Design, Development and Optimization of Composite Bonnet of Vehicle

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Abstract

The automotive industry is growing globally day by day. Now days the electric cars market are growing in our country. The industry is going through a transformational phase with increased pressure to reduced weight, increase volume and remain sustainable. Presently, a conventional vehicle body is made of metal or alloy steels. These conventional materials can be replaced with composites. The composite material can match the strength and mechanical properties of conventional materials. These materials can be used for light weighting (thereby leading to a reduction of emissions) and better design freedom (complex design profiles can be molded). The durability is more compared to conventional materials. With the advancement in the composite material technologies, it is going to be a key point in this era.

A reduced vehicular emission will significantly contribute towards a cleaner and greener pollution free atmosphere. The automotive emission norms are getting stringent over the years. Hence, this provokes the automotive manufacturers to push their research & development to the limits to meet these huge emission & safety standard barriers. This can be achieved by light weighting the components while providing enough strength without compromising the design requirements. The answer to all these questions is the use of composite materials whose strength to weight ratio is way better than even steel alloys. In composite manufacturing processes, the thickness of the product can be optimized since the process itself ensures production of varied thickness components from the moulds unlike sheet metal processes. Hence, optimization of component is necessary to know thickness at each location of the product. Here we have considered the Design Development and Optimization of composite hood for electric cars since hood is one of the main components of all body panels of a vehicle

Keywords: *VIP Process, FRP, glass fiber mats, lay up designing.*

1. Introduction

All over the world, Government attempt to support the transition to e-mobility Engine hood, is the hinged cover over the engine of motor vehicles that allows access to the engine compartment for maintenance and repair. In the last time the new material as composites are thoroughly researched for a lot of researcher team. These materials are used high performance began, in areas such as aerospace, military or aviation. Step by step these advanced materials are used in our day by day life in different domain such materials are Fibre-reinforced polymer which has an accelerated development.

The increasing demand on reduced emission, lower fuel consumption and higher safety in the automotive industry requires not only a development of alternatively powered vehicles, but also consistent light weight design. The use of lightweight materials such as glass or carbon FRP is a possible approach to achieve these goals.

In order to apply new light-weight materials in the manufacture of body components in its place of steel and metal, it is essential to estimate the new required dimension of the same part without loss of safety or stiffness. With the rapid development of computer technology and numerical methods, the field of optimization is actively being studied by many researchers. We should study the laminates with reference to change in area of the component. In contrast to metal materials FRP have very high values for specific stiffness and strength. The McLaren Company used these materials in there industry.

2. Process Methodology (with figures)

Design of Bonnet was started from the surface A after taking the approximate measurements in inch scales from the first prototype that's there in the product development & design centre & started on surface modelling workbench (Shape-Generative Shape Design); made the surface contour by surface modelling then converted it into solid part on Part Design workbench (mechanical design-part design) and performed other operations on part design itself and the final model was as shown in Fig1

Fig.1 Picture of Bonnet

After reviewing from the mentor, design started to make surface separately and it was tried out starting from surface A which was very difficult; just extracted the top surface from the solid model of previous design. There was also another way which was also given shot was modifying the surface design. Then the design of surface B was bit of hard nut to crack which was solved after rigorous thinking & imagination. The final & successful approach was started with the first sweep operation that performed for surface during design of previous model (fig5) and removing all other operations whiling keeping the sketches intact. Then the same method was followed as that for designing the previous model and the final design was as shown in Fig

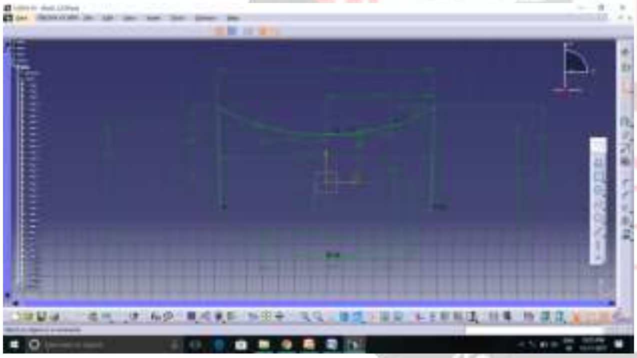

Fig.2 Sketching modelled on CatiaV5

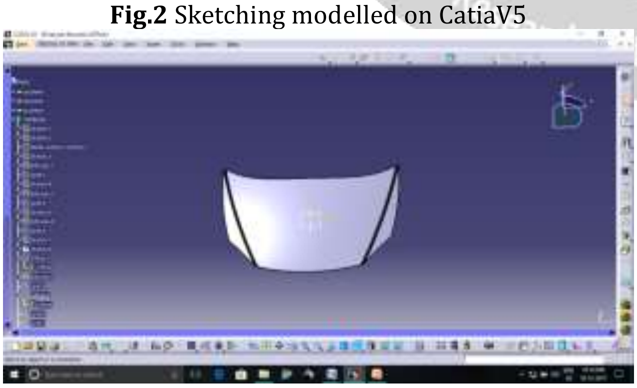

Fig.3 Sketching modelled on CatiaV5

After an understanding of Bonnet application & usages, it was figured out that most of load locations are on surface A only & hence designing of Surface A is primary requirement of Bonnet optimization process.

Notwithstanding the complex contours of Surface, a preliminary design was started based on approximate measurements and the measurements were only in lengths not in radii. The approach was same as that for Surface A (Surface modelled-part designed).

