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Design and Analysis of Car Bonnet by Using PRO-E Abs Ansys with FRP

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ABSTRACT:

Recently, Advance composite materials have taken the significant share with other engineering materials due to its mechanical properties and high strength to weight ratio. Advance composite like E-glass, S-glass, Carbon fiber, Kevlar are not yet confined at the aerospace industry but gradually these are taking over the position of other industries as well. Because of its attaining the high intricacy in designing factors and as well as cheaper mould design and also less cost in production of few numbers. The applications of FRPs are spirally increasing. The aim of this project is to develop a car bonnet with a help of FRPs inorder to sustain all the mechanical properties which are equivalent to the metals with the help of advanced computer aided software designs like PRO-E, ANSYS. In computer aided engineering to make the product proven in the realistic market.

I. INTRODUCTION:

Nowadays, in development of technology especially in engineering field make among the engineers more creative and competitive in designing or creating new product. They must be precise and showing careful attentions on what they produce. Here, we concentrate on automotive industry. The greatest demand facing the automotive industry has been to provide safer vehicles with high fuel efficiency at minimum cost. Current automotive vehicle structures have one fundamental handicap, a short crumple zone for crash energy absorption. One of the options to reduce energy consumption is weight reduction. However, the designer should be aware that in order to reduce the weight, the safety of the car passenger must not be sacrificed.

A new invention in technology material was introduced with polymeric based composite materials, which offer high specific stiffness, low weight, corrosion free, and ability to produce complex shapes, high specific strength, and high impact energy absorption. Substitution of polymeric based composite material in car components was successfully implemented in the quest for fuel and weight reduction. Among the components in the automotive industry substituted by polymeric based Composite materials are the bumper beam, bumper fascia, spoiler, connecting rod, Pedal box system, and door inner panel. The bumper system consists of three main components, namely bumper beam, fascia and energy absorber. The automotive body is one of the critical subsystems of an automobile, and it carries out multiple functions. It should hold the parts of the vehicle together and serve to filter noise and vibration. Additionally, it should be able to protect its occupants when accidents happen. To do this, the automotive body designer should create a structure with significant levels of strength, stiffness, and energy absorption.

Composite Materials:

Composite materials (also called composition materials or shortened to composites) are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons common examples include materials which are

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stronger, lighter or less expensive when compared to traditional materials.

Typical engineered composite materials include:

- Composite building materials such as cements, concrete
- Reinforced plastics such as fiber-reinforced polymer
- Metal Composites
- Ceramic Composites (composite ceramic and metal matrices)
-

Composite materials are generally used for buildings, bridges and structures such as boat hulls, swimming pool panels, race car bodies, shower stalls, bathtubs, storage tanks, imitation granite and cultured marble sinks and counter tops. The most advanced examples perform routinely on spacecraft in demanding environments.

Classification of Composites:

Based on reinforcements, there are five basic types of composite materials

- Fiber,
- Particle,
- Flake,
- Laminar or layered, and
- Filled composites

Fiber Composites:

In fiber composites, the fibers reinforce along the line of their length. Reinforcement may be mainly 1-D, 2-D or 3-D. Figure shows the three basic types of fiber orientation.

- 1-D gives maximum strength in one direction.
- 2-D gives strength in two directions.
- Isotropic gives strength equally in all directions.

Flake Composites:

A flake composite consists of thin, flat flakes held together by a binder or placed in a matrix. Almost all flake composite matrixes are plastic resins. The most important flake materials are:

- Aluminum
- Mica
- Glass

laminar Composites:

A lamina (laminae) is any arrangement of unidirectional or wovenfibers in a matrix. Usually this arrangement is flat, although it may be curved, as in a shell. A laminate is a stack of lamina arranged with their main reinforcement in different directions.

Filled Composites:

There are two types of filled composites. In one, filler materials are added to a normal composite result in strengthening the composite and reducing weight. The second type of filled composite consists of a skeletal 3-D matrix holding a second material. The most widely used composites of this kind are sandwich structures and honeycombs.

