FABRICATION OF HYBRID RACE CAR BODY PANEL WITH GLASS-FIBER COMPOSITE MATERIAL

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Abstract: The aim this project is about design and fabrication of a race car body panel with glass-fiber composite material and is to development of FRP body panel for Imperial of Innovative Engineers (ISIE) race car. The determination of plies and orientation for the composite body work is made based on the highest flexural strength which is the Chopped Strand Mat (CSM) fiberglass. The method of fabricating the composite bodywork is using manual hand lay-up technique for the whole process. The overall body panel weight is measured with the digital weighting scale and the overall weight of the bodywork is 9410 gram. The weight reduction of body panel from previous bodywork is approximate 1500 - 1800 gram which gives nearly 25% less weight compared to current bodywork and suggested to be implemented at the new style race car[1] bodywork section and it has already used composite material which is carbon-fiber. The bodywork also has achieved a high standard of quality and performance to the car. So, the fabrication that will be made through this project will open a new potential to experience the new type of material for bodywork of race car which using composite material instead of using sheet metal.

Keywords: Body panel, composite material, glass fiber, Hybrid composite, race car

I. INTRODUCTION:

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. Composite material is a material system composed of two or more dissimilar materials, differing in forms, and insoluble in each other, physically distinct and chemically inhomogeneous. The resulting products' properties are much different from the properties of constituent materials.

Reinforcement+ Matrix= Composite

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective[16]. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. Increasingly enabled by the introduction of newer polymer resin matrix materials and high performance reinforcement fibers of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion in uses and volume. The increased volume has resulted in an expected reduction in costs.

II. MATERIAL SELECTION:

The material for the body panel must be such that it fulfills all the pre-determined objectives and serves itspurpose. Some of these objectives are:1. It should be of low density in order to reduce the weight of our vehicle. 2. It must have adequate strength to bear the aerodynamic forces as well as its own weight. 3. It should be manufactured with ease. 4. The material must be readily available at a minimal expense. On the basis of these criteria the following comparison was made between various alternative materials suitable to make the panel as mentioned in Table 1. After the primary screening of the available material for body panels, E-glass and carbon fiber were discarded as the Carbon Fiber was very expensive and the other remaining alternative materials were comparatively thoroughly investigated as per Table 2. For ABS, there were some restrictions like the negative bends and angles could not be included in the design. Despite having the advantages of having more impact strength, machinability over FRP, it was overlooked. As per the operating conditions of the vehicle and pre-decided objectives, FRP was selected to make the entire body panel because of its low weight, minimal cost of material and fabrication, high load bearing strength, high shape holding property at high speed, excellent reparability etc.

Material	Density(gm/cm3)	Feasible manufacturing process	Availability	Cost
E-Glass	2.55	open moulding	high	Low
Carbon fiber	1.76	open moulding	very low	very high
acrilonitrile styrene(ABS)	1-1.05	Vacuum moulding	high	moderate

Table1. Initial evaluation of the suitable materials for panel manufacturing

Properties	FRP	ABS
Load bearing strength	High	Low
Impact strength	Low	High
Weight	Low	High
Brittleness	High	Low

Table 2 .comparison between FRP and ABS for panel material.

III MATERIALS USED

3.1 E- Glass Chopped Strand Fibers

E-Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiberglass.

E-Glass fiber in the form of chopped form mat (CSM) with different weight fractions such as 15%, 30% and 45% were used as reinforcement in CNSL- epoxy resin composites. Micro- hardness, tensile and flexural properties were investigated for all the composite panels of different compositions.

Figure 3.1: Fiber Glass

3.1.1 Properties

Properties that have made E-glass so popular in fiberglass and other glass fiber reinforced composite include:

- Low cost
- High production rates
- High strength
- High stiffness
- Relatively low density
- Non-flammable
- Resistant to heat
- Good chemical resistance
- Relatively insensitive to moisture

3.1.2 Specifications

The specifications of the E-glass are mentioned below:
Type:Filaments
TensileStrength:1700MPa
ModulusofElasticity:72.5GPa
Density:2.7
Acid-resistivity:
Alkali-resistivity:
Heat-resistivity

3.2 Polyester Resin

Polyester resins are unsaturated synthetic resins formed by the reaction of dibasic organic acids and polyhydric alcohols. Maleic Anhydride is a commonly used raw material with diacid functionality. Polyester resins are used in sheet moulding compound, bulk moulding compound and the toner of laser printers. Wall panels fabricated from polyester resins reinforced with fiberglass—so-called fiberglass reinforced plastic (FRP)—are typically used in restaurants, kitchens, restrooms and other areas that require washable low-maintenance walls.

he material is composed of pigments that are very similar to those used in other pavement markings. The pigments are used to impart color, hiding and other desirable properties, like all other markings. However, these pigments are pre-ground prior to being blended into the resin.

