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Experiment Simulation of Seat Belt and ISOFIX Anchorage for a Commercial Vehicle

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Abstract：In order to estimate the seat belt anchorage and ISOFIX anchorage system of a commercial vehicle typed M1 whether or not meet the new Regulation GB 14167-2013, a commercial vehicle seat model was established using finite element software LS-DYNA 3D. Based on the model, the anchorage strength of three-point seat belt was carried by experiment simulation and testing analysis，while the anchorage strength of ISOFIX was carried by experiment simulation analysis. The result shows that the simulation data of anchorage of three-point seat belt for commercial vehicle is in good agreement with the physical test, and the simulation model is valuable. While the ISOFIX anchorage has enough strength carried on by the new regulation.

Keywords: Vehicle Seat; Experiment Simulation; Seat Belt; ISOFIX; Commercial Vehicle

1 Introduction

It is calculated that commercial vehicles involved in Chinese fatal traffic accidents accounted for 96%, 92% and 100% respectively during from 2011 to 2013. Thus, commercial vehicle safety has became an important research area for the vehicle safety. The new regulation GB14167-2013[1] about vehicle safety belt anchorage, ISOFIX anchorage and top tether anchorage was promulgated in year 2013, which mandatorily require the new passenger seats of type M1 class vehicle should be equipped with at least 2 ISOFIX fixed point, and change the fixed way of seat belt to three points compulsory to improve the protection of commercial vehicles for occupant injury. In this paper, a experiment simulation model was carried for a commercial vehicle seat with three-point belt. Using finite element software LS-DYNA 3D, structural strength of three-point seat belt anchorage and ISOFIX anchorage was analyzed under the requirements of the new regulations, the results would be provided solutions to develop safety level for commercial vehicle seats.

2 Simulation Model of Vehicle Seat Test

For the improved seat frame model, it was pre processed to mesh elements. The seat frame structure, made of thin wall, is simulated by shell elements[2]. Cushion foam is a solid model, and using hexahedral elements to simulate it. The seat belt model combines two parts: the one that interacting with the mould was built as shell elements, simulating the sliding on the mould in all directions; the rest was built as 1D seatbelt, to increase some slack into belt[3].

According to GB14167-2013, the seat of three-point type safety belt in the M1 vehicle should be applied to the test load of 13500N±200N on the upper and lower human body module respectively. At the same time, an inertia load equivalent of 20 times the total weight of the seat must be exerted to the seat, which is applied to the center of it[1]. All the force are applied in the direction parallel to the vehicle longitudinal center plane, and the angle between force and horizontal line is upward 5-15 degrees. Also, the load should reach the specified value in 0.4s, 0.2s maintained, and then unload. The force loaded as shown in Figure 1.

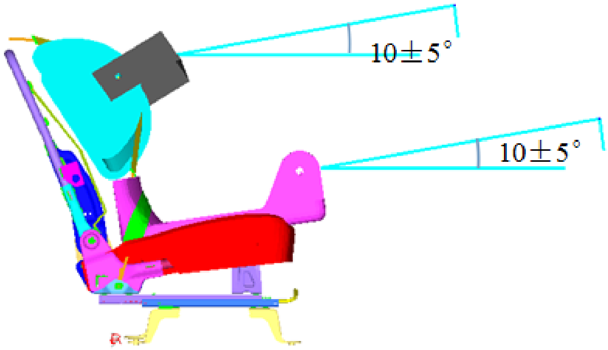
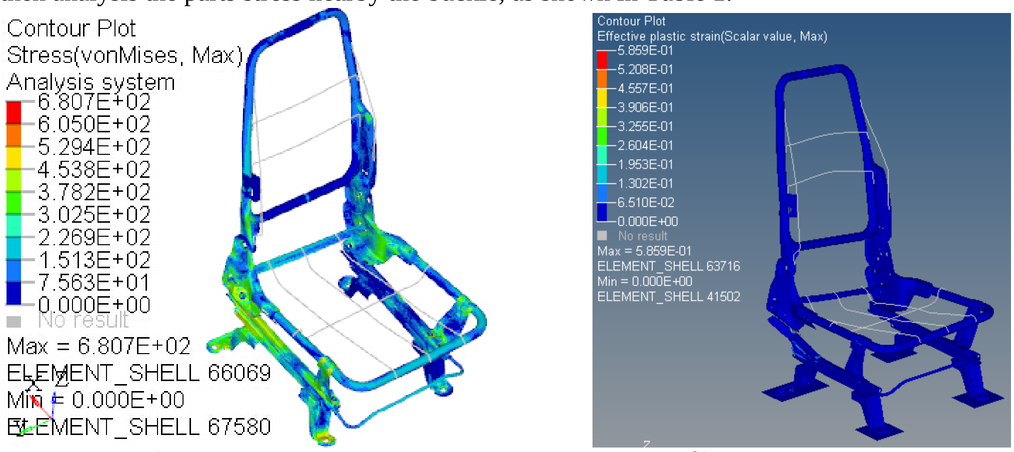


Figure.1 Loading Mode of Seat Test

3 Simulation and Test Comparison on the Belt Anchorage Strength

After simulation calculation, the deformation,stress and strain contours of the seat after the test are shown in Figure 2. According to the stress and strain contours, the stress concentrate in the vicinity of the seat rails with buckle[4]. And then analysis the parts stress nearby the buckle, as shown in Table 1.