Particle Composites:

- Particles usually reinforce a composite equally in all directions (called isotropic). Plastics, cermetsand metals are examples of particles.
- Particles used to strengthen a matrix do not do so in the same way as fibers. For one thing, particles are not directional like fibers. Spread at random throughout a matrix, particles tend to reinforce in all directions equally.
- Metal–plastic particle composites (e.g. Aluminum, iron&steel, copper particles)
- Metal–in–metal Particle Composites and Dispersion Hardened Alloys

II. FRP(FIBER REINFORCED PLASTIC/POLYMER)

FRP is composed of two main materials the reinforcement and the polymer matrix which bonds the reinforcement into one monolithic whole.

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There are various material possibilities for the use of both parts. Next to that composites are also composed of fillers and additives. The polymer is either of the thermoset or the thermoplastic type and based on resin products. The matrix is a continuous material which surrounds and supports the reinforcement by maintaining its relative position. Loose strands of e.g. glass fiber would not be structurally successful. Though the strength in FRP comes from the reinforcement, the polymer matrix delivers the form and ensures proper placement of the fibers. Next to that the resin also protects the reinforcement from outer influences such as weather, water, UV and so on. All resin types function more or less in the same way. Fibre Reinforced Plastics (FRP) is the generic term for a uniquely versatile family of composites used in everything from chemical plant to luxury power boats. An FRP structure typically consists of unsaturated polyester (UP) resin applied to a mould in combination with reinforcement, most commonly glass fibre, to form a part that is rigid, highly durable and low in weight. FRP provides an unrivalled combination of properties:

- Light weight
- High strength-to-weight ratio (kilo-for-kilo it's stronger than steel)
- Design freedom
- High levels of stiffness
- Chemical resistance

Types of manufacturing process of FRP

- Open mould production
- Closed mould production
- Bulk molding production
- Continuous production

Open Molding

Open mold methods allow for a rapid product development cycle because the tooling fabrication process is simple and relatively low cost.

Different open molding frp processing techniques are

1. Hand lay-up
2. Spray-up
3. Vacuum Bagging .
4. Automated tape-laying machines

Hand Lay-Up

The simplest of the fabrication processes, hand lay-up is used in low-volume production of large products, e.g., wind turbine components, concrete forms, and radomes. A pigmented gel coat is first sprayed onto the mold for a high-quality surface. When the gel coat has cured, glass reinforcing mat and/or woven roving is placed on the mold, and the catalyzed resin is poured, brushed or sprayed on. Manual rolling then removes entrapped air, compacts the composite, and thoroughly wets the reinforcement with the resin. Additional layers of mat or woven roving and resin are added for thickness. A catalyst or accelerator initiates curing in the resin system, which hardens the composite without external heat.

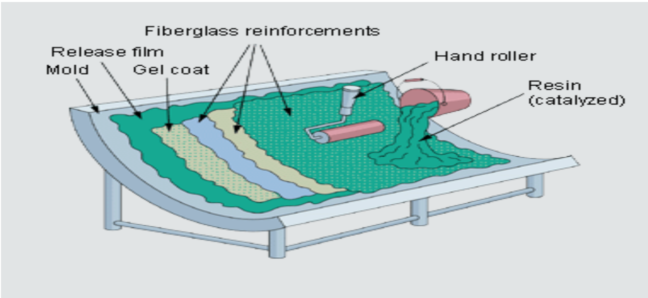

Fig 1: hand layup

Products Made by Hand Lay-Up

Generally large in size but low in production quantity - not economical for high production

Applications:

- Boat hulls
- Swimming pools
- Large container tanks
- Movie and stage props
- Other formed sheets

The largest molding ever made was ship hulls for the British Royal Navy: 85 m (280 ft) long

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Spray-Up

Similar to hand lay-up in simplicity, spray-up offers greater shape complexity and faster production. Spray-up utilizes a low-cost open mold, room temperature curing resin, and is ideal for producing large parts such as tub/shower units and vent hoods in low to moderate quantities. Chopped fiber reinforcement and catalyzed resin are deposited in the mold from a chopper/spray gun. As with lay-up, manual rolling removes entrapped air and wets the fiber reinforcement. Woven roving is often added in specific areas for thickness or greater strength. Pigmented gel coats can be used to produce a smooth, colorful surface.

