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The Study of Themoforing Material Improving Light-weight Vehicle Safety Performance

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Abstract: Enviroment protection is highly regarded with the new economy regulations, energy saving, exhaust reduction and material saving have became an important research topic in global encomy system. To automobile products, it is an important means to design light-weight vehicle for realizing fuel efficiency and exhaust reduction. Otherwise, the global main auto markets have more and more strict regulations about vehicle safety in recently years .automobile makers need design stronger body to satisfy those regulations .in this study ,to solve the conflict between light-weight and higher strength about materials. Take some body as the research object, using themoforing materials properly can realize the design in light-weight and high crashworthiness.

Keywords: vehicle safety performance, themoforing materials, light-weight

1 Introduction

With air pollution is becoming more and more serious recently in many cities, vehicle exhaust is a main cause of air pollution in the cities, the government agents also take it serious, and establish more strict regulations and standards. it shows the determination of the government agents to control air pollution. how to reduce fuel and exhaust ,and it should be an important performance target in new product development. now we still don't have better technologies in power. so reducing body weight is a more easy means to get the target of reducing vehicle weight and fuel.

However ,what is the light-weight vehicle. We can't think that, to simply reduce the size and space of vehicle frame, and reduce thickness of parts. we can't get the goal at the cost of safety performance. With the development of vehicle light-weight ,consumers are more strict with vehicle safety performance. more strict regulations and assessment programs have be established to face the main consumer market in Europe, north America , China and so on. For example, E-NCAP had added 100% frontal impact (rigid) in 2015,IIHS established small overlap frontal test in 2014,and C-NCAP also is becoming more strict.etc.

In this study, according to request of the passenger space safety performance, we try to apply themoforing material to a vehicle, and optimize it. Finally ,the safety performance of vehicle get GOOG level in the control of weight of the vehicle.

Table 1 the demand of fuel consumption and emission in China

CO_2exhaust g/km	2015	2020	2025
	167	120	95
Fuel consum L/100km	2015	2020	2025
	6.9	5.0	——

2 Defect of base structure design

Frontal small overlap test is most strict with carbody structure design in main assessment program systems currently. It is conducted at 64.4 ± 1 km/h and 25 ± 1 percent overlap. The test vehicle is aligned with the rigid barrier such that the right edge of the barrier face is offset to the left of the vehicle centerline by 25 ± 1 percent of the vehicle width .The rigid barrier is composed of a vertical steel plate, with a radius on the right edge . The front plate has a thickness of 38.1 mm, and is 1000 mm wide to the point at which the 150 mm radius begins(Figure 1). Traditional frontal crash tests include 100%frontal impact with rigid barrier (FRB)and 40% overlap with Deformable Barrier impact (ODB).

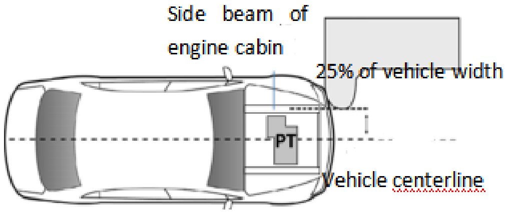

Figure1. Small overlap impact

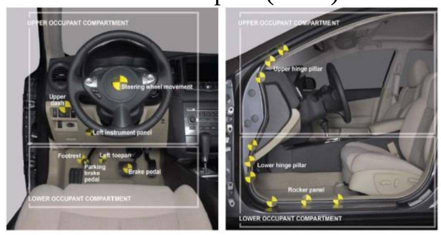

Figure2.characteristic points of passenger cabin

Currently, IIHS will be not considered when a new vehicle is designed, and for the vehicle, the result of the small overlap test program rating is not good. see figure 3.