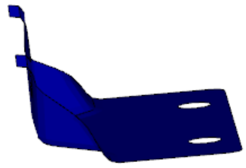
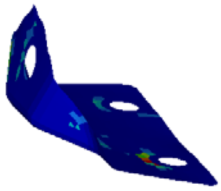
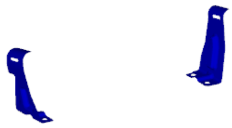
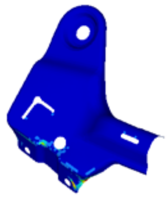
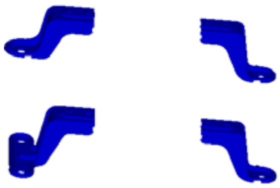
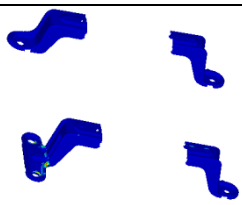
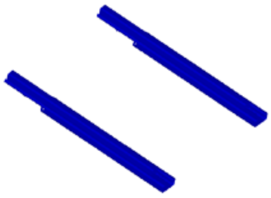
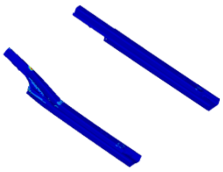
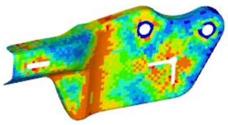
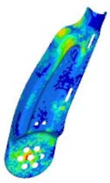
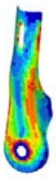


a)stress counter b)strain counter

Figure. 2 Counter of The Seat after Simulation

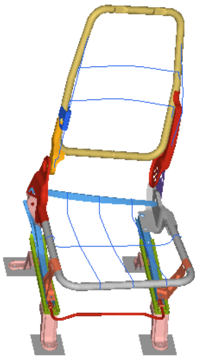
After compared the parts deformation before and after the simulation and the effective plastic strain of each part[5], we can see it that part1, 3, 4, 5, 8 has the possibility of failure or be torn apart due to large effective plastic deformation. Among which parts 1 and 3 are connected to the part 5 through two rivets, and the maximum deformation concentrated near the one rivet holes. Thus, it is concluded that there is a large deformation and even failure of that rivet. The maximum deformation of the part4 occur at the bend place, where have no strengthening, and the bend may be broken. The maximum deformation of part 8 is the place welded with other parts, where there is a welding to strengthen, so it is assumed that the part is safe and there is no risk of failure[6]. According to the analysis results above, it is determined that the seat structure can satisfy the strength requirement of safety belt anchorage in the GB14167-2013, and it will be accompanied by the permanent deformation and fracture of some parts.

Table 1: List of Main Deformation Parts

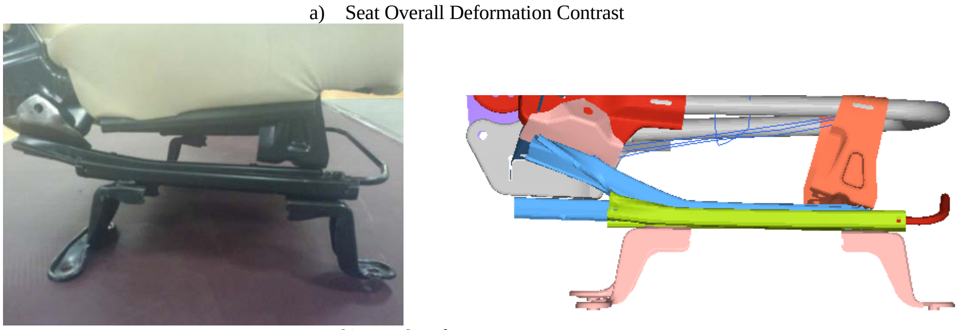
No	Before Deformation	After Deformation	Effective Plastic Deformation
1			0.044 The maximum stress concentrate in the rivet hole connecting sliding, where have large deformation.
2			0.0608 Maximum stress concentrate in the welding and bending, the part have large deformation.
3			0.235 The maximum stress focus on the weld, the other part have no larger stress
4			0.177 There is no large deformation of this part, and the maximum stress concentrate on the bend.
5			0.586 The place of slide rail linked with foot and connecting plate of cushion and back have the maximum stress, and the slide with buckle side is of large deformation
6			0.024 There is no large deformation of this part, and the maximum stress concentrate on the welding.
7			0.0468 There is no large deformation of this part, and the maximum stress concentrate on the welding.
8			409Mpa/0.124 There is no large deformation of this part, and the maximum stress concentrate on the welding.