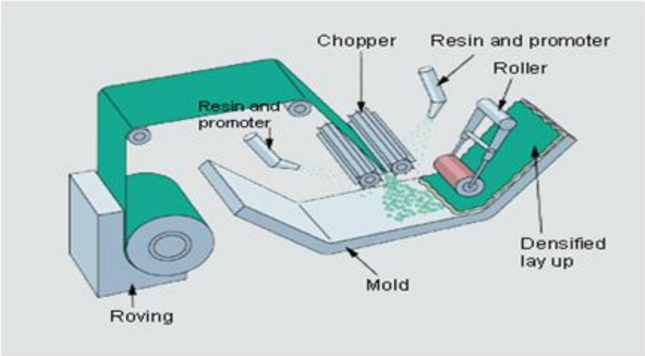

Fig2: spray up

Advantages:

- Wide range of part size potential
- Parts have one finished surface and require secondary trimming
- Best for low-volume, large and/or complex components
- Best for production rates of <1,500 parts per year*
- Lowest cost tooling option
- Can accommodate single or multi-piece molds
- Preferred method for prototype development - design changes are easy

Vacuum-Bag Molding

The vacuum–bag process was developed for making a variety of components, including relatively large parts with complex shapes. Applications are large cruising boats, racecar components, etc.

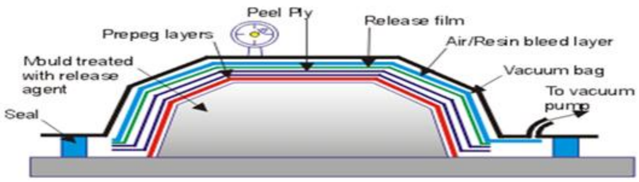

Fig 3: vacuum bag

Advantages:

- Simple design
- Any fiber/matrix combination
- Ok with cheap mold material
- Better quality for the cost

GLASS FIBRES

The idea to use fine glass fibers in weaving processes to produce textile glass was developed by the French physicist Ferchault de Réaumur in the late 18th century. However industrial production of continuous glass fibers only started in 1935 in Newark, Ohio, USA when the company Owens &Carning developed a production method suitable for industrial production. Production in Europe started only 3 years later in Germany. The first industry that used glass fibers was the electrical industry, hence the common name the glass fiber type “E-glass”. Since this the 1930’s glass fiber production has undergone a constant evolution of better products and more efficient production.

Glass fibers are the most widely used reinforcements; over 90% of all FRPs are made of glass fiber. The oldest and still most popular form is E-glass or electrical grade glass. Other types of glass fibers are A-glass or alkali glass, C-glass or chemical resistant glass, and the high strength R-glass and S-glass. Under laboratory circumstances glass fibers can resist tensile stresses of about 7000 N/mm2, whereas commercial glass fibers reach 2800 to 4800 N/mm2 Nowadays glass fibers are produced by a process called “direct melt system”. In this system the crude materials needed for glass production, such as limestone, silicon dioxide, aluminum dioxide, kaolin, quartz and others are grinded and checked for pureness.

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Afterwards they are inserted in a giant melting bath, where they are heated up to about 1600°C.

Types of Glass Fiber

As to the raw material glass used to make glass fibers or nonwovens of glass fibers, the following classification is known:

A-glass: With regard to its composition, it is close to window glass. In the Federal Republic of Germany it is mainly used in the manufacture of process equipment.

C-glass: This kind of glass shows better resistance to chemical impact.

E-glass: This kind of glass combines the characteristics of C-glass with very good insulation to electricity.

AE-glass: Alkali resistant glass.

Properties of e-glass

Generally, glass consists of quartz sand, soda, sodium sulphate, potash, feldspar and a number of refining and dying additives. The characteristics, with them the classification of the glass fibers to be made, are defined by the combination of raw materials and their proportions. Textile glass fibers mostly show a circular. In the following several tables will be presented to show some of the characteristics of the different glass fiber grades. The first table shows the chemical composition of the different glass fiber grades. The chemical composition is given here solely as an overview and introduction.

