Usage of LSTC_NCAC Hybrid III 50th Dummy in Frontal Occupant Simulation

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Abstract

Occupant simulation is very useful for vehicle restraint system and passive safety development. Since the requirements of safety assessment are more and more demanding, the occupant simulation models have to be more and more accurate. Dummy model is very crucial in occupant simulation, and is difficult for most vehicle manufacturer to build. To purchase a commercial dummy model is a very reasonable and safe choice. Alternatively, LSTC offers LSTC dummy models, which are free for LS-DYNA® users. It is foreseeable that LSTC dummy models may not be as stable as commercial ones. This article describes the usage of LSTC_NCAC Hybrid III 50th dummy in frontal occupant simulation, and try to give a preliminary guideline of usage in vehicle development.

Introduction

Since the requirements of safety assessment and regulations are more and more demanding, vehicle manufacturers spent a lot of time and money in developing restraint system. Crash dummies are full-scale anthropomorphic test devices (ATD) which simulate the human body in dimensions, weight and articulation. There are sensors equipped in crash dummy to measure physical quantities, such as acceleration, force, moment..., which are considered "injuries". Crash test are conducted with crash dummies to evaluate the safety performance of vehicle. Ultimately, dummy injuries are the assessment standard.

In order to reduce the development cost, computer-aided-engineering (CAE) is wildly used. Occupant simulation focuses on crash dummies behavior and injuries in vehicle passenger cabin undergoing a crash event. Since the requirements of safety assessment are more and more demanding, the occupant simulation model have to be more and more accurate. In this situation, CAE dummy model is very crucial to get a accurate simulation result. As mentioned before, the crash dummy is composed by many parts, joints and sensors, which is very difficult for most vehicle manufacturer to build the model. So that the commercial dummy models are provided by commercial company, which is a very reasonable and safe choice for car maker.

Livermore Software Technology Corporation (LSTC) offers an alternative choice, LSTC dummy models. LSTC dummy models are free for LS-DYNA users. These models are attractive to vehicle manufacturer because it can reduce the cost further. The usage of LSTC_NCAC Hybrid III 50th Dummy in frontal occupant simulation of target vehicle and the recommended guideline are presented in this paper.

Model Building with LSTC Hybrid III 50th Dummy

The overview of frontal occupant simulation regarding to target vehicle is as Figure 1 . The airbag and seatbelt models are come from restraint system supplier in MADYMO input files. In order to assemble them to LS-DYNA simulation, the transformation work was done. After transformation, virtual component tests were conducted to make sure the transformation is correct. Other components models, including instrument panel, steering wheel and column, pedal, carpet, seat, were built in detail respectively.

