INVESTIGATION OF LOW VELOCTY IMPACT ON MECHANICAL PROPERATIES OF SYNTHETIC AND NATURAL FIBER REINFORCED POLYMER MATRIX COMPOSITES USED FOR BIOMEDICAL APPLICATION

–By FEM Approach

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ABSTRACT

The presented work in this paper investigates the Analytical study of low velocity impact (LVI) properties and the study of Energy absorption behavior of E-glass fiber, Corbon and Jute fibre reinforced polymer composite with stacking sequence of {0/90/0/90} laminate plate and study of 10% weight fraction E-glass fiber corbon and jute fibre reinforced polymer composite material Finite Element Model is prepared using ANSYS Simulation Software According to the ASTM Standard D7136. The Drop weight Impact tests are conducted to Examine the Impact Behavior of Three different materials. The Dimension of Impacted Material Specimens were 150 mm in length, 150 mm wide and 2.5 mm (i.e. 4 plies) thick . The Low Velocity 2.8009 m/s and Drop height of 400mm is considered for carrying out the Finite Element Analysis. The Different material specimen are Analysed with Explicit Dynamic under Fixed Support condition. The Analytical results shows that 10% E-glass Fiber Composite plate undergone the Deformation of 1.07 mm and 48.75 joules of Energy Absorbed and the 10% Carbon Fiber Composite plate undergone the Deformation of 0.97 mm and 183 joules of Energy Absorbed where as the10% Jute Fiber Composite plate undergone the complete Deformation Failure ie Penetration. Jute fibre polymer Composite Fails to Absorb Energy. From this Study Impact resistance of the three different materials was evaluated and 10%Carbon Fiber Reinforced Polymer composite plate showed the highest impact resistance among them. Similarly displacement behavior of the three different materials was studied using the FE model.

Keywords: : E-Glass Fibre, Carbon Fiber, Jute Fiber,Low velocity impact, Energy absorbed, FEM.

1. INTRODUCTION

It is well-known that composite materials particularly polymer matrix composites used in Bio-medical a, Automobile and aeronautical applications are highly susceptible to impact damage, which can result in a decrease in stability, and energy absorbing capability [1]. In general, impact of composite materials are classified based on the velocity as low velocity, high velocity, and hyper velocity impact [2,3]. The finite element model of the human lower bone facilitates the investigation of dynamic responses of the lower extremity to lateral impact loading. The model consists of the femur, the tibia, and the knee ligaments. Linear viscoelastic material was used to describe the mechanical property of the Lower Bone. Boundary conditions were defined in accordance with the configu ration for lateral collision[4].Low velocity impact was investigated for E-glass/ Epoxy , kenaf/Epoxy , hybrid E-glass/kenaf/Epoxy Composites for different Energy , the results show that kenaf/Epoxy Sows the lower resistance to impact loading [5]. One of most common injuries in the clinical diagnosis is Fracture, The FEM (finite element method) is used to find out the process of impact fracture, the results show that the maximum stresses occurred at two crooks, 1/3 below the knee joint of the tibia and 1/3 above the ankle joint [6]. The low velocity impact testing of neat vinyl ester and nanocomposites shows that the addition of layered silicate into the polymer matrix can produce enhanced load bearing and energy absorption capability compared to the neat matrix[7]. The investigation of experimentally and numerically the low velocity impact (LVI) on a shear dominated composite laminate with stacking sequence [45/0/-45/90]3s Finite Element Analysis results compared against experimental results shows that very close relation exist , especially in terms of detailed ply-by-ply damage patterns[8]. The experimental investigation of low velocity impact properties of Kevlar fiber reinforced polymer matrix composite materials with respect to different thickness shows that the damage in the fibres was developed around the point of impact, which results in considerable strength loss [9]. The experimental and finite element simulation of Charpy test reveals that the Impact resistance of the three diaphysis locations of cortical bone was evaluated and middle diaphysis showed the highest impact resistance among them[13]. Mechanical impact loading of injection-moulded components was simulated, results predicts the f force vs. deflection were good [14]. High specific strength and high stiffness;_ Flame retardance;_ High moisture resistance;_ Good interfacial bonding between the fiber_polymer matrix to withstand various types of loads encountered during aircraft operation are some of the criteria for Selection of natural fiber-based composites in aeronautical applications[12]. The influence of impactor's velocity parameters ,impactor's geometry, the target plate properties, and thickness, on the response of a tropical wood plastic composite (WPC) Azobé/urea formaldehyde (Az/UF) plate under impact loading is reveals that applicability of Azobé tropical wood in fabricating WPCs is good [11]. The effect of carbon nanotubes (CNTs) on the impact response of carbon fiber reinforced composites (CFRs) under low velocity impact predicts that the including of CNTs in composite plates damage could be reduced[10].

