International Journal of Research and Reviews in Applied Sciences And Engineering (IJRRASE)
Vol 8. No.1 –2016 Pp.164-169

available at : www.ijcns.com
ISSN: 2231-0061

DESIGN AND IMPACT ANALYSIS OF LIGHT WEIGHT DOOR PANEL OF THE CAR

Vijayan.P
Mookambigai College of Engineering
Srinivasa Nagar, Kalamavur P.O
Keeranur, Pudukottai-622502.

ABSTRACT: T**he main aim of this project is to Design and analyze the Side impact on the light weight car door panel assembly with present using material of Steel replaced with the mono and hybrid construction of light weight Aluminum alloy, Magnesium Alloy and Steel. Impact Analysis is done with different speed and the crashworthiness is studied. Final analysis results are compared with Federal Motor Vehicle Safety Standard for crashworthiness and best of the result will be with respect to light weight design. The car door model assembly of outer and inner panel is done using modeling software CATIA P3 V5R14 and also analyzed using it.**

KEYWORDS: Impact analysis in the software CATIA P3 V5R14, Finite element analysis, Crash resistance comparison, Magnesium alloy

I. INTRODUCTION

Nowadays more research are going to design vehicle which uses fuel economically, by light weight engineering using low density material and with advance manufacturing and joining technology and thereby reducing the weight of vehicle.The growing demand for more fuel efficient vehicle to reduce energy consumption and air pollution provides a challenge for the automotive industry. The best way to increase fuel efficiency, without sacrificing safety is done by employing aluminum alloy and magnesium alloy within the body of the cars, due to its higher strength to weight ratio than that of conventional steel.Porsche Become First OEM to use Magnesium alloy as outer body panel and introduced the model of 911 GT3 RS sports car in Geneva international Motor show march 2015.Doors are typically hinged but sometimes attached by other mechanisms such as tracks, in front of an opening which is used for entering and exiting a vehicle. A vehicledoor can be opened to provide access to the opening or closed to secure it. This door can be opened manually, or powered electronically. Powered door are usually found on minivans, high-end cars, or modified cars. Unlike others types of doors, the exterior side of the vehicle doors contrast sharply from its interior side

1) The interior side is also known as the car door inner panel.
2) The exterior side of the door is door outer panel.

There are three different Architectures by which the Car door panel are used to be assemble,

1) Header Reinforcement
2) Separate Header
3) Integrated header

But here in this study we are using the integrated header type construction.

To meet these required properties of high-strength and high-toughness, high strength metals are used to replace conventional steel for use in side door impact beams. Weight reduction of cars is currently of great concern to manufacturers, due to the international movement of regulations in terms of fuel efficiency and gas emissions of passenger vehicles. In order to reduce weight, there are two important methods. One of these methods is to redesign automobiles parts to optimize their structure. By using thinning, hollowing, mini type and compound parts, car weight can be reduced. The other method is to replace traditional materials, like mild steel, with lightweight materials, such as aluminum alloy, magnesium alloy and high strength steel, and composite. Of these two methods, material replacement is generally more efficient in achieving a lightweight automobile than structural modification.

In this study the structural modification and impact absorption of material was investigated using three different material simultaneously using finite element analysis and compared to best way to reduce structural weight without sacrificing safety is to employ aluminum alloy and magnesium alloy , due to is higher strength to weight ratio than that of conventional steel. Aluminum alloy and Magnesium alloy are widely used in aerospace and automotive industries. They are a useful new candidate material for side impact, in order to improve impact energy absorption capacity and resistance plastic deformation

II. PROBLEM STATEMENT

Materials for lightweight construction n automotive engineering must meet complex rquirements, however. It is essential to combine good formability with high strength in service, excellent corrosion resistance and weld ability. The property criteria are as follows for different variant

Criteria	Steel	Aluminum Alloy	Magnesium Alloy
Formability	√	√	√
Strength	√	√	√
Surface quality	√	√	x
Join ability	√	√	√
Corrosion resistance	√	√	Reduced by electroplate or other process
Hemming	√	√	Roller type hemming tool is used

Table 1.1 Property criteria for Body In White application

III. LITERATURE REVIEW

Previous Study by research shows that replacing of steel with composite material like aluminum, carbon epoxy and S. glass epoxy reduce the damage percentage of car and increase the passenger safety and also the use of E glass, S glass, epoxy material reduces the weight, increase the cost but decrease the risk of collision. The use of Cast magnesium for side door inner panels can provide a good combination of weight, functional, manufacturing and economical requirements .However several challenges exist including casting technology for thin wall part design, multi material incompatibility and relatively low strength than steel .And finally concluded that 2mm magnesium design, through casting process enablers, has met or exceeds all stiffness requirement and part consolidation. It addition, a corrosion mitigation strategy has been established using industry accepted galvanic isolation methods and coating technology. The side impact force will be considered with respect to tractional force, drag force and Rear resistance.