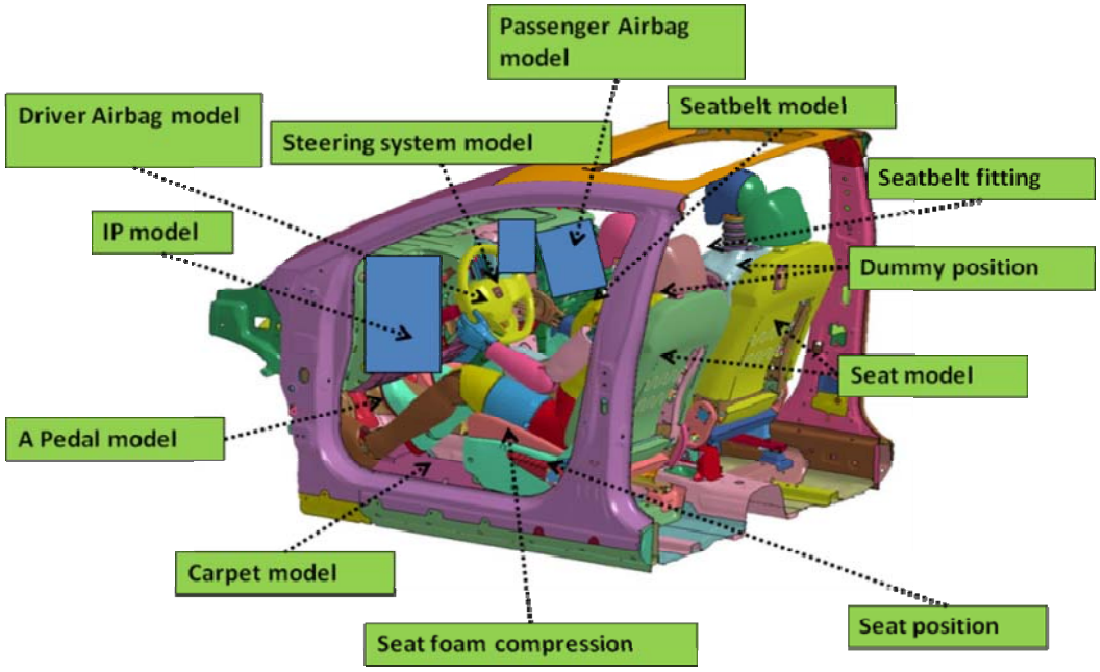


Figure 1. The overview of frontal occupant simulation regarding to target vehicle.

Dummy Positioning

Dummy positioning is very important in occupant simulation. Since crash dummy has a lot of degree of freedoms, there are always a slightly differences in dummy position. The differences of dummy positions sometimes cause different dummy kinematics and injuries. To avoid the dummy position difference factors in occupant simulation, positioning dummy according to test measurement is necessary. The LSTC dummy models keywords file contains %occinfo after *END, which is in charge of the dummy position and recognized by LS-PrePost®. LS-PrePost is recommended to position LSTC dummies as Figure 2.

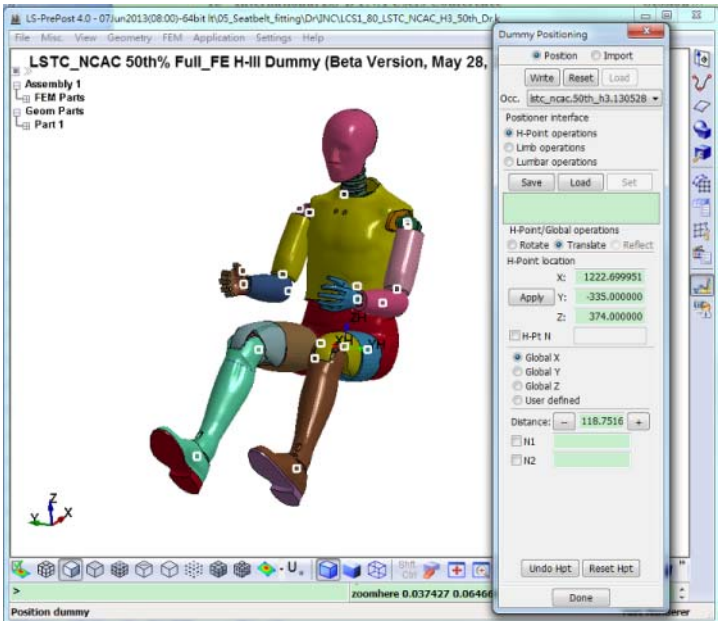
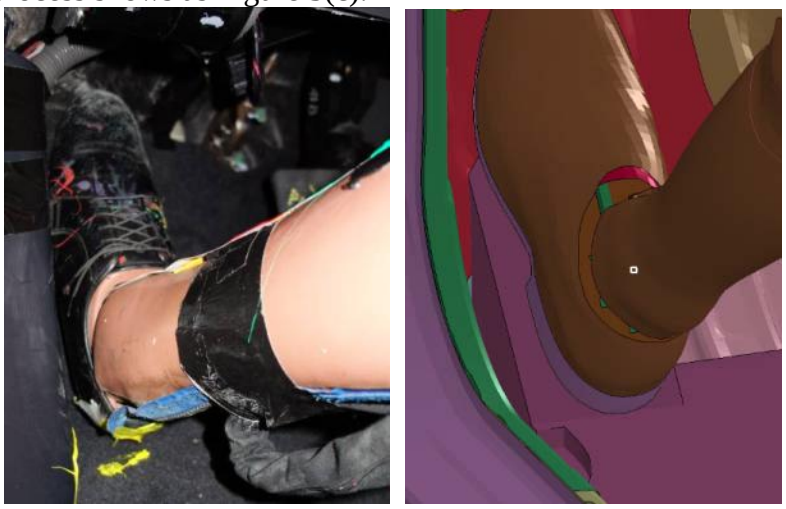