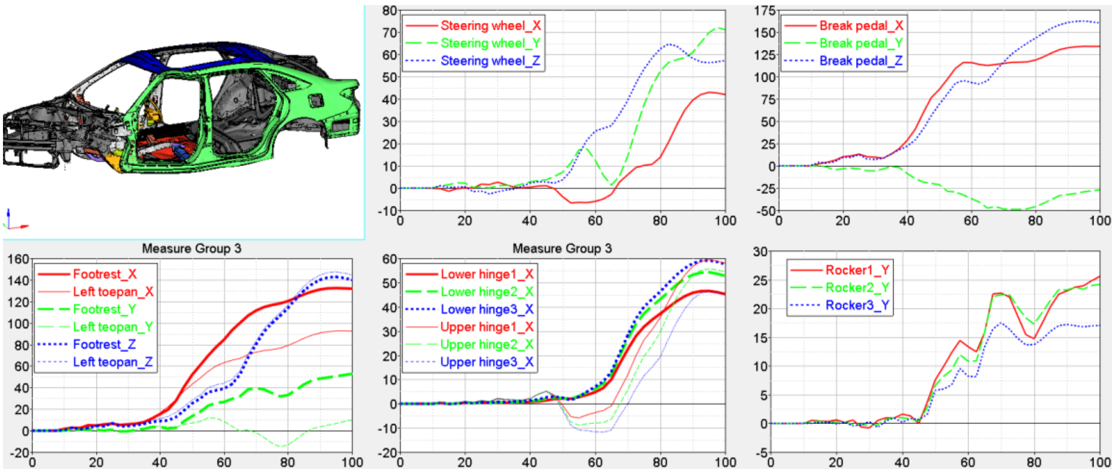

Figure 3 .the result of basic analysis

The program rating of three point in the lower hinge pillar of door is GOOD level, the others only get ACCEPTABLE level. the analytic result shows that passenger cabin have been broken during the small overlap test. and it can't provide enough living space for passenger in it.

3 Problems analysis

Compared with traditional frontal impact, small overlap impact have two special points: 1.high speed---64.4km/h, and it is the highest speed in current tests. The original energy is large, and deformed the vehicle ,at the same time, the vehicle absorbed more energy ,the left side endured largely impact. 2. the right edge of the barrier face is offset to the left of the vehicle centerline only by 25 ± 1 percent of the vehicle width. the side beam of engine cabin could not absorb engine efficiently.

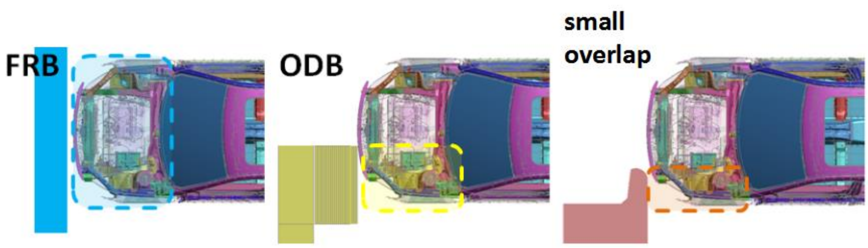

Figure.4.the contrast of Frontal Impacts absorbing area

Based on the above reasons, in the small overlap test, vehicle the collision load of vehicle body structure absorbing is bigger. see figure 5, choose some characteristic sections of impact load comparing with the corresponding section of FRB test, like the sections of A pillar of compartment Kickdown, and threshold. Can be seen from the results, the force of small overlap collision is a lot higher than FRB, and the collision area of FRB is larger. Loads of characteristic sections: 252kN & 209kN, 72kN &39 kN, 195 & 60, one of the biggest differences is the threshold beam structure, the different value of force reaches 135kN among them .so the vehicle of small overlap is more strict than FRB during the collision impact, to ensure that the vehicle body will provide enough space for passenger in collision .we need design stronger vehicle body structure than traditional FRB and ODB.

Table 2 the contrast offrontal impact tests

	Speed(km/h)	Deformed area	Barrier
FRB	50	big	rigid
ODB	64	middle	deformation
Small overlap	64.4	small	rigid

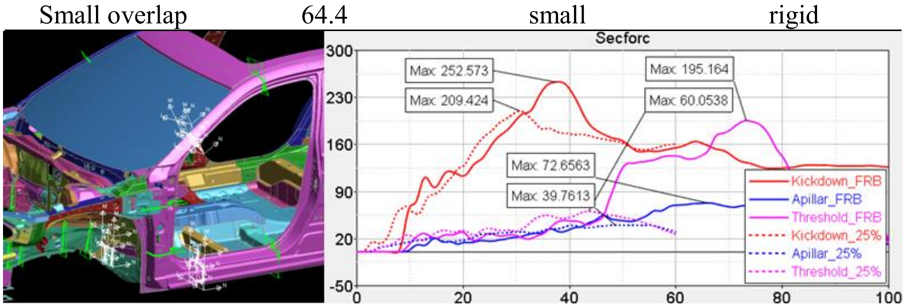

Figure5. the contrast of impact load in frontal impact tests

4. Body optimization

In this study we only described about this passenger compartment structure optimization process. On basis result of the analysis, it reflects the passenger compartment structure is weak. choosing the main structure of the region, as shown in figure 6, use two cases to strengthen and optimize, CASE1 considering the increase of body weight, CASE2 considering the target of body weight .

