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Research on the Test Simulation Method of Trolley Side Impact of UN R129

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Abstract: According to the trolley side impact condition of UN R129 children restraint system, 2 kinds of simulation test methods were developed and the feasibility was verified. Based on the validated test method, the numerical simulation of side impact in 3 different restraint systems (5-point-car seat belt, 5-point-ISOFIX and shield-car seat belt) with Q3 child FE dummy model was adopted. The kinematic response of the child occupant and the physical parameters of head, neck and thorax were analyzed. The results showed that the child occupant kinematic was different in various types of CRS. The injury physical parameters of child head in the ISOFIX CRS was the highest, the HPC15 and head acceleration (3ms) were 2085.0 and 171.7g. Chest acceleration (3ms) and neck bending moment value of child occupants in the ISOFIX CRS and shield CRS were much higher than children's injury tolerance limit. The chest and neck of a child occupant in a side impact are subject to high injury risk. The finding of this study could be valuable for child restraint system design for side impact.

Keyword: UN R129,Side impact,simulation method, Injury risk.

1 Introduction

The data show that the incidence of vehicle side impact accident happen frequently, second after the frontal impact, accounting for 26% of the total number of accidents. Side impact is one of the risk factors for children's injuries, 16% of child are non-fatal injuries caused by vehicle side impact [1].

Trolley test can save the research cost and period, which is very important for the research of child safety protection in vehicle side impact. In Europe, the United States, Japan and other developed countries in the automotive industry, child occupant side impact safety has been included in the regulatory system, and China has just started research, has not developed a formal laws and regulations and test methods [2]. Although there are some progresses in the test of trolley in China, the finite element simulation method of trolley test is still blank [3]. Based on UN R129 test requirements, two kinds of trolley side impact simulation model are established and the feasibility is verified. Based on the test method, 3 different structures of child restraint system were used to analyze the kinematic response and injury results of the children in side impact. Which provides reference for the improvement of side impact regulations and the design of CRS.

2 Method and Material

2.1 Trolley Side Impact Simulation Method of Using Absorbing Tube

The trolley side impact simulation test using the energy absorbing tube device shown in figure 1 (Method 1). The total weight of the trolley, CRS and dummy is 850 kg. The initial speed of the trolley, CRS, dummy is 7m / s, and the absorber device, the panel and the rigid wall are fixed. The output relative speed curve of the car and the door panel is found to meet the requirements of the regulation speed channel, shown in figure 2. Therefore, the simulation method of the trolley side impact simulation test using the energy absorbing tube device is feasible.

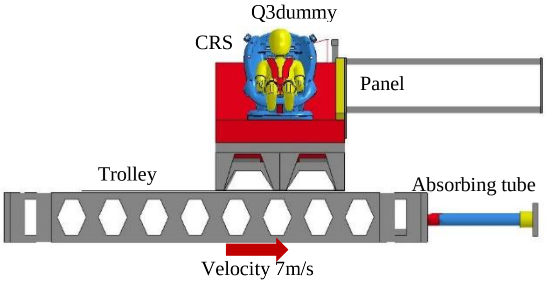

Figure1 test model (method 1)

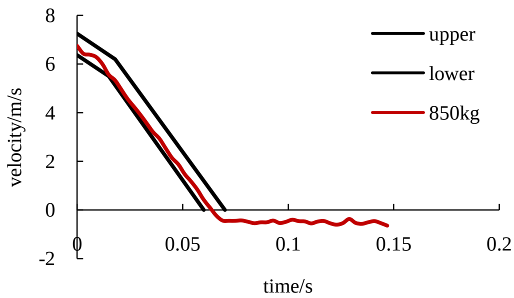

Figure2 velocity curve

2.2 Trolley Side Impact Simulation Method of Using Speed Curve

The method of using energy absorption tube is poor in repeatability, and it is difficult to control the speed curve in the channel. Therefore, a trolley side impact simulation model using the velocity curve as shown in figure 3 is established (Method 2). The relative speed curves of the trolley and the door panel obtained the method 1. The CRS and the dummy are given to at an initial speed of 7 m / s to prevent sliding relative to each other. The door panels remain fixed, the energy absorption tube device in method 1 is canceled, and the total model weight is 850kg, same as method 1.

