The Side Restraint System Development for FMVSS214

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Abstract: A great challenge has been posed to side impact restraint systems with the introduction of NPRM FMVSS214. With this new legislation, biomechanical injury levels must meet new requirements for 50%ile and 5%ile, in both high speed side MDB and oblique pole crash test scenarios. This greatly increases the level of protection required from restraint system components. In order to achieve this high level of protection, simulation tools and effective test methods have been developed within YFKSS to ensure vehicles meet the FMVSS214 requirements. This paper summarizes the development methodology and specific development tools used in the development of effective side impact protection systems.
Keywords: FMVSS214, Side restraint system, Sled test, Simulation

针对新 FMVSS214 法规的侧面约束系统开发

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摘要：新美国侧面碰撞法规（FMVSS214 NPRM）对侧面约束系统提出了更高的要求。 50％分位和 5％分位假人的伤害指标需同时在移动变形壁障撞击试验（MDB）和侧面斜柱碰试验满足新法规的要求。这极大的提高了侧面约束系统的保护要求。针对新 FMVSS214 法规的要求，延锋百利得开发了有效的仿真方法和试验手段来保证开发车型能满足新 FMVSS214 法规的要求。本文对这一有效的侧面保护约束系统的开发方法和相关开发工具做了简单总结。

1 Introduction

The worldwide activities to improve passive safety in side impact started in the 1980's with research work at the National Highway Traffic Safety Administration (NHTSA). A static side intrusion test was developed. This became the Federal Motor Vehicle Safety Standard No. 214 (FMVSS 214). In 1990 FMVSS 214 was extended to include the dynamic crabbed barrier test. This was the first side impact regulation that included a side impact dummy (SID) and was enacted in 1993, with a phase in of three years. In 1997 NHTSA included a lateral impact consumer test known as SINCAP. This was an additional test to the frontal NCAP. Instead of the FMVSS214 speed of 53 km/h, the rating test is completed with a velocity of 61 km/h. The rating is based on acceleration measured in the thorax region of the dummy. More than 40 cars were tested in the first year; none obtained the best score of 5 stars. In the following year two cars achieved a 5 star rating for the driver. Following a further 2 years the first passenger car improved to point of earning a double 5 star rating (for the first two seating rows). Today most cars have a 4 to 5 star rating and only one car in 2004 earned only a two star rating. [1]

Table 1 Comparison of current and new FMVSS214

		Current FMVSS 214	New FMVSS 214		
Test Mode		MDB	MDB	Oblique Pole	
Test speed		33.5 mph	33.5 mph	20 mph	
Impact angle		63 deg.	63 deg.	75 deg.	
#'s of test		One Test	One Tests	Two Tests	
Dummies	Front	USSID (front/rear)	ES-2	ES-2	SID-IIs
	Rear	---	SID-IIs	---	---

The upgrade of US-standard for side impact protection prescribes side impact crash tests with four different configurations, two oblique pole tests (75-degree, 32km/h) and one test with the "crabbed" mobile deformable barrier (MDB) shown as table1. The rule requires a new 20 mph, 75-degree oblique pole test run in two different configurations, one with a 50th percentile male (ES-2re) dummy and the other with a 5th percentile female (SID-IIs Build D) dummy. In addition to the oblique pole test, the rule requires a test with the ES-2re in the front seat and the SID-IIs Build D in the rear seat in the moving deformable barrier (MDB) dynamic FMVSS 214 side impact test, in place of the test with two 50th percentile male side impact dummies on the struck side of the vehicle (49 CFR Part 572 Subpart F (SID).When performing an oblique pole test, the vehicle impacts with an angle of 75°. [2]

Figure 1　Barrier and pole crash test schematic of New FMVSS214

2 The Methodology of Side restraint system development

In order to achieve this high level of protection, simulation tools and effective test methods have been developed within YFKSS to ensure vehicles meet the FMVSS214 requirements. The chart shown as Fig 2 summarizes the development methodology and specific development tools used in the development of effective side impact protection systems.