Component	E-Glass	R-Glass	A-Glass	C-Glass	AC-Glass
SiO_2	52,4	60,0	72,5	63,6	58
Al_2O_3	14,4	25,0	1,5	4,0	12.4
Cao and MgO	21,8	20,0	12,5	16,6	23
B_2O_3	10,6			6,7	
Na_2O and K_2O	0,8		13.5	9.1	

In the table below a composition between various glass-fiber types can be seen. It is clearly visible that the high strength R-Glass offers the best performance. It has both the highest tensile modulus as well as the highest tensile strength. The most used grade, the E–glass performs second best. It is also obvious that the fracture-strain for all glass types is quite low. Steel can typically take strains in excess of 10% before fracturing. A conclusion to be made here is, that glass fibers have a bad ductile performance compared to steel. They behave very brittle.

Type	E-Glass	R-Glass	A-Glass	C-Glass	EC-Glass
Density	2,6	2,53	2,68	2,52	2,72
Filament(not coated)	3.400	4.400	3.000	2.400	3.445
-Roving (coated)	2.400	3.600			
Tensile Modulus(N\mm2)	73.000	86.000	73.000	70.000	73.000
Fracture strain (%)	4.8	4.8	4.4	4.8	4.8

Next to that it is interesting to see that the differences between the manufactured and raw glass fiber material is quite noticeable. Whereas the raw material has a tensile strength modulus of 73.000N\mm2, the glass chopped strand mat has a tensile modulus that is 10%times lower, although it has a fiber content of about 30%.Among others, this leads to the conclusion that next to fiber content also the direction of the fibers is of great significance for the mechanical properties.

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Type	Unit	Woven Cloth	Chopped strand Mat	Continuous roving
Glass content	%	55	30	70
Specific gravity		1,7	1,4	1,9
Tensile strength	N\mm 2	300	100	800
Flexural strength	N\mm 2	15.000	7.000	40.000
Impact strength	KJ\m m2	150	75	250

III. MECHANICAL PROPERTIES FOR FIBER REINFORCED PLASTICS

Elastic Modulus and Compressive Strength

The main purpose of the engineering analysis is to establish the equivalent mechanical properties of the composite material, including the elastic modulus for the initial loading phase, the axial compression strength, the inertia moment, and the critical buckling load.

The equivalent material properties of the composite are related to the mechanical properties of the component materials, assuming strain compatibility between the plastic and the fiber reinforcement during the axial compression loading.

The following assumptions were used in this analysis. For the composite material section, the equilibrium equation under the applied load, F, can be written as:

$$F = \sigma_c A_c = n\sigma_b A_b + \sigma_p A_p$$

Where:
σ_c = Stress of the total section of the sample.
A_c = Cross-sectional area of the sample.
n = Number of bars in the composite section.
σ_b = Stress of the fiberglass bar.
A_b = Section area of the fiberglass bar.
σ_p = Stress of the plastic.
A_p = Section area of the plastic.
For axial compression, assuming elastic materials and strain compatibility between the plastic and the fiber reinforcement during the axial compression loading implies the relationships.

$$E = \frac{\sigma_b}{E_b} = \frac{\sigma_p}{E_p} = \frac{\sigma_c}{E_c}$$

Where:
E = Young's modulus.
E_b = Young's modulus of the bar.
E_p = Young's modulus of the plastic.
E_c = Young's modulus of the total section of the sample.
Solving theequations,yields the equation.

$$\frac{\sigma_c}{\sigma_b} = \frac{E_c}{E_b} = n\frac{A_b}{A} + \frac{E_p}{E_b}\left[1 - \left(\frac{nA_b}{A}\right)\right]$$

By making the following substitutions,
$\alpha = nA_b/A$, where α is defined as the area replacement factor,
$\beta = E_p/E_b$, where β is the relative axial stiffness coefficient,
$A_c = A$, where A_c is the section area of the composite sample,
The equation can be written in the form of the equation in:

$$\frac{E_c}{E_b} = \alpha + \beta(1 - \alpha)$$

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The equation yields the equivalent Young's modulus of the composite material as a function of the replacement factor α, the relative stiffness coefficient β, and the Young's modulus of the fiberglass bar E_b. For the SEAPILE composite material, equation 4 yields an equivalent Young's modulus value of E_c= 3.05 x 10^6 kPa (442.36 ksi); the difference between this calculated E_c value and the experimental result obtained for the composite sample E_c = 3.38 x 10^6 kPa (490.23 ksi) is less than 10 percent of the experimental value.

