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Novel way of manufacturing a carbon fiber monocoque chassis

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Abstract – *Monocoque chassis is a single body structure on which each and every component of the vehicle is mounted. Carbon fiber monocoque chassis generally makes cars stronger, lighter, and more rigid. Nowadays, Carbon Fiber Reinforced Polymers (CFRP) are been widely used in automotive industries, some of the components like wheel rims, bodyworks, transmission shafts, etc are made of CFRP. They come under the category of composites which are made from two or more constituent materials with significantly different properties that, when combined, produce a material with characteristics different from the individual component. CFRP's are manufactured by a three step process which starts from pattern, mould and then the final product. In this paper a new method of manufacturing CFRP is proposed which helps in saving time, money and manpower it is also useful for single product manufacturing.*

Key Words: **Monocoque, CFRP, Chassis, Mould, Vacuum bagging, Al honeycomb, Extruded polystyrene foam.**

1. INTRODUCTION

One type of innovative and high performance chassis designs is the carbon fiber monocoque. The term "monocoque" is a French word meaning "single shell." This describes the monocoque as a stressed outer surface in which the load is distributed. This kind of design has been applied to the structures of cars, boats, and airplanes. In the case of race cars, a carbon fiber monocoque is a carbon fiber tub that is used as a chassis. Many high performance cars use this design [10]. The main purposes of the monocoque are, first, to provide rigid, safe, and sufficiently strong supports and protection to the driver, engine, and all components on a car at minimum weight. Second, the monocoque should enable the suspension to exhibit excellent handling [2]. The most common materials used in the production of a monocoque chassis are composites, in particular carbon fiber reinforced polymers (CFRP) and Kevlar, because they exhibit high stiffness and strength to weight ratio properties and can be formed to virtually any geometry. However, there are some disadvantages, such as intricate design procedures, high cost and complex manufacturing processes. CFRP monocoques offer among the highest stiffness to weight ratios, when compared to any material and chassis type combination. This is the primary reason why carbon fiber composites are extensively used in car chassis design [3].

Composites are made from two or more constituent materials with significantly different properties that, when combined, produce a material with characteristics different from the individual component. CFRP are manufactured by combining carbon fiber mat and epoxy resin. They are manufactured by using various manufacturing techniques such as hand-layup, vacuum bagging, resin infusion, autoclave, etc. In this paper we will be using hand-layup and vacuum bagging technique in which carbon fiber mat and epoxy resin are hand-layed and then the product is cured under vacuum, room temperature and pressure for 24 hrs.

1.1 Existing method of manufacturing

Manufacturing of a carbon fiber product is a three step process which involves firstly manufacturing a pattern which can be made of wood, foam, aluminum, etc. from the pattern a glass fiber mould is prepared by laying glass fiber mat and resin. In the glass fiber mould the carbon fiber mat is layed with epoxy resin and then it is vacuum bagged and cured at room temperature or cured in an oven (Autoclave) at elevated temperatures and pressures. In this way a carbon fiber product is obtained. The process can be summarized as follows:

Pattern ⇒ Mould ⇒ Product

1.2 Proposed method of manufacturing

Manufacturing of the carbon fiber product in the existing way makes the product costly. In this paper a new method of manufacturing is proposed in which the mould is eliminated and the carbon fiber produced is obtained directly from the pattern, making the carbon fiber product cheaper. The process can be summarized as follows:

Pattern ⇒ Product

2. CAD MODELING

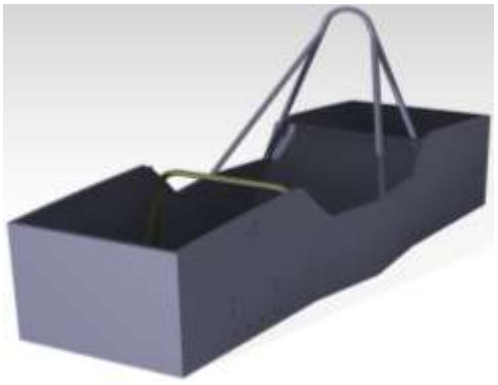

Fig -1: CAD model of monocoque chassis

Cad modeling of monocoque chassis was done in CATIA V5R21-Part design module. The chassis was modeled according to the driver packaging, different loading conditions and mounting points present on it. Fig -1 shows the final CAD model of monocoque chassis. The wooden pattern was also modeled on CATIA V5R21; Fig -2 shows the draft of the wooden pattern. The pattern shown is of negative type.

