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DESIGN AND ANYLISIS OF CAR BONNET BY USING PRO-E AND ANYSIS 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.

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.

CAR BONNET:

A car bonnet is the front part of the car where the engine is contained also referred to as the hood. It is used as the shield to the car engine from climatic and human harm and also keeps the engine away from the driver to minimise chances of catching fire.

In order to design a successful lightweight vehicle and significantly improve the crash performance of current cars, technological development is still needed. If the automotive body could extend its front end during or right before a crash, and also objects falling on the bonnet the mechanism of absorbing the crash energy would be totally different from that of the passive structure.

During a frontal crash, the front side member is expected to fold progressively, so as to absorb more energy and to ensure enough passenger space. To do so, various cross sections and shapes have been investigated for the front rail of the automotive body to maximize crashworthiness and weight efficiency their design included reinforcing the cross-section. For several decades, bumper design has focused on material and structure. Andersson investigated the applicability of stainless steel for crash-absorbing bumpers to increase crash performance in automotive vehicles. Butler studied the design of efficient epoxy structural foam reinforcements to increase the 9 energy absorbed in front and rear automotive bumper beams. Carley introduced Expanded Polypropylene (EPP) foam technologies and techniques for bumper systems. Cheon developed a new composite bumper that has two pads at each end of the bumper. Evans and Morgan studied

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thermoplastic energy absorbers for bumpers.

Fig(1.1) Car bonnet

MECHANICAL PROPERTIES OF SHEETMETALS

The tensile mechanical properties and static fracture characteristics of partially annealed low carbon mild steel are reported. Partially annealed samples were prepared by annealing the previously cold-rolled (0%, 28% and 50% cold reduction) steel sheet at 610°C in a salt bath for 0, 60 and 300 s. These samples were subjected to tensile tests to determine their mechanical properties and to Charpy impact tests and Kahn-type tear tests to measure their tensile fracture properties. It was concluded that the crack initiation and crack propagation energies are linearly related to the corresponding tensile mechanical properties. Furthermore, a transition in the behavior of partially annealed steel occurs at an energy level of 40 J and at the following mechanical properties:

ultimate tensile strength, 6.2×10^2 MPa;
yield stress, 6.1×10^2 MPa;
Charpy impact energy, $2.5 \times 10^5 Jm^{-2}$;
total elongation, 12%.

Below this point the material is more resistant to crack propagation than to crack initiation.

Common materials used in the manufacture of the car bonnet are

1. Aluminium
2. Iron alloys

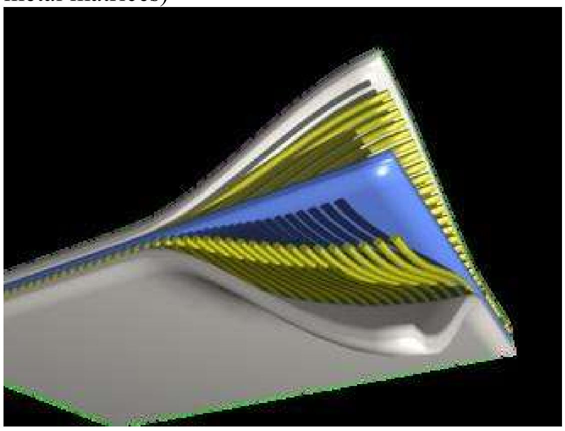
They are used for their durability and strength properties in common and mostly used the aluminum alloy for its low weight and temperature resistivity.

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 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)



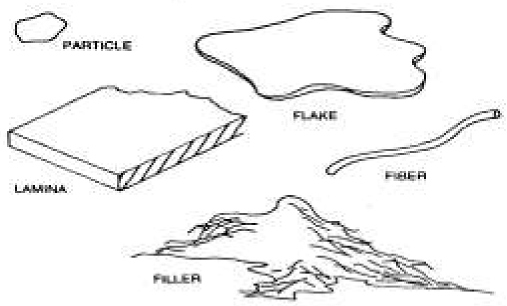
Fig(2.1) Composite material

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



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Fig(2.3)

4PHYSICAL PROPERTIES

The physical properties of composite materials are generally not isotropic (independent of direction of applied force) in nature, but rather are typically anisotropic (different depending on the direction of the applied force or load). For instance, the stiffness of a composite panel will often depend upon the orientation of the applied forces and/or moments. Panel stiffness is also dependent on the design of the panel. For instance, the fibre reinforcement and matrix used, the method of panel build, thermoset versus thermoplastic, type of weave, and orientation of fibre
axis to the primary force.