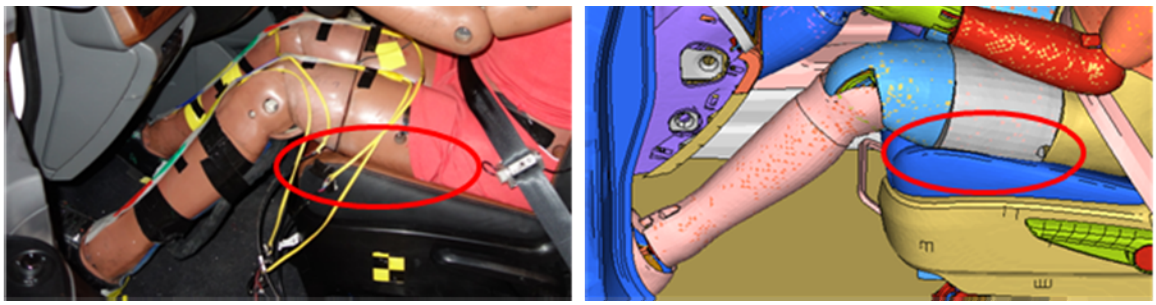
Figure 2 LS-PrePost is recommended to position LSTC dummies

Release Joint Stop Angle to Achieve Test Dummy Position

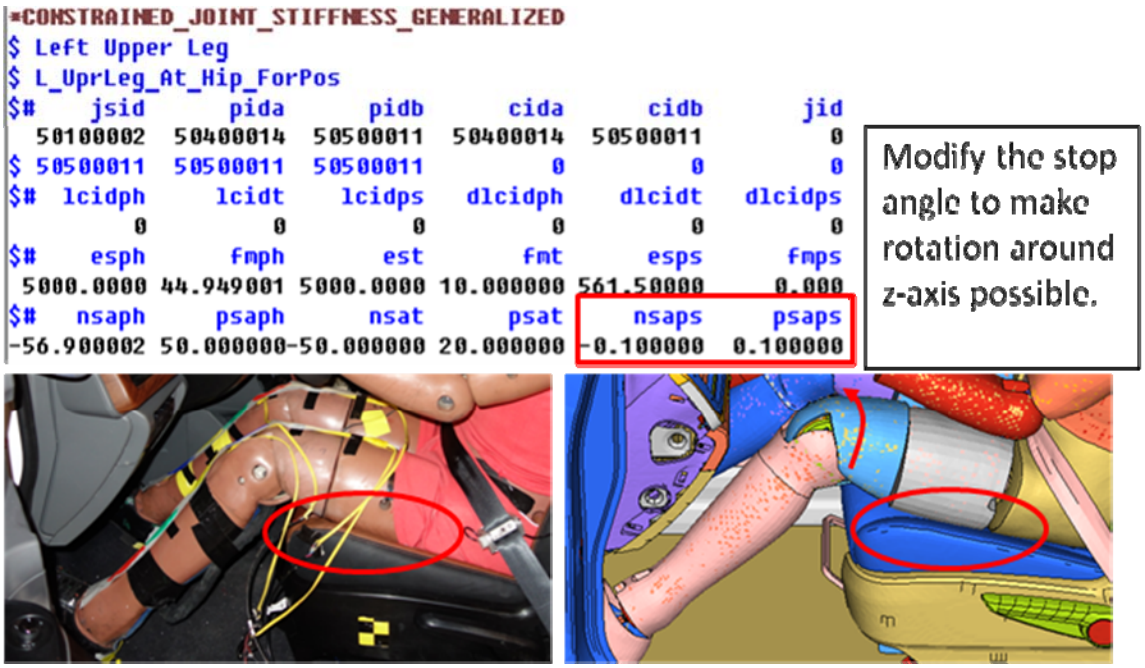
It was found that the rotation around z-axis of upper leg is not allowable in LSTC Hybrid III 50th dummy, which makes the test dummy position is unachievable, as Figure 3(a) and (b). The distance apart of the outside metal surfaces of the knees is 295mm in test, and the left foot is placed on footrest. It is impossible to achieve above two conditions without rotation around z-axis of upper leg. In order to solve this issue, modified the stop angle to make rotation around z-axis possible. After achieve test dummy position, modified the stop angle again to recover the original setting. The modification process shows as Figure 3(c).



