FINITE ELEMENT ANALYSIS ON PREPEG USED IN STRUCTURAL PARTS OF AUTOMOBILES

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ABSTRACT:

Nowadays. Composite materials are being applied in several industries due to the possibilities of designing products with light weight and high stiffness. Despite such advantage, designing a part made of composite material is a hard task compared to tradition material selection approach because of their great number of free parameters, as fiber directions, number of plies, matrix and fiber material.

Almost all automobiles (at least those which correspond to design with a rear wheel drive and front engine installation) have structural parts. The weight reduction of the structural parts can have a certain role in the general weight reduction of the vehicle and is a highly desirable goal, if it can be achieved without an increase in the cost and decrease in the quality and reliability.

In our project, a tensile specimen (according to ASTM A370) is designed using ANSYS ACP workbench and analysis was performed using ANSYS static structural workbench. Analysis performed on 6 different materials which includes conventional structural steel. Epoxy Carbon (230GPA) and High Modulus Epoxy Carbon (395GPA) both Uni Directional (UD) and WOVEN. Results were compared among these chosen fibers and found that High strength Epoxy carbon (395GPA) was the optimum material for manufacturing the structural parts of automobile under different orientations.

Keywords- Composite Material, Tensile specimen, workbench &ANSYS ACP.

1. INTRODUCTION:

In the present scenario, Composite materials like carbon fiber (CFRP), typically used in the aerospace and automotive sectors, are being used increasingly in energy, sports, construction and marine applications. Their composite nature, however, makes accurate simulation a challenge.

In this innovative project, we are using ANSYS. Ansys offers a complete suite of tools to help you overcome this challenge. Front and center is Ansys Composite Prep Post (ACP), a dedicated tool for composite layup modeling and failure analysis. You can generate layered composite models for implicit and explicit structural and thermal, as well as fluids, simulations.

ACP provides efficient layup and best-in-class solid element modeling capabilities and a platform that offers many ways to exchange model information. Beyond the modeling of composite structures, Ansys Composite Cure Simulation (ACCS) simulates the curing manufacturing process. It helps you to simulate the curing process of a part and predicts residual stresses and process- induced distortions.

For example, NASA and many commercial companies have dedicated extensive research efforts towards developing different methods for manufacturing and certifying composite pressure vessels for use in space for both satellites and shuttles.

Current methods of certifying laminate properties for aerospace applications rely heavily on experimental testing initially and confirmed with finite element analysis. Once the initial part and methods have been verified, follow up parts and methods using similar principals can be verified with just finite element simulations.

2. EXPERIMENTAL ANALYSIS:

2.1 Problem Definition:

After studying different papers on composites, we have chosen our project motto on the application of the prepeg on structural steels of automobile under normal feasible working conditions under different orientations.

Determining the right material during the selection process is very important. The material selected should meet the expectation of the engineer. The material should prove mechanically feasible and should be economical. [11] Apart from this the selected material must convincingly prove better than the currently used material.

In this project, we are using different types of epoxy based fibers and a tensile test specimen subjected to different loads with different orientations with different materials in ANSYS ACP. From the experiments, observations are noted and the material 395 UD shows optimum design condition for maximum stress with minimum deflection is found out.

Software Used- ANYS ACP (PRE).

3. DESIGN AND ANALYSIS:

Initially, a tensile specimen is designed in ansys as shown in the figure below

Then it is transferred to setup after creating it as a complete solid with zero thickness. After, that the following procedure follows:

a. Open setup, select and create Fabrics under Material Data.
b. Add new rosette to model and define a rosette type as parallel.

c. Create new oriented element set using rosette and elements set as required.

d. Create Ply Group with the help of oriented elements and enter an angle, no layers.

e. Create Ply with different angles as required.

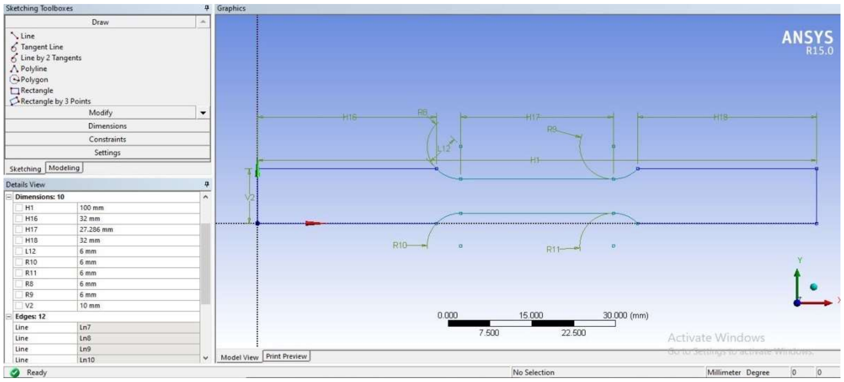

Fig.1. Design model

f. Update the model and convert to a solid model.

i. Drag and drop static structural workbench to project schematic and connect setup cell from ACP (Pre) to model cell in static structural, select option “transfer solid data”.

ii. Open the model cell in static structural and Check the geometry.