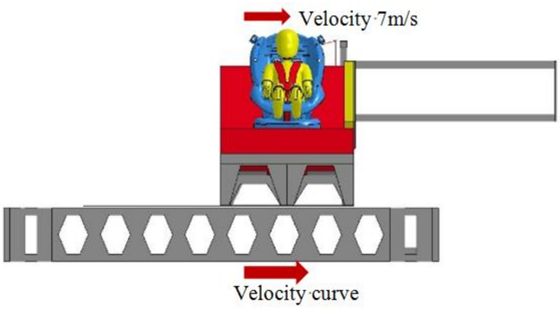

Figure3 test model (method 2)

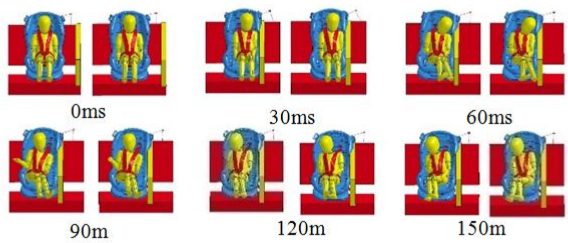

Figure4 kinematic response of CRS and dummy

To verify the feasibility of method 2, the kinematic response of CRS and child dummy in both methods was investigated. As shown in figure 4, the left side is Method 1 and the right side is Method 2. It can be seen from the figure, the two methods of child occupant kinematic response is basically same.

The damage values of Q3 dummies in the two methods were shown in Table 1. It can be seen from the table, the two damage value of the relative error is less than 6%. It can be seen that the two methods are equivalent and feasible.

Table 1 damage values

	HPC15	Head acceleration （3ms）/g	Chest acceleration （3ms）/g	Neck tension force/N	Neck flexion moment/N m
Method 1	536.0	80.3	54.4	1522.7	26.8
Method 2	568.6	83.8	55.8	1607.7	26.5
Relative error	5.73%	4.18%	2.61%	5.28%	1.21%

3 Analysis of child occupant injuries under different constraints

Based on the method 1, 3 different structures and validated CRS were used to analyze the response and injury risk of the children in side impact. The 5-point-car seat belt (3 - point), 5-point-ISOFIX (ISOFIX) and shield-car seat belt fixed (shield) were adopted.

3.1 Head injury

Figure 5 shows the head acceleration curve. Observation shows, the child's head acceleration peak appears concentrated between 0.03-0.05s, when the seat started contact with the door panel. 3-point seat due to the car seat belts fixed flexible,and the seat belt absorbs a certain amount of energy, so that move smoothly. While the seat flank deformation also absorbs a certain amount of energy, so the head acceleration peak is smaller. After ISOFIX seats contact with the door, the energy transmitted entirely to the seat and Q3 dummy, resulting in a larger peak in children's head acceleration. At the same time, ISOFIX concentrated in the bottom of the seat, resulting in the upper seat big inertia, the head side flexion occurs, but also a certain reverse movement. In the shield CRS, because the seat adopts more foam absorbing parts, and the seat quality is light inertia, the energy transmitted to the child occupant is small. At the same time, because the 5-point belt is not adopted, the motion of dummy head was small, and the peak acceleration of the head was smaller than the other two conditions.

3.2 Chest injury

Figure 6 shows the chest acceleration curve for Q3 dummy under 3 different constraints. It was observed that the time of peak acceleration of the chest was similar to that of the head acceleration peak. 3-point seat due to the flexible fixed way, and the deformation of the seat side to absorb a certain amount of energy, so the chest acceleration is small. ISOFIX rigid connection device, the child occupant in the upper body inertia during exercise, in the course of the movement by the 5-point type of strap greater force, resulting in a large chest acceleration. Shield-type seat, although the quality of light inertia, but the dummy hit the shield, resulting in secondary damage, thereby increasing the chest acceleration. It can be seen from the figure 6, ISOFIX seat and shield-type seat in the child occupant chest acceleration peak is significantly higher than the 3-point seat, because the 3-point seat flank device in the collision process to absorb a certain amount of energy, thereby reducing the chest injury.