(a) The left foot is placed on footrest



(b) The Y position of femur is different between crash test and CAE model



(c) Modified the stop angle to make rotation around z-axis possible, then achieved test position

Figure 3 Release joint stop angle to achieve test dummy position

After the difference between CAE dummy and test condition is acceptable, it is recommended not to use the dummy keyword file saved by pre-processor directly. The reason is some special keywords are not supported by pre-processors. Using the dummy keyword file directly may cause problems unexpectedly. It is recommended to replace the *NODE section in the original dummy keyword file by the positioned one. Actually, the only part in dummy keyword file should by changed after positioning is *NODE section. Theoretically LS-PrePost is no problem to output LSTC dummies, but it will never wrong to play safe in this case.

Dummy Renumbering

Sometimes dummy renumbering is necessary. There are two most common situations: (1) there are more than one dummies in one simulation model. (2) the current dummy numbering is not in line with numbering rule. Fortunately, dummy renumbering only have to be done one time.

Due to the current dummy numbering is not in line with numbering rule of HAITEC, we following the instructions from LSTC to renumber it. It is recommended to renumber LSTC

Hybrid III 50th dummy by LS-PrePost. Further detail please refer to APPENDIX B of "LSTC.NCAC_H3_50TH.130528_BETA.pdf"

Seatbelt Fitting

There are a variety of pre-processors provide the function of seatbelt fitting. Some of them are considering the thickness of the parts selected to fit the seatbelt. In this case it will cause problem. The pelvis block of LSTC HybridIII 50th dummy is much more thicker than others, which shows in Figure 4. When fit the seatbelt by the software considering the thickness, the seatbelt fitted would have a lot of slack. To solve this problem, simply change the thickness of pelvis to 0.01mm. Recover the thickness of pelvis after seatbelt fitting is done.

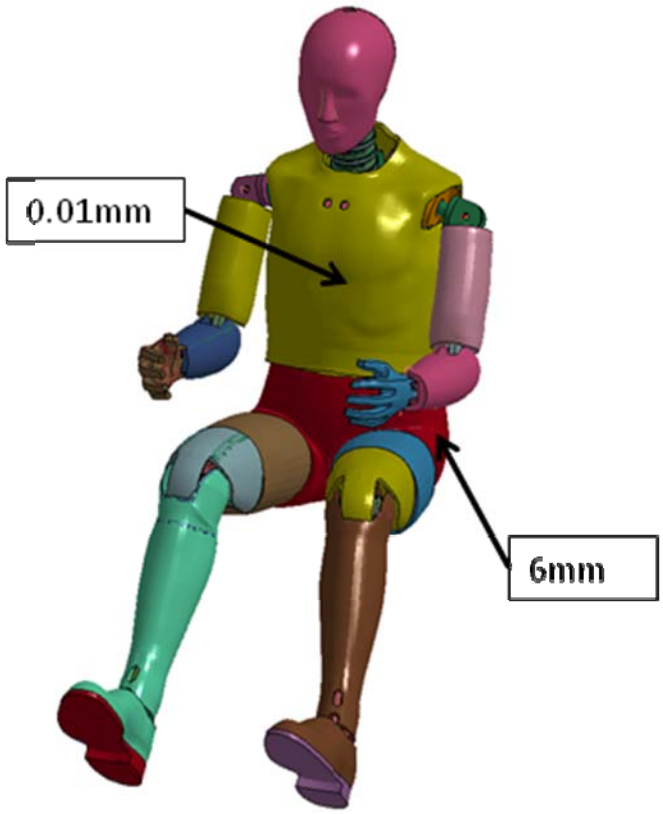


Figure 4 The thickness difference in LSTC HybridIII 50th dummy model

Modification and Best Practice

Once the Occupant CAE model is finished, there are still some modification have to do to make the model more reality. The majority problems in occupant simulation is the contact problem. For example, Losing contact in the running process leads penetration; negative volume of soft part due to inadequate contact definition, etc. Following is the issues and solutions collection we encountered during the model checking with LSTC HybridIII 50th dummy.