IV. IMPACT FORCE CALCULATION:

Tractive force based on engine torque(T_E)	=	E_T x η x G_T x G_A)/R
Tire model taken	=	225/45R17
Rolling Radius of wheel (R)	=	(0.5x(17x25.54))+(225x0.4)
Engine Torque (E_T)	=	127 N. m
Transmission Efficiency (η)	=	0.95 %
Transmission ratio at second gear (G_T)	=	8.02
Rear axle ratio (G_A)	=	1.51
Applied Tractive Force (T_E)	=	(127x0.95x8.02x1.5)/(0.318)
Maximum permissible limit for Tractive force ($T_{F\,max}$)	=	µ x W
Adhesive co efficient between tire and road surface (µ)	=	0.015
Weight of the car (W)	=	1190 kg
Maximum permissible limit for tractive force ($T_{F\,max}$)	=	0.015 x 1190
	=	175.1085N
Aerodynamic resistance (A_R)	=	C_D x A x ρ x V^2 x½
Density of air at 1 atm and 25° C (ρ)	=	1.164 kg/m³
Frontal Area (A)	=	1.40 x 1.65 m²
Drag Co-efficient C_D	=	0.42
Aerodynamic resistance (A_R)	=	0.42 x 1.40 x1.65 x 1.164 x ½ x $(13.889)^2$
	=	108.8 N
	=	108.8N
SIDE IMPACT FORCE	=	T_E - ($T_{F\,max}$ + A_R)
	=	4564 –(175.1085 + 108.8)
	=	4497 N

FORCE IMPACTED:

SPEED Km/hr	50	60	70	80	90
TRACTIVE (N) FORCE	4564	4564	4564	4564	4564
AERO DYNAMIC RESISTANCE (N)	108.8	156.84	213.5	279.8	352.9
ROLLING RESISTANCE (N)	175.1	175.1	175.1	175.1	175.1
FORCE IMPARTED (N)	4497	4545	4602	4668	4742

IV. MODELING OF CAR DOOR PANEL:

The car door panel of outer and inner panel is modeled separately as per the specification using CATIA and analyzed with the same. This Door panel is subjected to Distributed force which is assigned to be the bumper force with different speed and results of von misses stress, and displacement are been tabulated. The thickness is considered as 1.2mm for inner and outer panel of the entire concept. The shell model of the door panel is shown as follow.

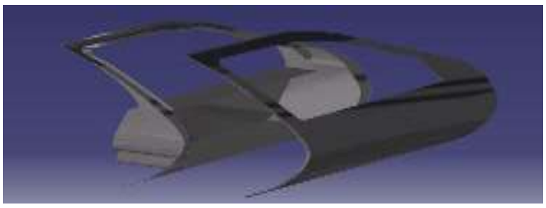

FIG 1. CATIA MODEL OF ASSEMBLY

MATERIAL PROPERTIES

MATERIALS DETAILS	DENSITY (Kg/m3)	YOUNG'S MODULUS (Gpa)	Yield STRENGTH (Mpa)
MAGNESIUM ALLOY	1798	45	230
STEEL	7860	20	1655
ALUMINIUM ALLOY	2710	70	275

V. MODEL DETAILS:

SHELL BODY		
CONCEPT. NO	MODEL PROPERTIES	MESHING NODES AND ELEMENT
1 AZ91D ONLY	Characteristics: Volume 0.006m3; Area 6.013m2; Mass 10.681kg; Density 1798kg_m3	Entity / Size: Nodes 72015; Elements 207244
2 GA440 ONLY	Characteristics: Volume 0.006m3; Area 6.013m2; Mass 46.692kg; Density 7860kg_m3	Connectivity / Statistics: TE4 207241 (100.00%); BAR 1 (0.00%); SPIDER 2 (0.00%)
3 AA6016 ONLY	Characteristics: Volume 0.006m3; Area 6.013m2; Mass 16.099kg; Density 2710kg_m3	
4 AA6016/ AZ91D	Characteristics: Volume 0.006m3; Area 6.013m2; Mass 14.355kg; Density Not uniform	
5 GA440/ AZ91D	Characteristics: Volume 0.006m3; Area 6.013m2; Mass 34.439kg; Density Not uniform	