In the design verification stage, the test result shows that the seat met the strength requirements of seat belt anchorage in the GB14167-2013. The comparison of the seat after test and simulation are shown in Figure 4. The right extension of the seat slide, after test and simulation, both had permanent plastic deformation, and the rivet connecting

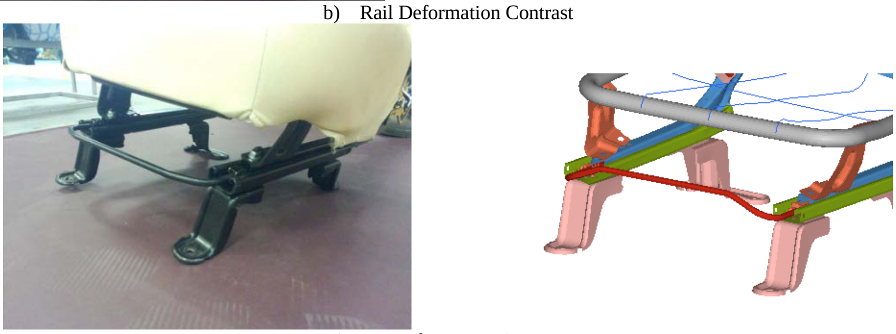
part1, 3, 5 is trend to be pull c ulation and experiment are also generated in the same direction of the tilt deformation. The experim these two regions are in good agreement with the simulation results. Part 4 of the bending in the ex t, while in the simulation has only a plastic deformation. Through the analysis and comparison, the 4 is 13mm, while the actual sample size is 5mm, which seriously affects the deformation of thi he phenomenon of being torn apart at the weak area. The results by comparing the simulation and mulation model is of high accuracy.



a) Seat Overall Deformation Contrast



b) Rail Deformation Contrast



c) Foot Deformation Contrast

d) Foot Torn Place Contrast

Figure. 4 Seat Comparison of Post Simulation and Test

4 ISOFIX Fixed Point Test

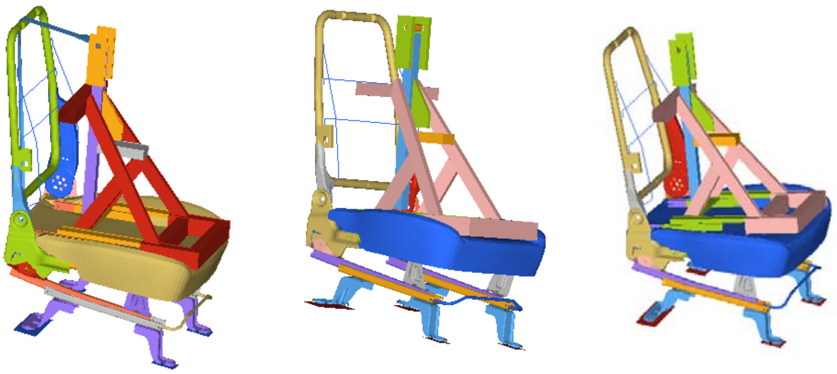
According to regulations GB14167-2013 requirements, the M1 vehicle seat belt fixed way is forced to change to three-point type, at the same time, the seat must be equipped with at least 2 ISOFIX anchorages. Therefore, after the model above mentioned has been verified by the test of seat belt anchorage strength, modify the size of part 4 according to the actual situation, and carried out the simulation analysis of the strength of ISOFIX on this basis model.

According to the requirements in GB14167-213, the strength of the ISOFIX anchorage systems shall be tested applying the forward and oblique forces, as prescribed in Table2. In case of ISOFIX top tether anchorage, an additional forward force test shall be performed as prescribed in Table2 [7-8].

Table 2: Directions of Test Forces

Direction	Angle	Force
Forward	0±5°	8KN±0.25KN
Oblique	75±5° (to both sides of straight forward, or if any worst case side, or if both side are symmetric, only one side)	5KN±0.25KN

Simulation results are shown in Figure 5. It is shown that there is no failure around the ISOFIX anchorage system, and the maximum deformation position is the extension of right slide. The effective plastic deformation of test a, b, and c are respectively 15.7%, 29.9% and 25.4%. It is inferred from the safety belt anchorage verification stage, the deformation amount is in a safe range, so the strength of ISOFIX anchorage system can meet the requirements.



a)ISOFIX Top Tether Anchorage Forward Force Simulation b) ISOFIX Anchorage System Forward Force Simulation
c) ISOFIX Anchorage System Oblique Force Simulation

Figure. 5 Simulation Result of ISOFIX Anchorage Strength

5 Conclusions

This paper carried out a simulation about the three-point safety belt anchorage strength of a new developed commercial vehicle according to the new regulations GB14167-2013 requirements. The simulation results are in good agreement with the test. Based on this model, simulated the ISOFIX anchorage system static test, and predicted the ISOFIX structure strength meet the requirements of new regulations.

Acknowledgement

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