The equivalent shear modulus, G_c, of the composite material can be calculated from the theory of elasticity assuming that the FRP composite is an isotropic elastic material. This assumption does not take into account the anisotropy of the composite material induced by the preferential direction of the fiber reinforcement. Accordingly the equivalent shear modulus, G_c can be calculated by the equation,

$$G_c = E_c / 2(1+\upsilon_c) \qquad \upsilon_c = \upsilon_p$$

Where:

υ_c and υ_p are the Poisson's ratio values of the composite material and its recycled plastic component, respectively. The equivalent compression strength, R_c, of the composite material is given by the equation.

$$R_c / R_b = \alpha + \eta(1-\alpha)$$

Where:

η = R_p/R_b, the compression strength ratio of the component materials.

R_p = Compression strength of the fiberglass bar.

R_b = Compression strength of the recycled plastic mobilized at the failure strain of the fiberglass bar (e = 2.6 percent).

For the SEAPILE composite material, the equation yields an equivalent compression strength R_c = 7.4 x 10^4 kPa (10.73 ksi); the difference between this calculated R_c value and the experimental result obtained for the composite sample, R_c = 6.8 x 10^4 kPa (9.86 ksi), is about 8.8 percent of the experimental value. The effect of the recycled plastic on the behavior of the composite material can be analyzed considering the failure load factor (FLF), defined as the ratio of the failure load F_c of the composite material to the failure load nF_b, defined as the failure load of the bar multiplied by the number of bars in the composite material. The FLF can be calculated by the equation

$$FLF = \frac{F_c}{nF_b} = \frac{E_c A_c}{E_b n A_b} = 1 + \beta\left[\frac{1}{\alpha} - 1\right]$$

illustrates the experimental relationships between the applied axial load and the axial strain for the group of 16 bars and the composite material. The results show that, at failure by axial compression, the recycled plastic has only a limited effect on the load-bearing capacity of the composite material. The equation in figure 22 yields an FLF of 1.068, which is quite consistent with the experimental results (FLF = 1).

Moment of Inertia:

Bending moment, assuming elastic materials and strain compatibility between the plastic and the fiber reinforcement during bending, implies the relationships

$$\frac{M}{y''} = E_c I_c = E_p I_p + E_b \sum I_b * \left(1 - \frac{E_p}{E_b}\right)$$

Where:

M = Bending moment.

y″ = Second derivative of the displacement variation with depth.

SI_b = Sum of the moments of inertia of all the fiberglass bars with respect to the axis ofsymmetry of the composite material section.

I_p = Moment of inertia of the recycled plastic section with respect to the axis of symmetry ofthe composite material section.

The moment of inertia (I_c) of the composite material can be derived by rearranging the equation to give the equation

$$I_c = \left[\frac{E_b}{E_c}\right]\left[\frac{E_p}{E_b} I_p + \sum I_b * \left(1 - \frac{E_p}{E_b}\right)\right]$$

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Moment of inertia $I_c(1)$

By substituting β for E_p/E_b, the equation can be rewritten as the equation

$$I_c = \left[\frac{E_b}{E_c}\right]\left[\beta I_b + \sum I_b * (1-\beta)\right]$$

Moment of inertia $I_c(2)$

The relative inertia moment coefficient λ is given by the equation

$$\lambda = I_p / \sum I_b$$

Preceding equations can be combined and rearranged to give the equation

$$I_c / \sum I_b = [1 + \beta(\lambda - 1)] / [\alpha + \beta(1-\alpha)]$$

Critical Buckling Force

The critical buckling force, P_{cr}, can be calculated according to Euler's equation:

$$P_{cr} = \frac{\pi^2 EI}{l^2}$$

Critical buckling force P_{cr}

Where:

E = Young's modulus.

l = Length of the bar.

I = Moment of inertia.

