.

Karthik B, Kiran Kumar TVU, Authentication verification and remote digital signing based on embedded arm (LPC2378) platform, Middle - East Journal of Scientific Research, 20 (12), 2014, 2341-2345.

Karthik B, Kiran Kumar TVU, Vijayaragavan P, Bharath Kumaran E, Design of a digital PLL using 0.35Î¼m CMOS technology, Middle - East Journal of Scientific Research, 18 (12), 2013, 1803-1806.

KBledzki Kessler A, Rikards R, Chate A, Determination of elastic constants of glass/epoxy unidirectional laminates by the vibration testing of the plates, Composite Structure, 59, 1999, 2015-2024

Philomina S, Karthik B, Wi-Fi energy meter implementation using embedded linux in ARM 9, Middle - East Journal of Scientific Research, 20 (12), 2014, 2434-2438.

Saravanan T, Sundar Raj M, Gopalakrishnan K, Comparative performance evaluation of some fuzzy and classical edge operators, Middle - East Journal of Scientific Research, 20 (12), 2014, 2633-2633.

Saravanan T, Sundar Raj M, Gopalakrishnan K, SMES technology, SMES and facts system, applications, advantages and technical limitations, Middle - East Journal of Scientific Research, 20 (11), 2014, 1353-1358.

Toshion Ogasawara, Keiji Onta, Shinji ogihara, Tomohiro yokozeki, Eiichi Hara, Torsion fatigue behavior of unidirectional carbon/epoxyand glass/epoxy composites, Composite Structures, 90, 2009, 482-489

Vijayaragavan SP, Karthik B, Kiran Kumar TVU, A DFIG based wind generation system with unbalanced stator and grid condition, Middle - East Journal of Scientific Research, 20 (8), 2014, 913-917.

Vijayaragavan SP, Karthik B, Kiran Kumar TVU, Effective routing technique based on decision logic for open faults in fpgas interconnects, Middle - East Journal of Scientific Research, 20 (7), 2014, 808-811.

Vijayaragavan SP, Karthik B, Kiran Kumar TVU, Privacy conscious screening framework for frequently moving objects, Middle - East Journal of Scientific Research, 20 (8), 2014, 1000-1005.

Ying Shan, Kin Liao, Environmental fatigue behavior life prediction of unidirectional glass-carbon/epoxy hybrid composites, International journal of fatigue, 24, 2002, 847-859

Yue CY and Looi HC, Influence of thermal and microwave processmg on mechanical and interfacial properties of glass/epoxy composite, School of mechanical and production Engineering, Nanyang Technological University, Nanyang Avenue, Singapore, 2263, 1995.

Zhang IC, Cutting composites, Adiscussion on mechanics modelling, Journal of Material processing Technology, 209, 2009, 4548-4552.