3.1 Structural Analysis in Ansys:

- Open model cell in static structural and select static structural from model tree.
- Apply constraint on one end of the shaft.
- Apply Moment force of 1000N on the other end of the shaft.
- Select Total deformation, Von misses, shear strain from Solution option and execute the solution.
- At project schematic right click on solution cell from static structural and select “Transfer data”.
- Open modal workbench and select total deformation option from solution part.

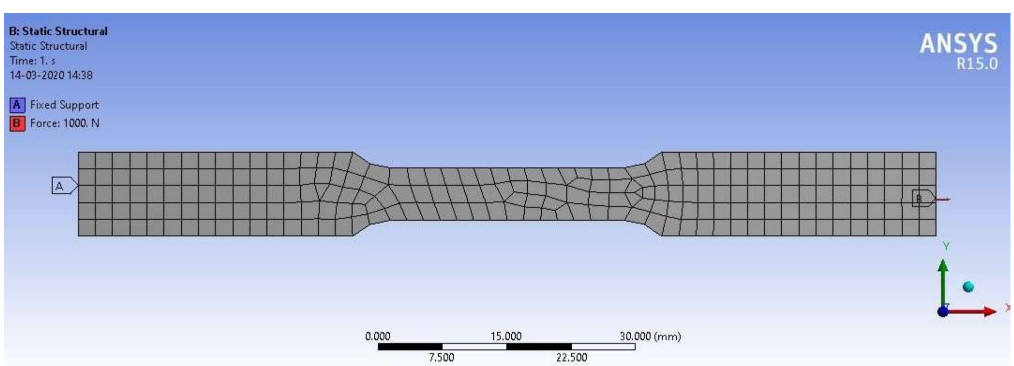

Fig.2. Mesh

3.2 Results:

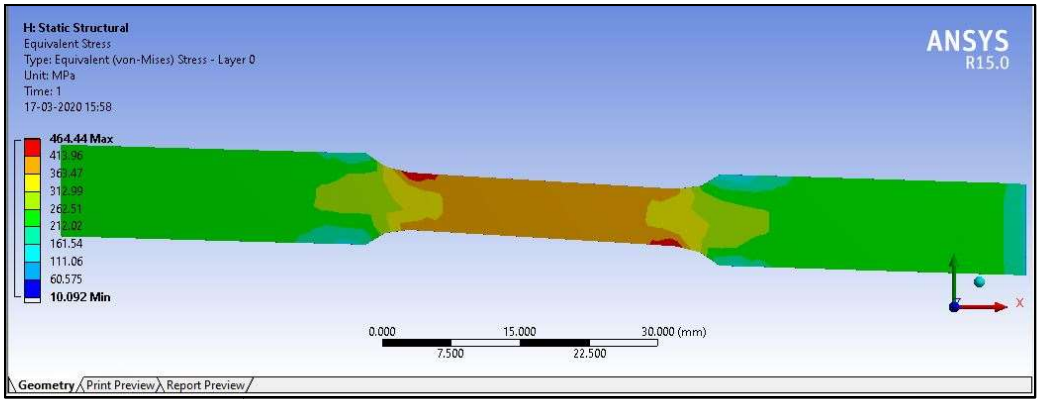

Fig.3. Von Misses Stress

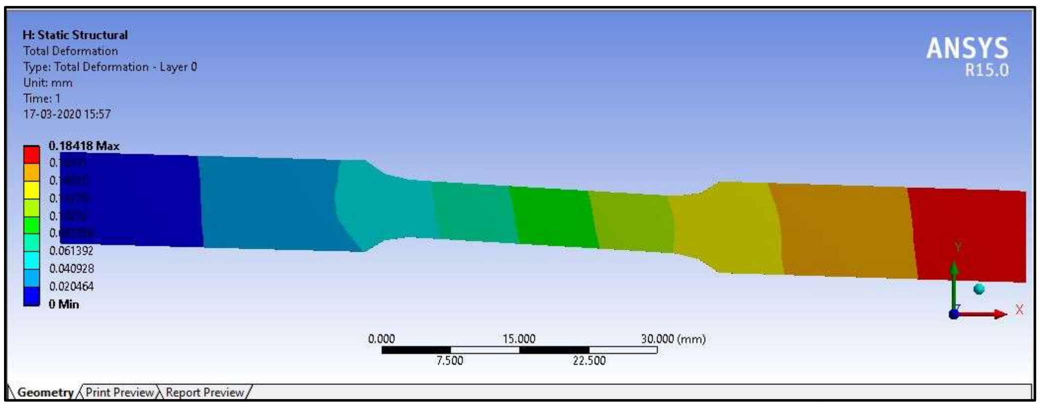

Fig.4. Total deformation

3.3 Properties of 395 UD:

Table 1: Epoxy Carbon UD 395GPa PrePeg- Orthotropic Stress Limits.