For the fiberglass bar sample (E = 1.6 x 10^7 kPa (2,320.6 ksi); l = 9 cm (3.5 inches); I = 19.16 cm^4 (0.46 $inch^4$)), the equation in figure 28 yields the calculated critical buckling load of P_{cr} = 3,736 kN (839.8 kips). For a given fixed boundary condition at the top and at the bottom of the bar, k = 0.5, P_{cr} = 1,868 kN (419.9 kips). This buckling load exceeds the compression failure load of 591.6 kN (133 kips), causing the bar to collapse by peripheral disintegration. The equivalent critical buckling load, P_{cr}, of an axially loaded bar confined in a low shear modulus material such as the recycled plastic is given by the equation in figure

$$P_\alpha = \frac{P_\alpha^0}{1 + \frac{P_\alpha^0}{G_c A}}$$

IV. Design of Car Bonnet

The dimensions that show on the plot are derived from the 3D model dimensions and remain dynamically linked to the source 3D files. The link is bidirectional: if you edit the 2D drawing, the 3D model dimensions change accordingly.

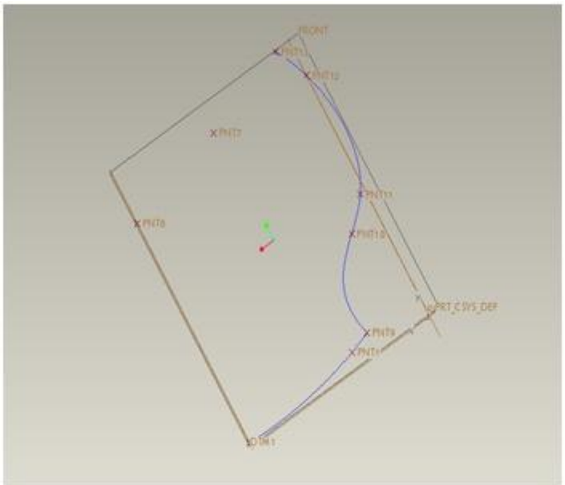

Fig4: connecting the points through the curves

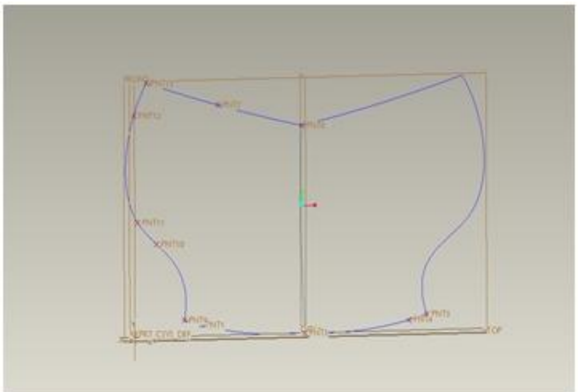

Fig 5: by taking the mirror to get the exact shape on the other side

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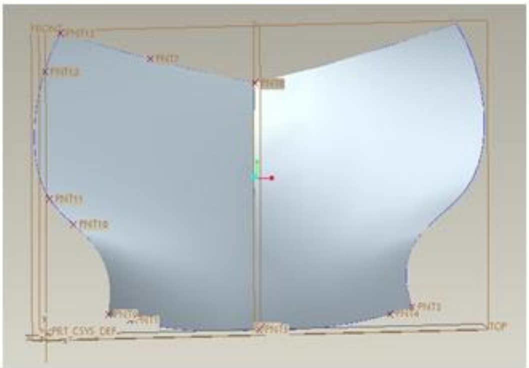