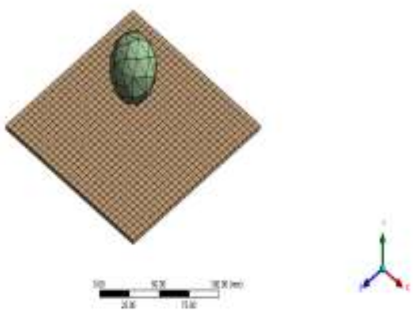
2. MATERIALS AND METHODS

The Ansys Workbench is used to prepare the Finite Element Model and Simulate the Energy Absorbing capabilities of different material. The Specimens dimension considered were 150 mm in length, 150 mm wide and 2.5 mm (i.e. 4 plies) thick. The lamination angle is measured with respect to the x-axis (i.e. 00fibers run parallel to the x-axis and 900fibers run parallel to the z-axis). Accordingly, the angle is rotated about the y-axis. No. of plies = 4 Ply thickness = 0.625 mm Layup = [0/90/0/90]. The Elemental Properties considered here are Shell 181, 4-noded quadrilateral shell element, with four nodes and six degrees of freedom per node.Tetra 285, 4-noded quadrilateral shell element, with four nodes and three degrees of freedom per node. The mesh was progressively refined to ensure convergence. The Number of elements in the model is 1090 and Number of nodes are 1026.The finite element model and boundary conditions are shown in figure-1. the orthotropic material of E-glass , Carbon and Jute are tabulated in Table-1.

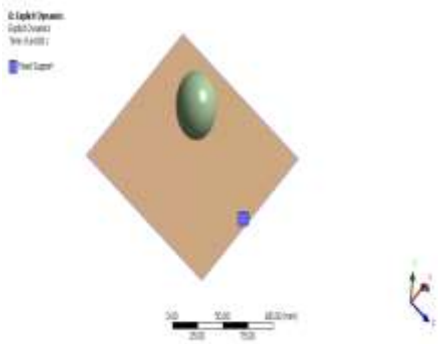
Property	E-glass /epoxy	Carbon /epoxy	Jute /epoxy
Fiber volume fraction, Vf	0.1	0.1	0.1
Matrix volume fraction, Vm	0.9	0.9	0.9

Young's Modulus in the 1-direction, E1 [GPa]	10.36	14.36	5.06
Young's Modulus in the 2-direction, E2[GPa]	3.75	3.76	3.7
Young's Modulus in the 3-direction, E3 [GPa]	3.75	3.76	3.7
Shear Modulus in 1-2 direction, G_{12} [GPa]	1.6	1.57	1.61
Shear Modulus in 2-3 direction, G_{23} [GPa]	1.28	1.26	1.61
Shear Modulus in 3-1 direction, G_{31} [GPa]	1.28	1.26	1.29
Poisson's ratio in 1-2 direction□□□□□□	0.33	0.34	0.35
Poisson's ratio in 2-3 direction□□□□	0.33	0.34	0.35
Poisson's ratio in 3-1 direction□□□□□	0.33	0.34	0.35

Finite Element model.



Boundary condition



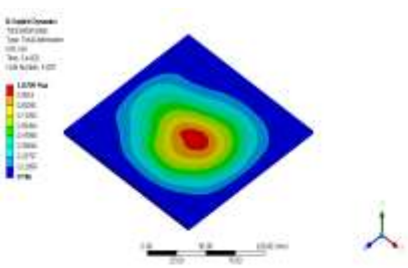
Details of "Drop Height"

Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Input Type	Drop Height
Define By	Drop Height
Drop Height	0.4 m
Impact Velocity	2.8009 m/s
Coordinate System	Global Coordinate System
Direction	-Y Direction
Suppressed	No

Figure-1: Finite element model of a plate shell subjected to external pin ball drop (400 mm Height)

3. Results presentation and discussion

A) Glass/Epoxy Composite Plate.