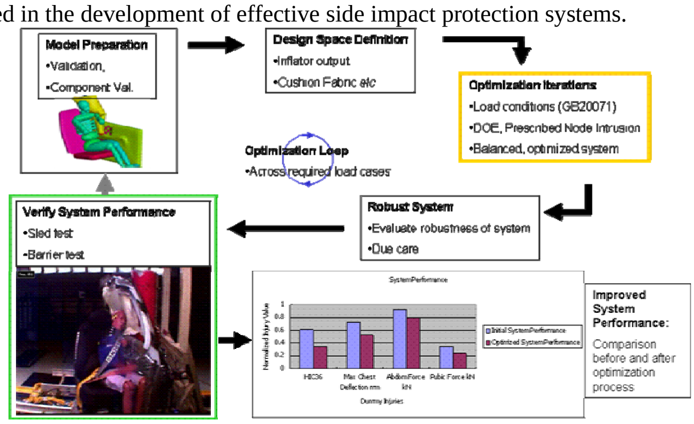

Figure2　Methodology of YFKSS Side restraint system development

2.1 Drop tower test and simulation

The drop tower test specifications are created by extracting the reactive restraint system model from the vehicle system model and subjecting it to a series of component tests. The boundary conditions and measured responses constitute the physical component test boundary conditions and performance targets respectively. This activity therefore creates the link between the numerical model and physical component and also the vehicle system and component tests, see Figure 3.

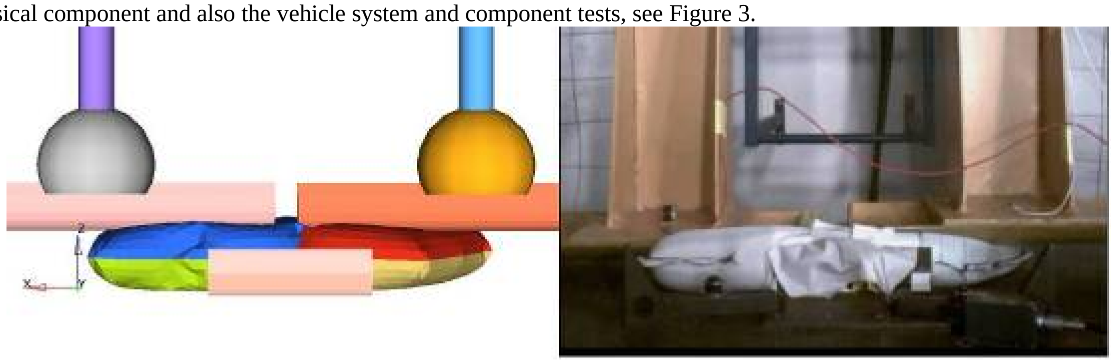

Figure 3　Drop tower model and test

2.2 Numerical model

If the vehicle crash environment is obtained from numerical simulation data, a sub-structure model can be used to drive the restraint simulation model with dummy model. The interactive character can be researched by tuning several key parameters. Airbag shape, venting, airbag fabric material are good such examples since they are typically used as tuning parameters significantly influences the dummy injuries. This activity relies heavily upon the accuracy and physical equivalence of the vehicle and dummy numerical models and is particularly sensitive to those entities that interact directly with the restraint system.

The dimensioning load cases, associated vehicle crash environment behavior and the restraint system design properties are able to be identified by the numerical model. The process of finding one restraint system that satisfies all load cases can be automated by using the optimal design targets for each of the restraint systems design properties that were derived in DOE results, like airbag venting. The numerical models are shown as Fig.4.