Fig 6: by using the blend option

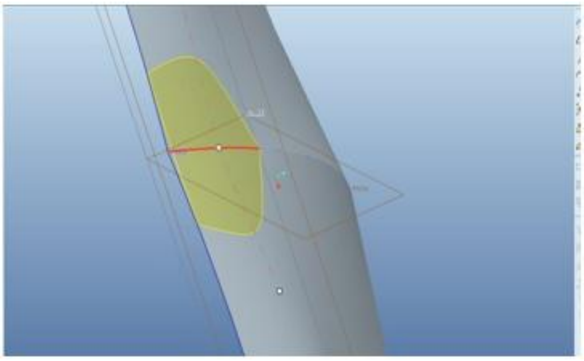

Fig 7: smoothing the edges

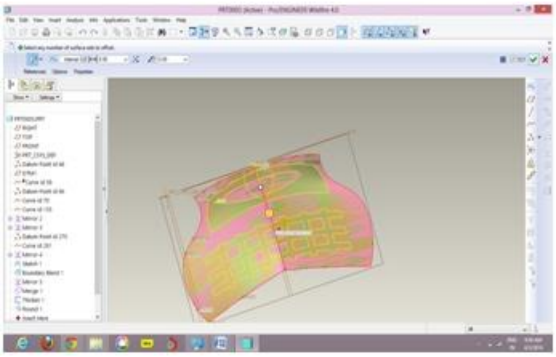

Fig8: by using the offset command

ANSYS mechanical is a comprehensive FEA analysis tool for structural analysis including the linear and non-linear and dynamic loading. The engineering simulation product provides a complete set of elements behavior material models and equation solvers for a wide range of mechanical problems. In addition ANSYS mechanical offers thermal analysis and coupled physics involving capabilities involving acoustic, piezoelectric thermal-structural and thermo-electric analysis.