OUTER PANEL   INNER PANEL

CONCEPT: 1.*Outer/inner Panel* MAGNESIUM ALLOY

(90Km/hr)

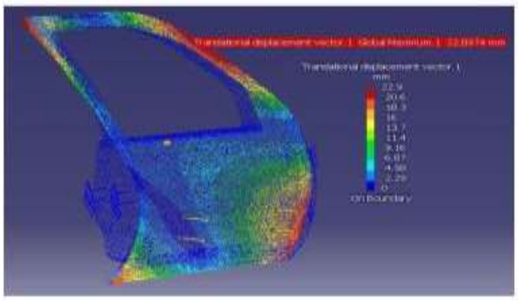

FIG.2. TRANSLATIONAL DISPLACEMENT ANALSIS

VI. RESULTS AND DISCUSSION

The car door panel impact analysis are carried out in static analysis option in CATIA with respect different speed and the results displacement, vonmises stress are been tabulated as follows.

CONCEPT: 1.*Outer/inner Panel* MAGNESIUM ALLOY (90Km/hr)

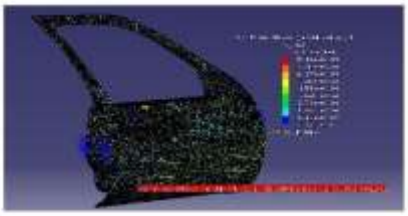

FIG 3.VONMISES STRESS ANALYSIS

CONCEPT: 1.*Outer/inner Panel* MAGNESIUM ALLOY

S.No	Wt Kg	SPEED Km/hr	STRESS N/m^2		DISPLACEMENT mm	
			MIN	MAX	MIN	MAX
1	10.68	50	$3.57e^{+008}$	$8.63e^{+007}$	2.14	21.4
2		60	$3.6e^{+008}$	$8.73e^{+007}$	2.16	21.6
3		70	$3.65e^{+008}$	$8.84e^{+007}$	2.19	21.9
4		80	$8.96e^{+007}$	$8.96e^{+007}$	2.22	22.2
5		90	$3.76e^{+008}$	$9.11e^{+007}$	2.29	22.9

TABLE 1:RESULTS FROM CATIA ANALYSIS

Likewise the analysis are done for all other concept as mentioned and tabulated as follows.

CONCEPT: 2 .*Outer/inner Panel* STEEL

S.No	Wt Kg	SPEED Km/hr	STRESS N/m^2		DISPLACEMENT mm	
			MIN	MAX	MIN	MAX
1	46.69	50	$2.36e^{+008}$	$9.2e^{+007}$	0.492	4.92
2		60	$2.38e^{+008}$	$9.3e^{+007}$	0.498	4.98
3		70	$2.41e^{+008}$	$9.42e^{+007}$	0.504	5.04
4		80	$2.45e^{+008}$	$9.55e^{+007}$	0.511	5.11
5		90	$2.49e^{+008}$	$9.7e^{+007}$	0.519	5.19

TABLE 2: RESULTS FROM CATIA ANALYSIS

CONCEPT: 3.(Outer/inner Panel ALUMINUM ALLOY

S.No	Wt Kg	SPEED Km/hr	STRESS N/m^2		DISPLACEMENT mm	
			MIN	MAX	MIN	MAX
1	16.09	50	$3.28e^{+008}$	$8.6e^{+007}$	1.37	13.7
2		60	$3.32e^{+008}$	$8.69e^{+007}$	1.39	13.9
3		70	$3.65e^{+008}$	$8.76e^{+007}$	1.41	14.1
4		80	$3.41e^{+008}$	$8.92e^{+007}$	1.43	14.3
5		90	$3.46e^{+008}$	$9.07e^{+007}$	1.45	14.5

TABLE 3: RESULTS FROM CATIA ANALYSIS

VII. CONCLUSION

According to this study of static impact analysis of the car door panel shows the response of car door panel with respect to different speed condition with composite and fully construction outer and inner panel. The stress and displacement behavior under the different impact force condition used to find the crash resistant of the door panel to satisfy the FMVSS standard. The maximum level of stress and displacement are as follows;