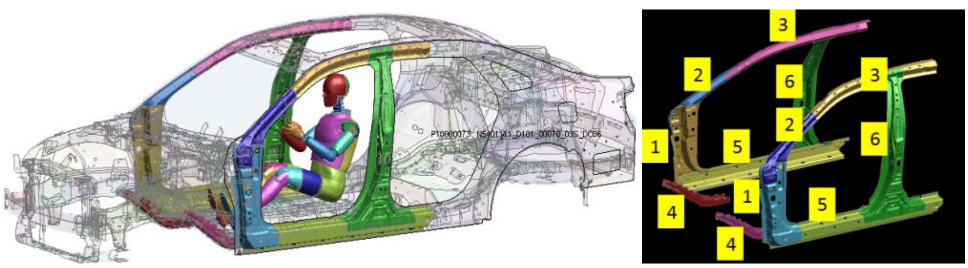

Figure6. main structure area of passenger compartment

Table 3 the contrast of optimizing cases

Part ID	CASE1			CASE2		
	material	thickness/mm	mass/Kg	material	thickness/mm	mass/Kg
1	B340/590DP	1.5	9.8		1.2	8.3
2	H260YD	2.0	5.3		1.4	4.2
3	B400/780DP	1.8	8.5	BR1500H	1.4	7.1
4	B400/780DP	1.6	4.7	S	1.5	4.3
5	B400/780DP	1.8	15.9		1.5	12.8
6	B400/780DP	1.8	16.9		1.4	14.3

Total	——	——	61.1	——	——	51

From the table above, we could get this, the vehicle weight of using thermoforming material for passenger compartment space (12 main structures) and strengthening scheme is 10KG lighter than the vehicle weight of using common dual-phase high strength steel to optimize .lightweight effect is obvious. In the Case of using thermoforming material ,the material is Baogang steel BR1500HS, its yield strength reachs 1000 MPa, tensile strength reachs 1400 MPa, respectively it is double higher than dual-phase high strength steel , so it can be achieved similar to strengthen effect with using a relatively thin structure, from the contrast of two cases analysis results in the small overlap collision condition, we can see that the results of two strengthening cases in the performance of the optimization is almost equivalent, as shown in figure 8.

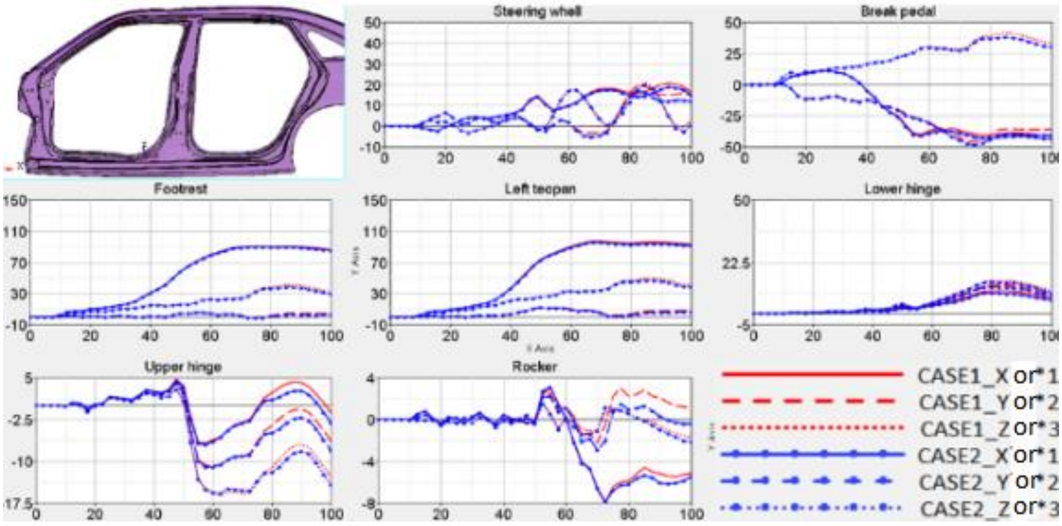

Figure8 the contrast of optimizing analysis

However, the elongation of thermoforming material is about 5% in this case of using thermoforming material, this kind of material in principle applies only to small deformation and is more inclined to maintain the integrity of the structure in collision performance.

5. Conclusion

From the analysis of this paper, we could get that because of the high mechanical properties of thermoforming material ,it can be used for optimal design of the passenger vehicle structure strengthening. The thermoforming process less dependens on the complexity of the structure designing, this material can be used in strengthening the body Kickdown, B pilllar and some regional complex structures; the strength of thermoforming material steel is nearly double higher than ordinary dual-phase high strength steel, using less this material could achieve the same result as the common high strength steel. However the extension rate of the nature thermoforming material (maybe in the future, the technology will have breakthrough in research and development of new materials) is relatively low, it is not suitable for large deformation area during collision, and easy to cause abnormal fracture failure of vehicle structure.

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