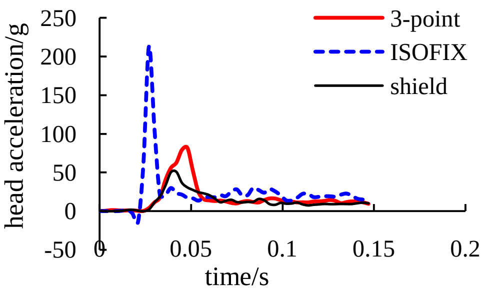

Figure5 head acceleration

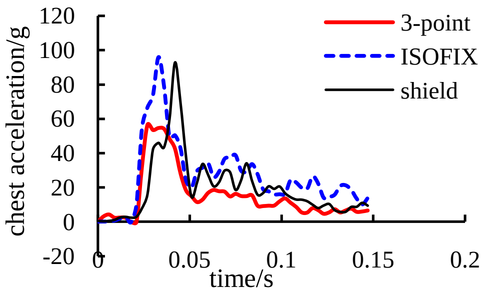

Figure6 chest acceleration

3.3 Neck injury

Figure 7 and figure 8 show dummy neck tension force and neck flexion moment curve. Observed, dummy in 3-point seat get the maximum neck tension, but the minimum neck bending peak. Because the panel hit the 3-point seat lower part, the child's trunk and hip movement of the crew, the head got greater lateral flexion, resulting in a larger neck stretch. But the head around the trunk of the torsion is smaller of bending less. The relative movement of the child occupant, torso and head under the ISOFIX seat constraint is relatively small, so the neck tensile force is small, but because of the large twisting of the head around the torso, the neck bending value is large. The dummy under the shield-type seat restraint is similar to the condition of ISOFIX seat restraint.

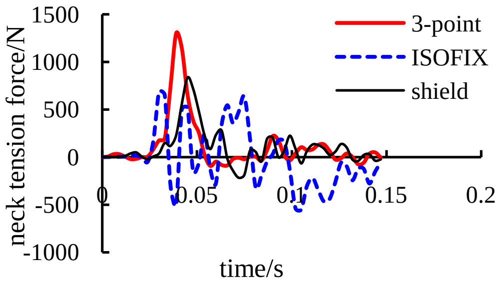

Figure7 neck tension force

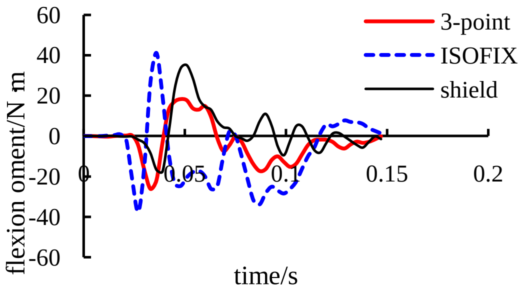

Figure8 neck flexion moment

The damage results were shown in Table 2. The head injury value of the dummy in ISOFIX CRS is larger than the child injury tolerance limit. In the side impact, dummy in 3-point CRS was close to the children's injury tolerance limit, the chest acceleration (3ms) and the neck flexion of the dummy in other two conditions were much higher than child tolerance limit, so child get serious injury in side impact.

Table2 Q3 dummy damage parameter [4]

	HPC15	Head acceleration （3ms）/g	Chest acceleration （3ms）/g	Neck tension force/N	Neck flexion moment/N m
3-point	536.0	80.3	54.4	1522.7	27.4
ISOFIX	568.6	171.7	89.2	804.6	41.8
shield	153.7	50.5	83.6	841.2	35.4
index	800.0	80.0	55	2120	268

4 Conclusions

Based on the European regulation UN R129, two side impact simulation methods were developed and verified. From the different restraints of the dummy injury situation, the following conclusions can be drawn:

(1) The 3 CRS in this paper are all certified, the injury value of the child occupant in the frontal impact is within the reference value, but in the side impact, the child occupant has a higher risk of injury. At the same time, the child occupant kinematics responses in different child restraint systems are different.

(2) In the side impact, the head, neck and chest of the child occupant under ISOFIX restraint were severely damaged.

(3) The chest injury value and the neck injury value exceeded the child tolerance limit, which indicated that the neck and chest of the child could be seriously damaged in side impact.

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