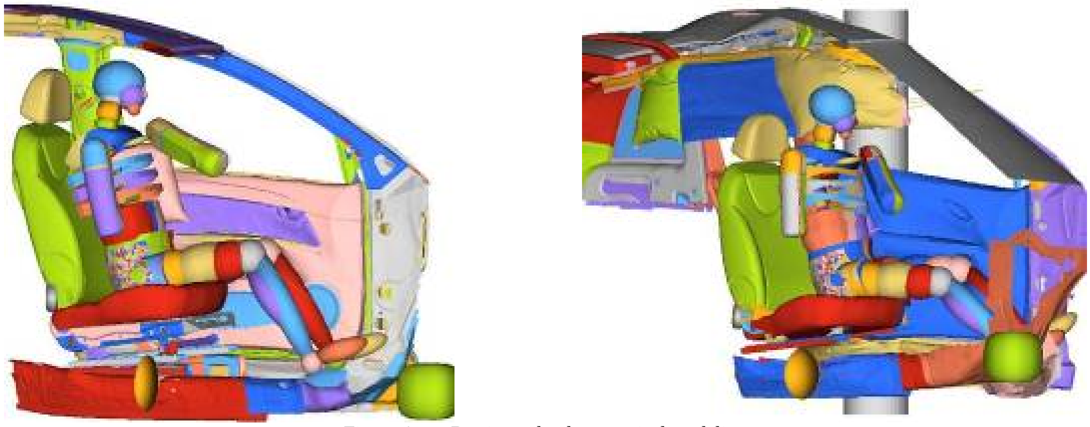

Figure 4 Barrier and pole numerical modeling

2.3 Side sled tests

2.3.1 Sled test setup

The moveable deformable barrier strikes the vehicle, causing large deformations, which in turn causes occupant injuries. The YFKSS side sled system simulates this intrusion by allowing the seated occupant, the side structure and door to move relative to the sled buck. The relative motion is permitted by mounting the seat and door structure on rails, which in turn are mounted on the sled buck (see fig. 5). This figure shows that on acceleration of the sled buck, the door and seat can move relative to each other, thereby simulating the vehicle intrusion during the crash. The door structure movement is restricted by a bulkhead mounted on the sled buck, Careful adjustment of this relative motion is necessary for good correlation. This process is described in a later section.

The side structure is prepared by cutting one side of the body in white. The door inner is welded or bolted to this side structure so it can be reused. Figure 5 shows the car structure. Hexcel, similar to the material representing the deformable part of the moveable barrier, is mounted to the side structure at the appropriate height. This hex cell provides the correct stiffness when the door structure strikes the dummy. Seat belt, door trim, B-pillar and other trims are also fitted.

Figure 5 MDB Sled set up

Figure 6 Pole Sled set up

Figure 5 and 6 shows the actual sled test set up at YFKSS. The side structure, cut from the BIW, can be seen mounted to buck on 2 rails. Actual vehicle seat is mounted on two rails at the correct height and distance relative to the door. Euro SID 2 dummy is set up according to the legislative protocol with respect to H-point location, dummy angle etc. A series of metal blockers guidelines and attachments prevent rebound once the dummy and seat have moved into the door and fully loaded the structure. The sled pulse is shot, matching the acceleration time history at typical location on B-pillar. The inertia of the dummy and seat causes the dummy to strike the door, simulating the intrusion seen in an actual barrier test.

2.3.2 Correlation Process

In addition to correlating the acceleration pulse on the sled structure to barrier pulse, dummy injury values should also be correlated to actual dummy injury values seen in the barrier test. Direct comparisons of time history dummy injury readings between sled test and barrier test are made to correlate and validate sled test process. Several set-up parameters can be tuned to improve dummy injury correlation.