The marking has polyester resin that is mixed with a reactive solvent, a styrene compound. Normally, solvents are expected to evaporate and not participate in the setting up process. In addition to acting as a solvent, the styrene participates in the polymerization process. In order for this material to begin to react, a catalyst must be added to initiate the reaction.

The figure below shows the idealized chemical structure of typical polyester

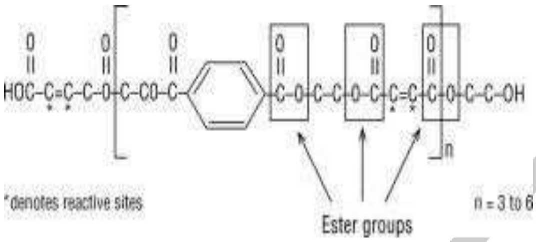

Figure 3.2: Chemical Structure

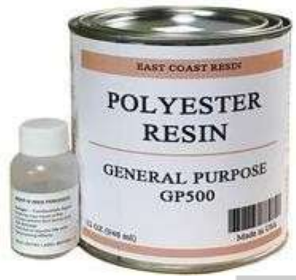

Figure 3.3: Polyester Resin

3.2.1 Advantages

Essentially two components in one container
- Long lasting and durable
- Does not discolor badly
- Relatively inexpensive
- Works well on concret

3.2.2 Disadvantages :

- Peroxide catalyst is a very reactive oxidizer
- Requires placarding as a hazardous material
- Requires commercial drivers license
- Flush solvent is fl ammable and a hazardous waste
- Moisture in surface a major factor and detriment
- HMA paving oils are a detriment
- Set up time depends on type of resin (usually 3-20 minutes)
- Diffi cult to determine whether mixed properly

3. 3 Catalyst- Nickel Phosphorous

A new nickel-catalyst method is developed to activate the glass fiber surface. When the activation is completed, a layer of continuous and dense film is formed on the substrate. The activated film contains a great deal of nickel oxide particles which can become the active sites after they are deoxidized in the electro less bath. In the activated film on the glass fiber, the content of Ni element is 41.01 wt. %, the content of O element is 45.64 wt. % and the content of P element is 13.35 wt.%. Ni-P coatings obtained under the optimum pretreatment conditions are uniform, continuous and adhered to the glass fiber surface.

3.3.1 Catalyst Costing

Resin, Gel coat, Pool coat and Flow coat are some of the polyester resin products that use a minimum quantity of 1% catalyst (MEKP-NA2) and a maximum quantity of 3% catalyst (MEKP-NA2). For costing purposes 2.5% is the average amount of catalyst calculated per kg.
Again for costing purposes 2.5% catalyst is used on resin, pool coat, gelcoat and flowcoat is the amount of catalyst used. Note: Most of all the products used in unsaturated polyester resin products, you will have to add a catalyst to it to get it to solidify. We recommend that you always make. sure that you use the correct ratio's and quantities

Figure 3.6: Nickel Phosphorous Catalyst

3.4 Hardener- MEKP (Methyl Ethyl Ketone Peroxide)

MEKP is a colorless to yellow liquid with mint like odor. It is used as a hardening agent for fiberglass-reinforced plastics and as a curing agent for unsaturated polyester resins. It acts through the formation of free radicals that catalyze the polymerization of the plastic monomer. It has a low residual hydrogen peroxide content making it ideal for use in gel coats. The MEKP acts as a catalyst when mixed with the resin. The chemical reaction that follows causes heat to build up and cure or harden the resin.

Figure 3.7: MEKP Hardener

IV PREARATION OF THE MOULD

4.1 **Process oModeling**

The process of molding is explained below in a step- by- step process:

Blocks of Styro foamwork best for preparing the required mould shapes have curves or other non-linear forms. Simply cut or shave the foam into desired shape. Use the sand paper for smoothing rough seams. Resin can be mixed in a clean plastic container, but because it generates heat when it sets, extreme care should be taken. Make sure that the hardener is being added according to the respective quantities. Right amount of hardener is to be measured. The quantities are mentioned in the below table.