Epoxy_Carbon_UD_395GPa_Prepreg > Orthotropic Stress Limits

Temperature C	Tensile X direction MPa	Tensile Y direction MPa	Tensile Z direction MPa	Compressive X direction MPa	Compressive Y direction MPa	Compressive Z direction MPa	Shear XY MPa	Shear YZ MPa	Shear XZ MPa
	1979	26	26	-893	-139	-139	100	50	100

4. RESULTS AND DISCUSSIONS:

4.1 Epoxy Based Carbon PrePeg:

Table 1:

Orientation 1 :- (0-15-30-15-0)°

		Uni-Directional			Woven		
Material Types / Properties		230Gpa	230Gpa wet	390Gpa	230Gpa	230Gpa wet	390Gpa
Deformation (mm)		0.3247	0.31437	0.2287	0.2207	0.2327	0.1630
Elastic Strain Von-Misses		0.0066	0.00653	0.0049	0..0040	0.0042	0.0039
Equivalent Stress Von-Misses (Mpa)	Max.	353.46	352.76	383.09	203.42	208.73	224.65
	Min.	24.437	23.912	21.869	67.45	66.789	61.93
Strain Energy (Mj)		0.3347	0.3269	0.2266	0.2477	0.2793	0.1882
Max. Principal stress (Mpa)		355.16	354.16	391.15	206.41	210.72	225.11
Min. Principal stress (Mpa)		5.811	5.310	3.911	4.981	4.658	3.857

4.1.1 UD:

For the 2nd orientation the EPOXY based carbon material UD 390 gives the maximum yielding capacity up to 464.44 MPa and with a very less deformation of 0.18418mm and after those 230 UD WET material exhibits the same range values.

For orientation 1 the EPOXY based carbon material 390 UD gives the maximum yielding capacity up to 383.09 MPa and a slight deformation of 0.2287mm.And after that material 230 UD gives similar values.

4.1.2 WOVEN:

For the 2nd orientation the EPOXY based carbon material 390 WOVEN gives the maximum yielding capacity up to 217.05 MPa and with a very less deformation of 0.159mm and after that 230 WOVEN WET material exhibits the same range values.

Table 2:
Orientation 2 :- (0-45-90-45-0)$^{\circ}$

		Uni-Directional			Woven		
Material Types / Properties		230Gpa	230Gpa wet	390Gpa	230Gpa	230Gpa wet	390Gpa
Deformation (mm)		0.28603	0.2835	0.18418	0.23210	0.25120	0.15903
Elastic Strain Von-Misses		0.006413	0.006340	0.004432	0.00410	0.00420	0.002912
Equivalent Stress Von-Misses (Mpa)	Max.	440.45	443.85	464.44	204.1	205.68	217.05
	Min.	14.294	13.209	10.092	74.31	76.57	69.994
Strain Energy (Mj)		0.5126	0.51083	0.33012	0.30112	0.31112	0.22049
Max. Principal stress (Mpa)		443.61	446.78	467.09	206.4	209.4	220.48
Min. Principal stress (Mpa)		7.3101	6.775	4.7506	3.712	4.819	3.943

5. CONCLUSIONS:

Finally it is concluded that the present methodology is an effective approach to determine epoxy based carbon fiber performance in various aspects right from the selection of orientation, static analysis.

1. For different orientations the material 395 UD shows maximum strength and minimum deflection. After those material 230 UD wet is best.
2. Von-Misses stress varies linearly in decreasing order as shown in results.
3. 395 woven is not suitable for structural steels under different orientations and shows poor performance among other materials.
4. For structural steels UD is better than WOVEN.

6. SCOPE OF THE FUTUREWORK:

1. We can do Debonding between composite layers.
2. Composite tube under quasi-load using Is-dyna.
3. Impact test of composite material by using Is-dyna.
4. Crash test on composite model.
5. Creating rotor model with composite material in ACP.
6. Cure simulation of composite material.
7. Bird strike on composite wing.

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