CONCEPT: 4 .*Outer panel* ALUMINUM ALLOY AND *Inner Panel* MAGNESIUM ALLOY

S.No	Wt Kg	SPEED Km/hr	STRESS N/m²		DISPLACEMENT mm	
			MIN	MAX	MIN	MAX
1		50	3.57e+008	8.56e+007	1.38	13.8
2	14.25	60	3.6e+008	8.65e+007	1.39	13.9
3		70	3.65e+008	8.76e+007	1.41	14.1
4		80	3.7e+008	8.88e+007	1.43	14.3
5		90	3.76e+008	9.03e+007	1.45	14.5

TABLE4: RESULTS FROM CATIA ANALYSIS

CONCEPT: 5 *Outer Panel* STEEL AND *Inner Panel* MAGNESIUM ALLOY

S.No	Wt Kg	SPEED Km/hr	STRESS N/m²		DISPLACEMENT mm	
			MIN	MAX	MIN	MAX
1		50	3.57e+008	9.18e+007	0.534	5.34
2	34.44	60	3.6e+008	9.28e+007	0.54	5.4
3		70	3.65e+008	9.4e+007	0.547	5.47
4		80	3.7e+008	9.53e+007	0.554	5.54
5		90	3.76e+008	9.68e+007	0.563	5.63

TABLE5: RESULTS FROM CATIA ANALYSIS

AT MAXIMUM IMPACT FORCE:

S.No	WEIGHT Kg	STRESS N/m²		DISPLACEMENT mm	
		MIN	MAX	MIN	MAX
1	10.68	3.76e+008	9.11e+007	2.29	22.9
2	46.69	2.49e+008	9.7e+007	0.519	5.19
3	16.09	3.46e+008	9.07e+007	1.45	14.5
4	14.25	3.76e+008	9.11e+007	1.45	14.5
5	34.44	3.76e+008	9.68e+007	0.564	5.64

TABLE1: RESULTS OF CATIA ANALYSIS

The maximum allowed crush resistance for FMVSS standard is 152 mm at initial load condition of average 1020kg load condition. Based on the analysis report of the car door panel ,we can conclude that the concept 2 of magnesium alloy of mono construction and concept 4 of hybrid construction are light weight and satisfy the crash standard of resistance at maximum Distributed force of 4742N.

REFERENCES

[1] FMVSS Standard 214,*NHTSA TECHNICAL REPORT*," , www.nhtsa.dot.gov

[2] George.Y.H.Chi, *Statistical Evaluation of the Effectiveness of federal motor Vehicle SafetyStandard 214: SIDE DOOR STRENGH*, Reportno 5 of 7, , The center for the Environment andMan, Inc.

[3] J.Jekl, J.Auld, C.Sweet (2015), *Development of a Thin-Wall magnesium Side Door Inner Panel For Automobiles* , International Conference in Canada.

[4] JFE TECHNICAL REPORT 10 DEC 2007 , *High-Performance, High-Strength Steel Sheetsfor Exposed Auto Body Panels*

[5] MMRC-F-202, *Design and manufacturing ofcar Doors: Report on*

Visits made to US,European and Japanese Car Manufacturers in2007, March 20085
[6] MMMS, *Multi-Disciplinary design optimization of composite car door for structural performance, NVH, Crashworthiness, Durability and manufacturability*.
[7] Mohd Fadzi Abollah (January – June 2013),*Prelimary Design of side door impact beam for passenger cars using Aluminum Alloy*, Center of Advanced Research on Energy,Malaysia,ISSN:2180-1053, Vol.5 No.1
[8] NADCA Product Specification Standards for Die Castings/2009
[9] Open Accessed 7 Dec. 2014 , *Materials*. ISSN 1996-1944. <http://www.mdi.com/journal/materials>
[10] Stephern. J. Rattenbury, *Vehicle Deformation in Real-World Side impact Crashes and Regulatory Crash Tests*.
[11] Tsingu Science and Technology (December 2006) , *Car side Structure Crashworthiness in Pole and Moving Deformable Barrier Side Impacts*, ISSN 1007-0214 13/15 pp725-730 Volume 11, Number 6.
[12] <http://www.brill.nl/mmms>.