Resin	Liquid Catalyst - MEKP NA2 (Ml)
50 g	1 ml at 2%
100 g	2 ml at 2%
250 g	5 ml at 2%
500 g	10 ml at 2%
1 kg	20 ml at 2%
1.5 kg	30 ml at 2%
2 kg	40 ml at 2%
5 kg	100 ml at 2%
10 kg	200 ml at 2%
25 kg	500 ml at 2%

Table 4.1 Catalyst and Resin Measurement

Figure 4.2 Front and side View of Nose Top

The Styrofoam seem to melt into the resin as you spread it, and you can use the brush and additional coats of resin to build up the layer of fiberglass to a thickness of up to 1⁄4inch (0.6 cm). As we spread the resin over the Styrofoam, make sure to apply it over corners and weak spots with the same coverage that you would over flat, easy-to-reach surfaces. If you fail to get good coverage in corners, for example, your fiberglass will eventually develop weaknesses in those corners. Clean up any tools or spills with a solvent containing acetone before the material harden.
Fiberglass is usually applied in layers until it is thick enough to give the required strength you desire to achieve.2 layers were being made for the body to be in the right shape. If possible, try laying down the fiberglass mat with the fibers oriented in different directions with each new layer. Fiberglass is strong across its axis but weak along its axis; if you can orient the strand mat so that its weak points are distributed along various axes instead of a single axis, you'll end up with much stronger fiberglass. If you have covered your form or mold with, you should be able to peel the form from inside the shape or peel the shape off of the form. The fiberglass will not stick to the Styrofoam. Repeat the steps of applying mat and resin until the finished the required thickness.i.e 3mm

Proposed model of Racing Cars

The ethos for the Eco-1 racing car was simple: ‘Create a highperformance racing car that had a conscience’. Wherever possible, sustainable materials and manufacturing processes were used during construction. Eco-1 has tyres, bodywork, brake pads, lubricants and fuel made from natural, renewable materials. The chassis is made from steel and aluminium which can be recycled easily and efficiently. The tyres have a component which is made from Potato or maize starch and are commercially available road legal tyres that offer very low rolling resistance. The hydraulic oil and the engine oil are a plant oil ester (which can also be used in a standard road car). The brake pads are made from CNSL (Cashew Nut Shell Liquid), Hemp and Jute, and the fuel to power the vehicle is derived from wheat. In total the racing car is 90-95% recyclable or biodegradable. Just because the materials the car is made from are friendly to the environment, it doesn’t mean that performance has to be compromised. It is a car with a power-to-weight ratio of 350bhp per tonne, a car that does 0- 62mph in four seconds, and that will go on to a top speed in excess of 125mph. Fig. 1 Eco-1 racing car

V CONCLUSIONS:

After the completion of the process, some of the notable conclusions drawn were as follows:

1. The overall body panel weight is measured with the digital weighting scale and the overall weight of the bodywork is 9410 gram. The weight reduction of body panel from previous bodywork is approximate 1640 gram which gives nearly 25% less weight compared to current bodywork and suggested to be implemented at the new style race car bodywork section and it has already used composite material which is carbon-fiber.

2. The design was accurate complying fairly with the rules and regulations of the rulebook. It incorporated the aerodynamic features, safety and aesthetics in the vehicle and the most optimal design fulfilling all the pre- requisite objectives were attained after sufficient periodic iterations.

3. FRP was selected as the material for making the body panels as it turned out to be the most optimal choice among the alternatives abiding the constraints and meeting the requirements.

4. The fabrication of the mold and body panel turned out to be simple, cost effective but time consuming.

Future Scope

There are scopes in this papr in order to achieve the project objective.

In addition to being an engineering exercise, the formula SAE competition is about making an exhilarating formula style car that would entice a customer to purchase a ride. The key to improvisation is the analysis and critical testing of the present design and products. This opens the gates for further modification to improve the product's cost effectiveness, ease of manufacturability, durability, aesthetics, ergonomics etc.

The first thing the potential customer sees is the body. The use of FRP in this manufacturing process has many advantages. It provides a strong scratch resistant surface which is easy to install, maintain and repair. It is light weight, provides sufficient strength and can be fabricated using simple tools. However, manufacturing the body panels by Hand- layup open molding process is clumsy and time consuming.

Similar improvements in the technique, materials and manufacturing methods of FRP would yield better results.The body panel of the FSAE race car is still an unexploited domain where several opportunities for innovations and improvements lie. FRP has also a vast potential not only in the automobile industry but in all spheres of technological advancements. In future, additional consideration should also be given to the aerodynamic loads as well as the refinement of design for the ease of manufacture with a very serious consideration.

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