In contrast, isotropic materials (for example, aluminium or steel), in standard wrought forms, typically have the same stiffness regardless of the directional orientation of the applied forces and/or moments.

The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties: Young's Modulus, the shear Modulus and the Poisson's ratio, in relatively simple mathematical relationships. For the anisotropic material, it requires the mathematics of a second order tensor and up to 21 material property constants. For the special case of orthogonal isotropy, there are three different material property constants for each of Young's Modulus, Shear Modulus and Poisson's ratio a total of 9 constants to describe the relationship between forces/moments and strains/curvatures.

Techniques that take advantage of the anisotropic properties of the materials include mortise and tenon joints (in natural composites such as wood) and Pi Joints in synthetic composites.

2.5 BENEFITS:

Composite materials offer higher specific strength and stiffness than other conventional materials. Readily available carbon fibre composites will match the stiffness and strength of high-grade aluminium in all directions, at less than two-thirds the density. Specialist grades can be double the strength and stiffness of steel in the fibre direction.

Excellent strength and stiffness to weight ratio

The relative lightness of composite materials enables use of bigger sections that are inherently stiffer and stronger for bending and torsion. This is a considerable advantage for engineered structures. On a basic box section Aluminum, Titanium and Steel have very similar specific strength and stiffness which can be exceeded by even Black Metal application of carbon fibre composites. Tailoring the direction of the fibres to where they work efficiently can give 4 times stiffer or 2.5 times stronger per weight. Tapering the lay-up or increase the aspect ratio of the section improves performance further and can yield stiffness at 20 times and strength four times than the metallic baseline.

- **Ability to form complex shapes**

Composites can be used to make complex shapes without using high pressure tools, because the composite is formed when the matrix cures or goes solid. Consequently, the geometry of the part is very flexible, whether produced in low volume by manual lay-up pre-preg cured in a press or autoclave or using dry fibre performs infused with liquid resin in a closed mould.

The ability to mould complex shapes allows greater potential for consolidating the number of individual components in an assembly and structurally offers the advantage of inherent stability and buckling resistance. The use of core materials can further enhance the out of plane stiffness and moves composites into a different league.

- **Durability**

Composites offer outstanding fatigue and durability potential and are in general very tolerant to environmental effects such as UV damage, moisture, chemical attack and temperature extremes.

- **Damping characteristics**

Composites have the ability to reduce induced vibrations rapidly.

2.6 PLASTICS:

In contrast to the history of composites, the history of plastics is still very recent. The generally accepted start of the “plastic age” was in 1868 when John W. Hyatt developed the first real synthetic material in the USA. He produced a solid, stable nitrocellulose which is now well known as celluloid. The next big step in the history of reinforced plastics was the invention of “Duroplast” or “Bakelite” in the 1910’s. The Belgian inventor Leo H. Baekeland was the first one to control a known reaction of phenol and formaldehyde to such an extent that fillers such as sawdust, paper or other fibrous materials could be added to produce the first real reinforced plastic. The name “Bakelite“ was introduced shortly after the First World War in 1922.

Other developments in the field of Fiber Reinforced Plastics were “Formica”, “Celleron” and reinforced rubber. Formica was invented in 1913 by Daniel J. O’Connor; it was produced by pressing rolls of paper into a plate. Before pressing it the paper was soaked in resin. After hardening of the plate a solid sheet remained. Formica was primarily used as electric insulator.

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Celleron is a material that was used in the 1930's to produce non-metallic gears. It was a composite of cotton- or linen fibers and phenolic resin. The primary reason for the production of these new gears was noise reduction in automotive engines.

One of the first known man-made composite construction materials: Straw-clay composite MSc Thesis Literature Study | Feasibility Study on fiber reinforced polymer cylindrical truss bridges for heavy traffic A few decades earlier, in 1850-1890 fiber reinforced rubber was developed. Driven by the transportation growing industry the need for air inflated rubber tires grew. In 1887 the Scott John B. Dunlop developed a new kind of fiber reinforced rubber air inflatable tires. He also built the first air inflated tire factory in that year.