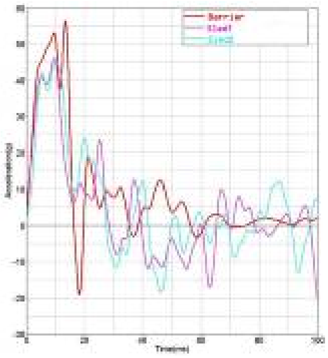

Figure 7 Pole Sled set up

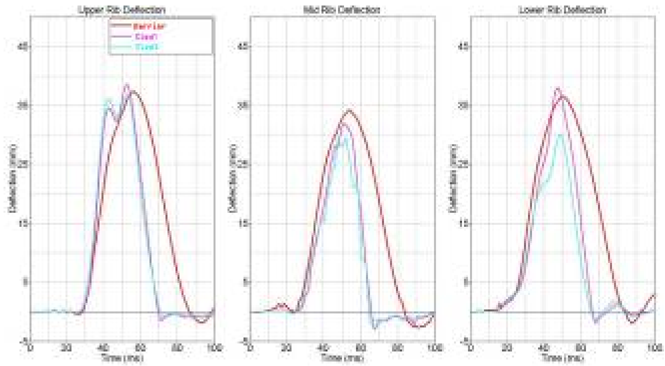

Figure 8 Pole Sled set up

These set up parameters are for example Hyge set pressure, to alter the onset or aggressiveness of the pulse, initial distance between the bulk head and the door to affect the initial peak value of the pulse. The initial angle of the door, which simulates the deformation pattern affects the contact area of dummy and door. Depth and stiffness of hexcel; this effects the contact stiffness between dummy and door. Fine tuning these parameters leads to a baseline correlation, accurately predicting the injury values of the EuroSID2 dummy. As previously mentioned, certain injury areas should be focused upon. These injury values would receive the greatest effect from any airbag countermeasure implementation. Fig.7 shows the sled pulse match to barrier crash test. Fig.8 shows the correlation of rib deflection between pole sled tests and barrier crash test.

2.4 Optimization

Once numerical model is correlated to sled test, the link between virtual design and barrier crash environment is built. The Optimization of the restraint system can be started with DOE tools under the multi-load cases complying the regulation. The key parameter can be identified and several interactive loops of simulation and sled tests will be done to find the optimal design.

Normally ribs deflection are the most important injury index in oblique pole test, which are also most difficult target to satisfy. DOE results show that several parameter take great effect on this injury, as airbag shape and airbag pressure etc. The best results are able to achieve by carefully tuning these parameters. The Fig.9 gives a example of optimization history of rib deflection injury in Pole test scenario. Fig.10 show actual test results of rib deflection injuries, which are improved continuously by fine tuning the main parameters of side restraint system. It shows that the methodology is effective during the development process of side restraint system.

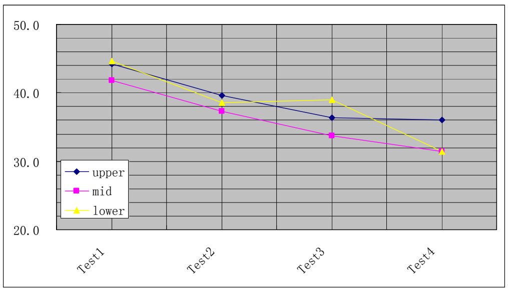

Figure 9 Optimization history of rib deflection

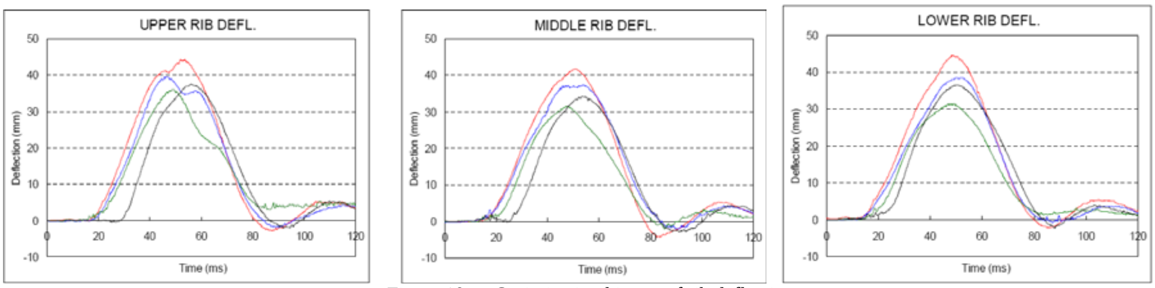

Figure 10 Optimization history of rib deflection

3 Conclusion

In order to achieve high level of protection, simulation tools and effective test methods have been developed within YFKSS to ensure vehicles meet the FMVSS214 requirements. The chart summarizes the development methodology and specific development tools used in the development of effective side impact protection systems. YFKSS are able to simulate side impact barrier tests in a 12” Hyge sled test environment. The example shown in this paper that the methodology is effective during the development process of side restraint system.

References

[1] National Highway Traffic Safety Administration Federal Motor Vehicle Safety Standards; *Side Impact Protection*, Part 571. (FMVSS 214 Revision 2004).
[2] FMVSS NO. 214 AMENDING SIDE IMPACT DYNAMIC TEST ADDING OBLIQUE POLE TEST (OFFICE OF REGULATORY ANALYSIS AND EVALUATION NATIONAL CENTER FOR STATISTICS AND ANALYSIS Aug 2007).