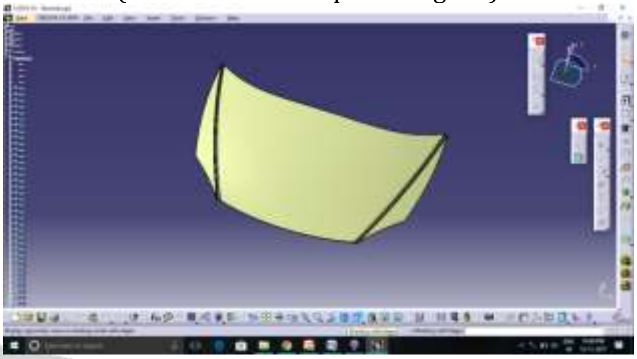

Fig.4 Sketching modelled on CatiaV5

Composite material

Composite material is a material composed of two or more distinct phases(matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents.

A combination of two or more materials to form a new material system with enhanced material properties.

Examples of reinforcements are glass fibers, carbon fib ers, silicon carbide fibers etc

Classification of composites

(Based on matrix material)

Metal Matrix Composites (MMC)

Metal Matrix Composites are composed of a metallic matrix (aluminum, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

Ceramic Matrix Composites (CMC)

Ceramic Matrix Composites are composed of a ceramic matrix and embedded fibers of other ceramic material (dispersed phase).

Polymer Matrix Composites (PMC)

Polymer Matrix Composites are composed of a matrix from thermoset (Unsaturated Polyester (UP), Epoxy (EP)) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon, Polystyrene) and embedded glass, carbon, steel or Kevlar fibers (dispersed phase).

We used Polymer matrix Composites due to its advantages

Laminate Composites

Laminate composites consist of layers with different anisotropic orientations or of a matrix reinforced with a dispersed phase in form of sheets.

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When a fiber reinforced composite consists of several layers with different fiber orientations, it is called multilayer (angle-ply) composite.

Laminate composites provide increased mechanical strength in two directions and only in one direction, perpendicular to the preferred orientations of the fibers or sheet, mechanical properties of the material are low.

Polymer Matrix Composite (PMC) is the material consisting of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods.

Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties:

Tensile strength of one of the strongest polymers - epoxy resin is 20000 psi (140 MPa). In addition to relatively low strength, polymer materials possess low impact resistance.

Results

Test report

Moulded at Pune (by PDBC)

Test Properties	Test Method	Unit	Results	
			Vacuum Infused	Vacuum Infused
Glass Percentage	ISO 3451	%	Uni-directional mats	Bi-directional mats
Specific Gravity	IS 13411	-	71.2, 71.8, 71.3	71.4, 70.8, 71.8
Water Absorption	IS 13411	%	1.90, 1.92, 1.93	1.86, 1.88, 1.86
Heat Deflection Temperature @ 1.80 Mpa	IS 13411	°C	0.12, 0.11, 0.10	0.16, 0.14, 0.14
Flammability	UL 94 - HB	Score	250+, 250+	250+, 250+
	UL 94 - V0/V0	Score	Pass	Pass
Flexural Strength	ISO 178	Mpa	Fail	Fail
Tensile Strength	ISO R 527	Mpa	694, 679, 630, 687	476, 460, 482, 515, 495
[illegible]		Mpa	-	-
[illegible]		Mpa	671, 664	373, 431
[illegible]		Mpa	72, 67	118, 89
Izod Impact Strength (Notched)	IS 13411	kJ/m²	85, 84	438, 388
Charpy Impact Strength	ISO 179	kJ/m²	300+ (specimen not break)	300+ (specimen not break)
Compressive Strength	BS IS ISO 604	Mpa	110+ (specimen not break)	130+ (specimen not break)
Arc Resistance	IS 13411	Sec	230, 241, 307, 236, 235	445, 389, 408, 451, 408
Volume Resistivity	IS 3396	Ohm.cm	130, 129, 130	131, 130, 130
Surface Resistivity	IS 3396	Ohm	1.34 x 10^{13}	1.89 x 10^{13}
Barcol Hardness	ASTM D 2583	-	4.80 x 10^{14}	9.14 x 10^{14}
			54, 55, 56, 52, 50	58, 62, 70, 64, 55
Test specimen thickness	-	-		
			4.0 ± 0.2 mm	6.2 ± 0.2 mm

Future Strategy

Design and develop components using composites materials in the automotive industry and compare the result between the software analyses with physical analysis.

Continue to do research on applicability of composite materials in the automotive industry.

Design and Develop components using composites materials in the automotive industry.

Since the composites has potential to reduce the weight of vehicle, improve fuel efficiency, reduce the emission and also reduce the weight and improve the quality of the automobile. Therefore it is suitable to be widely in the automobile industry.

Composites like carbon fibre reinforced plastics can be the alternative for steel and aluminium alloys.

Conclusion

The major application of this project other than thickness optimization of tailgate is switching to composite material from sheet metal which gives a drastic weight reduction in product.

The use of composites over other sheet metals has enabled to achieve a mass saving of 25% to 35% over a similar dimensioned sheet metal.

This ensures automobile manufacturers to get even more light weight vehicles in near future to cutdown emissions and meeting safety norms while the Indiangovt.will be moving towards stricter emission & safety norms i.e. BS VI by 2020.

Composite material are highly anisotropic nature, parts can be made even more light weight by optimizing local thicknesses.

Since it has a fabrics, matrices & lamina library that vastly contains almost all type of reinforcement & resin properties (both mechanical and thermal properties).

We can give input as the volume fraction of resin and reinforcement and then it will automatically develop the lamina property after which we lay the lamina in desired layers & of defined sequences and orientations.

It is very useful to Automotive Industry to switch the material from conventional to composite.

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