Fig(2.6) Plastics

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. 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. In their raw form they consist of loose molecular chains e.g. monomers which are dissolved in a substance. When the suitable curing agent, catalyst or accelerator is added to this substance, these chains begin to cluster and form a solid, three dimensional structures. The differences between the resins lie in their strength, curing, and hardening and in the quality of the fiber-resin interface. The other substantial part of FRP is the reinforcement fiber. There are a number of different types of reinforcement which differ foremost in their strength, their modulus and their elongation. All types of reinforcement can be implemented in the FRP in various weaves, filament or chopped strand mats, combination mats or roving the symbiosis. When the two parts are combined in the proper way, the curing agent will bond the fibers to the polymer and will form a structure. Performing this curing process in a controlled environment will dramatically increase the quality of the FRP product.

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 moldingfrp processing techniques are

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

Curing in Open Mold Processes

Curing is a term in polymer chemistry and process engineering that refers to the toughening or hardening of a polymer material by cross-linking of polymer chains, brought about by electron beams, heat or chemical additives

- Curing is required of all thermosetting resins used in FRP laminated composites

- Curing cross-links the polymer, transforming it from its liquid or highly plastic condition into a hardened product
- Three principal process parameters in curing
    - Temperature
    - Time
    - Pressure

Properties of e-glass:

Component	E-Glass	R-Glass	A-Glass	C-Glass	AC-Glass
Sio2	52,4	60,0	72,5	63,6	58
Al2o3	14,4	25,0	1,5	4,0	12.4
Cao and MgO	21,8	20,0	12,5	16,6	23
B2O3	10,6			6,7	
Na2O and K2O	0,8		13.5	9.1	

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.

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

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,

APPLICATIONS

1. Building and Construction

With its low maintenance and low weight, FRP is finding many applications building and infrastructure projects. UP resins can be mixed with glass fibre and fillers to cast synthetic marble and solid surfaces for kitchens and bathrooms, as well as roof tiles. For large projects such as bridges and wind generators, low weight for easier installation combined with low maintenance and durability make FRP an ideal alternative to conventional materials.

Fig(3.2(a))

2. **Marine industry**

Marine is an excellent example of an industry that has been completely transformed with the advent of FRP. Especially in the leisure boat sector, FRP has largely replaced traditional wood and steel building methods. An outer layer of gelcoat gives unlimited colour options, weather protection and a high gloss, low maintenance finish to boat hulls and decks. FRP is used in the construction of boats in all shapes and sizes from competition kayaks to sailing yachts to 'floating gin palaces'. The material is also used for naval vessels such as submersibles, mine hunters and high speed patrol boats.

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Fig(3.2(b))

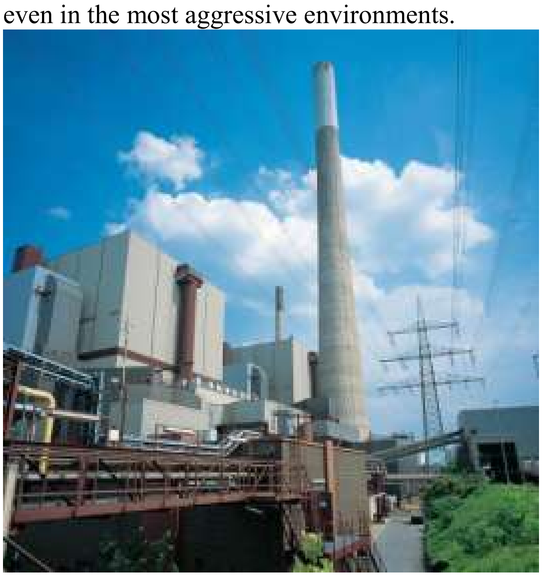
3. **Transportation**

Low weight, mouldability and high quality surface finishes make FRP an ideal material for automotive car body panels such as tailgates, fenders, roofs and complete truck cabs. High dimensional tolerance and heat resistance also makes FRP parts highly suitable for structural and under-bonnet parts such as engine sumps, valve covers and front assemblies. Separate metal components can be replaced by a single multi-functional FRP part.

Fig(3.2(c))

4. Chemical plant and pipes

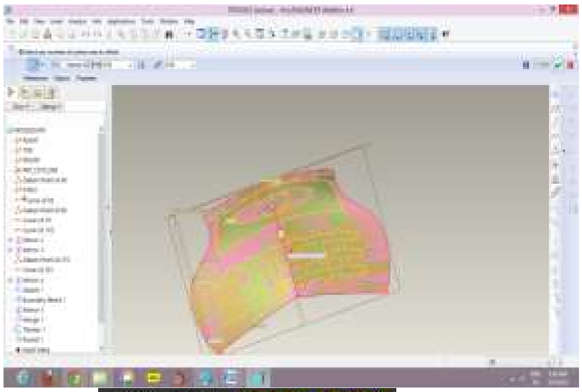
With its excellent resistance to corrosion and chemical attack, FRP is widely used in the chemical industry for the construction of pipe work and for chemical storage vessels, fume scrubbers and many other high performance applications. Vinyl ester and epoxy vinyl ester resins have been developed to give high levels of chemical resistance even in the most aggressive environments.