V. ANALYSIS

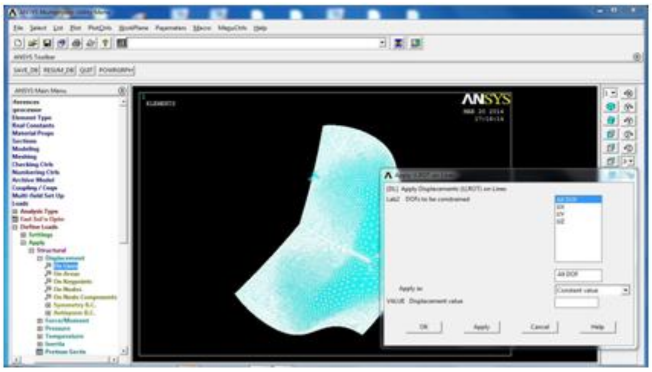

Fig 9: Defining displacement in all DOFs

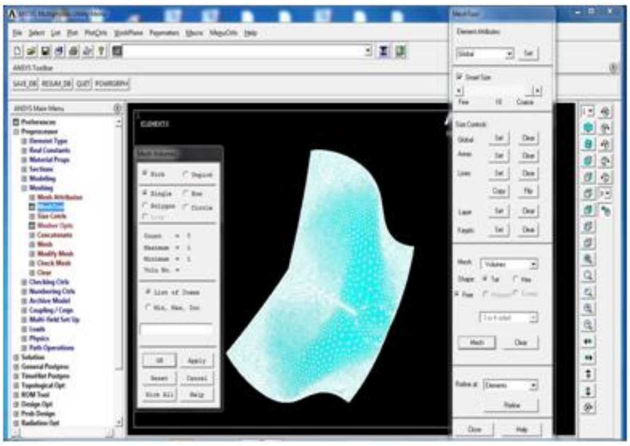

Fig 10: Meshing the part

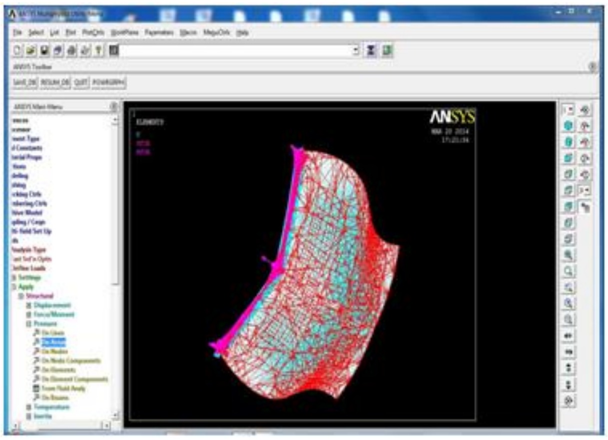

Fig 11: Applying pressure on bonnet

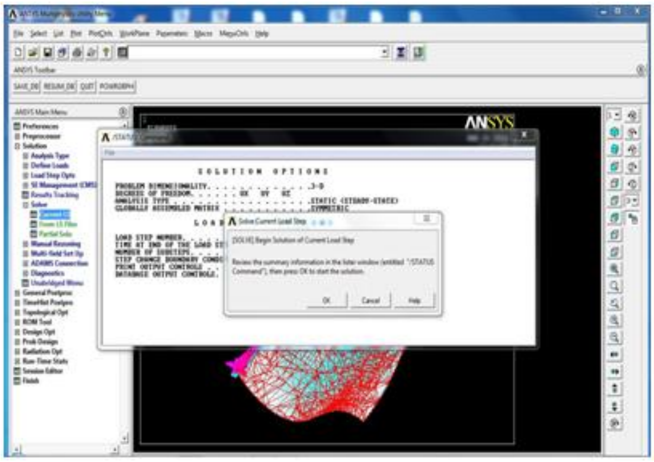

Fig 12: Solution done

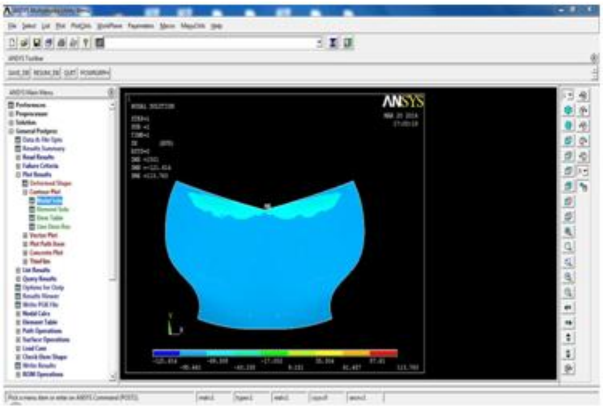

Fig 13: Stress in x-direction

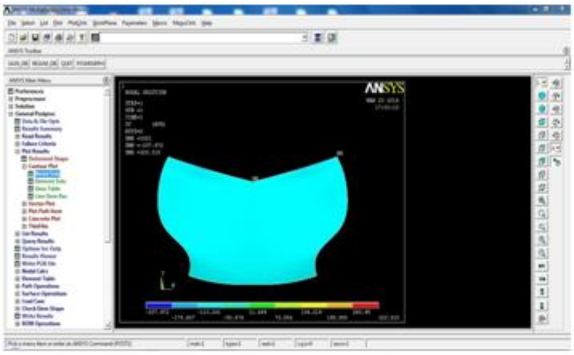

Fig 14: Stress in y-direction

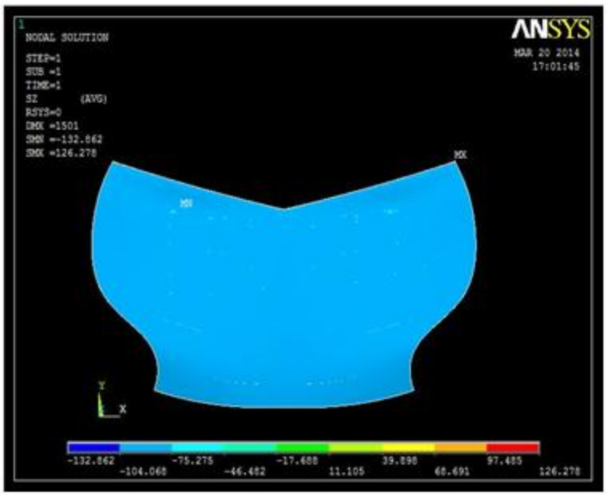

Fig 15: Stress in z-direction

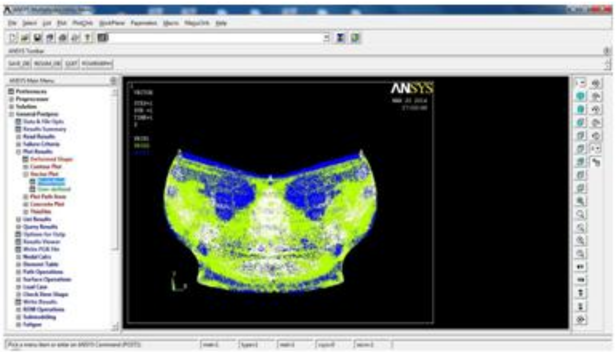

Fig 16: Vector plot

VI. CONCLUSION:

The designing of the car bonnet and analyzing it in the ansys has successfully done.The FRP(fibre reinforced plastics) materials due to its excellent mechanical properties in engineering field increase its applications throughout each and every engineering aspect. The application of the FRP is nearly going to be see in the field of aero industry due its light weight and high strength to resist the forces and its reasonable cost to be used.

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