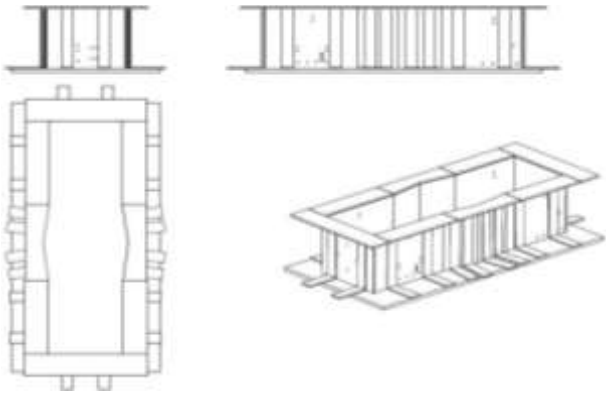

Fig -2: Draft of wooden pattern

3. MANUFACTURING

In this paper wooden pattern is used, the carbon fiber product is manufactured using hand layup and vacuum bagging technique and cured at room temperature and atmospheric pressure for 24 hrs. A sandwich structure is used comprising of carbon fiber – cores (Aluminium honeycomb/Extruded polystyrene foam) - carbon fiber to form the monocoque structure. Aluminium honeycomb is used as core at the hard-points (i.e. A-arm mounting points) and extruded polystyrene foam is used as core at the remaining places.

3.1 Wooden pattern

The pattern was manufactured using wooden plies; screws were used for assembling the plies together. Holes for hard-points (i.e. A-arm mounting points) were drilled on the wooden plies before assembling them, now before releasing the carbon fiber product from the pattern the holes will be drilled on the product, through the holes present on the wooden pattern. This is done to maintain the center distance between the holes and thus achieve accuracy in manufacturing the carbon fiber product. Wooden L-angles were made to support the wooden plies vertically. Sunmica sheets were pasted on the wooden pattern from inner side to give it a glossy finish so that the same level of finish could be obtained on the carbon fiber product. Putty was used to seal all the gaps in the pattern to make it leak-proof. Fig -3 shows the final wooden pattern which was ready for carbon fiber layup.

Fig -2: Final wooden pattern

3.2 Carbon fiber layup

Once the wooden pattern was ready it was cleaned using acetone to remove dirt and dust present on its surface. Wax and release gel were applied on the pattern to fill small scratches so as to make it smooth and glossy. As shown in the Fig -3: (a) carbon fiber mat and epoxy resins were layed in the pattern using brushes and rollers. Once the carbon fiber mat was layed completely then vacuum bagging was done and cured for 24 hrs at room temperature and pressure as shown in the Fig – 3: (b).

(a) (b)

Fig -3: (a) Carbon fiber layup, (b) Vacuum bagging

3.3 Releasing the product

Before releasing the product holes were drilled in the product through the holes present on the pattern with the help of drill machine. As shown in the Fig -4: (a) the screws in the pattern were removed using a screw-driver and the plies were disassembled one by one. This process of releasing the product ensures no damage is caused to the product. Fig -4: (b) shows the final released product and no damage was caused to the product & also the finish obtained was excellent.

(a) (b)

Fig -4: (a) Releasing the product, (b) Released product

3.4 Finishing the product

The carbon fiber product was cut according to design and sharp edges where smoothened with the help of sand paper. Fig -5 shows the final finished carbon fiber monocoque chassis made of carbon fiber mat, epoxy resin, Al honeycomb & extruded polystyrene foam.

Fig -5: Final wooden pattern

4. COMPARISION

The carbon fiber monocoque chassis for a car was manufactured as per the proposed method; Table -1 shows the comparison between the two methods of manufacturing composite monocoque chassis.

Table -1: Comparison between processes

PROCESS	Existing method	Proposed method
PATTERN (Wooden)	Rs.5,019	Rs.5,019
MOULD (Glass fiber)	Rs.15,000	Rs.0
PRODUCT (Carbon fiber)	Rs.52,972	Rs.52,972
TOTAL	Rs.72,991	Rs.57,991

Difference in two methods = Rs.15,000.

Comparison between the two methods shows that eliminating the mould making process has saved cost in manufacturing the carbon fiber product. The main advantage of this process is that it saves a lot of time and manpower which is involved in manufacturing the mould. When a single product is to be manufactured like in this case the proposed method is very useful.

5. CONCLUSION

Carbon fiber monocoque chassis for a car was manufactured using a new novel method which is different from the existing method of manufacturing a monocoque chassis. Eliminating the mould making process has not affected the quality of the final carbon fiber product, it has good surface finish and there are no defects present in it, also it has saved Rs.15,000 by adopting this new process.

Glass fiber is non-biodegradable in nature; products made of glass fiber needs to be buried in ground to dispose them. Eliminating the mould making process reduces waste generation and helps to save our environment from its harmful effects. So the proposed method for manufacturing carbon fiber products should be adopted.

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