Fig(3.2(d))

Design of car bonnet:

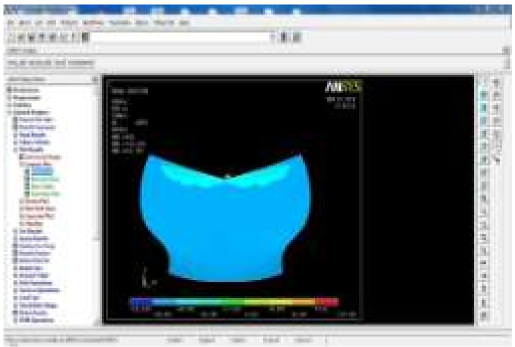
Suppose you want an extrusion centered on a rectangular surface. You could place the extrusion by measuring half the sides of the rectangle and using dimensions to locate its x-y position. However, your design intent is to have the extrusion centered, even if the length or width of the surface changes. Pro/ENGINEER gives you the tools to create models based on this kind of information.



ANSYS

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.

Stress in x-direction



Fig(5.2(h))

Stress in y-direction

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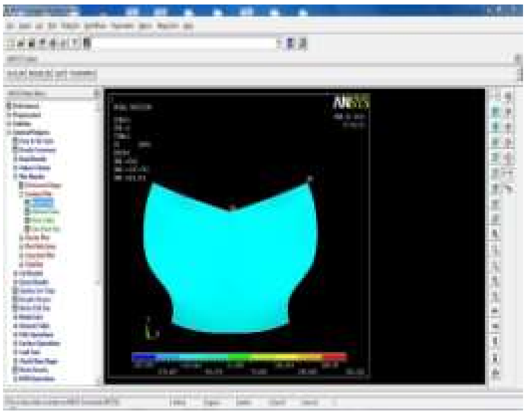
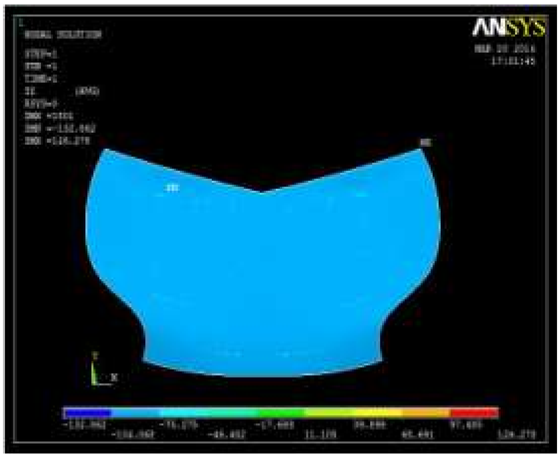


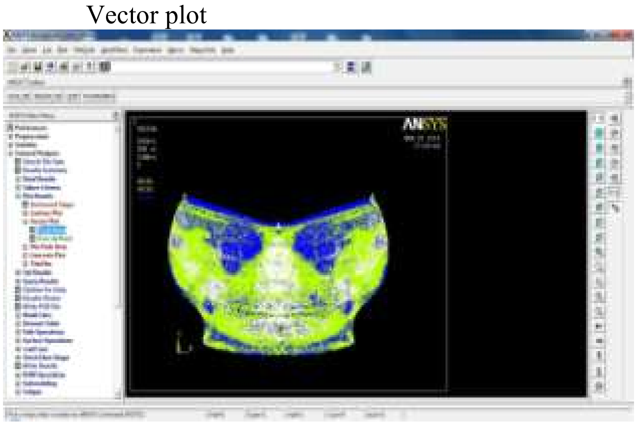
Fig(5.2(i))

Stress in z-direction



Fig(5.2(j))

Vector plot



Fig(5.2(k))

CONCLUSION

The desigining of the car bonnet and analyzing it in the ansys has successfully done.

FUTURE SCOPE

The FRP(fibre reinforced plastics) materials due to its excellent mechanical properties in engineering field increases its applications throughout each and every engineering aspects. 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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