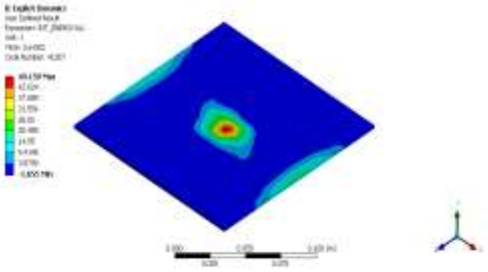


Figure-2:Total deflection of E-glass/Epoxy composite plate. Figure-3:Energy of E-glass/Epoxy composite plate

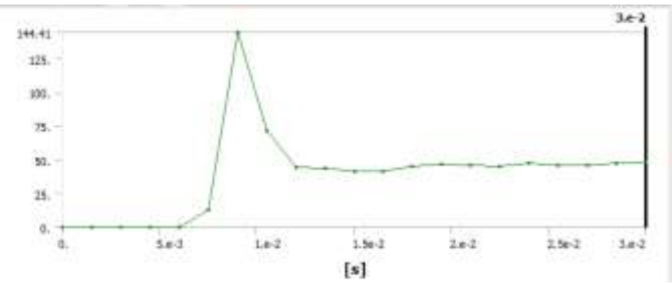
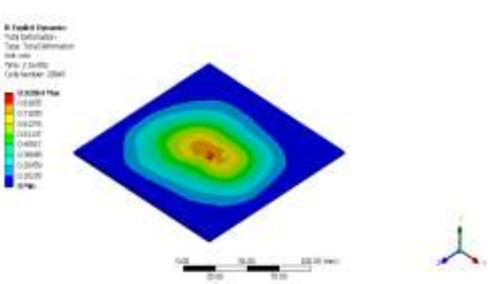


Figure-4:Energy Absorbed Vs time .

B) Carbon/Epoxy Composite Plate.



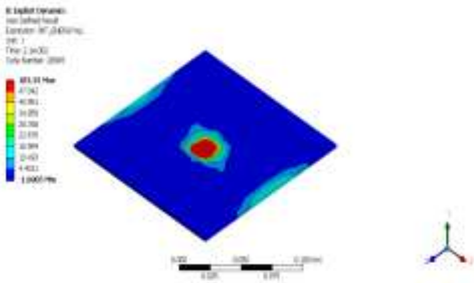


Figure-5:Total deflection of Carbon/Epoxy composite plate. Figure-6:Energy of Carbon/Epoxy composite plate

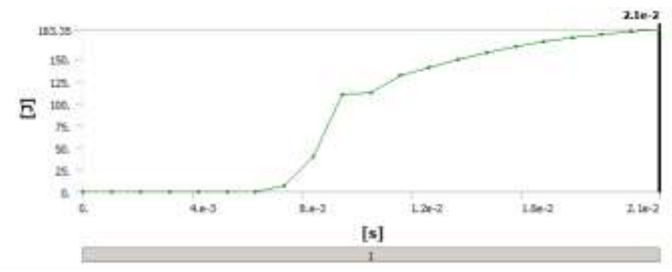


Figure-7:Energy Absorbed Vs time.

Comparison of FEA low velocity impact for various material properties of composite Plate.

Material Properties	Deflection [mm]	Energy [J]
E-glass /Epoxy	1.07	48.15
Carbon /Epoxy	0.92	183
Jute /Epoxy	---	---

From the Finite Element results 10% E-glass Fiber Composite plate absorbed 48.75 joules of Energy and the 10% Carbon Fiber Composite plate absorbed 183 joules of Energy where as the10% Jute Fiber Composite plate undergone Penetration.

Impact energy obtained from the experimental results is divided by the net cross sectional area of the specimen to convert it into Impact resistance. In the finite element simulation, the specimen is under impact loading due to inertia of hammer (pendulum). The Energy absorbed Vs Time is plotted for both e-glass and Carbon specimen are shown with the help of its contour profile in Figure -4 and Figure -7 respectively.

4.CONCLUSION

From this Study Impact resistance of the three different materials was evaluated and 10%Carbon Fiber Reinforced Polymer composite plate showed the highest impact resistance among them. From this study we can say that even though the Energy Absorbing Capacity of carbon Fiber reinforced Composite is high, still with reference to other aspects like cost and strength etc, hence Synthetic fiber(E-glass) is the better and suitable material particularly for Biomedical Application, where Energy absorbing capability required is not much. The Natural Fiber(Jute)Reinforced material is failed to absorb the Energy as the impactor is penetrated through the Specimen.

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