Null Shell for contact

The heel of right foot was hooked by floor padding. As the result, the heel part occurred negative volume. The reason causes the negative volume issue is the contact force between heel and floor padding was too weak, made the node of heel penetrated through floor padding and cannot be parted. To correct this, increased the thickness and Young's modules of the null shell of heel part as Figure 5.

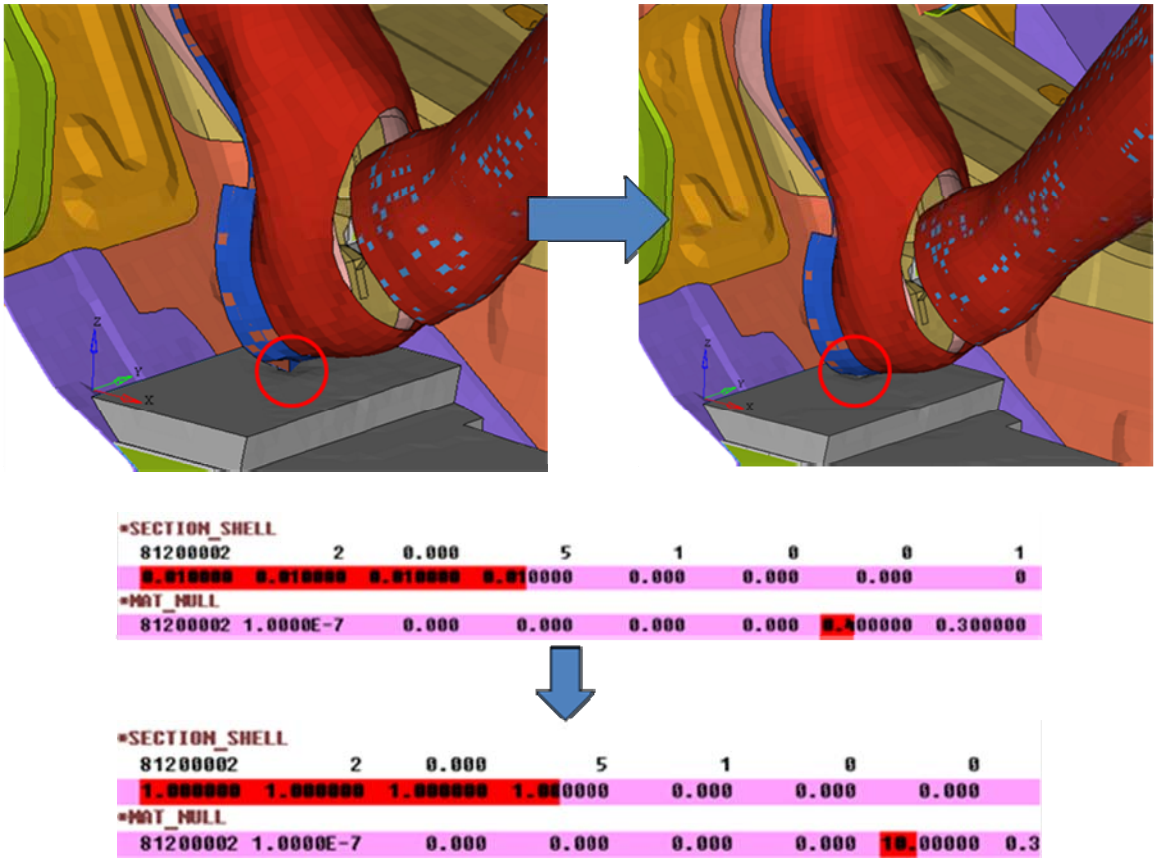


Figure 5 Increased the thickness and Young's modules of the null shell of heel

2D slipring

The typical seatbelt setting in LS-DYNA is 2D shell elements for contact with dummy, 1D seatbelt elements for slipping through slipring. This methodology works very well in most situation, but sometime fails near buckle area due to the complex contact behavior between dummy and seatbelt. It was found that the deformation of dummy abdomen is too large and unrealistic during our model checking. We tried a variety of countermeasures to fix this problem, but no one works except 2D slipring. Ultimately, 2D slipring is the best solution in this situation.

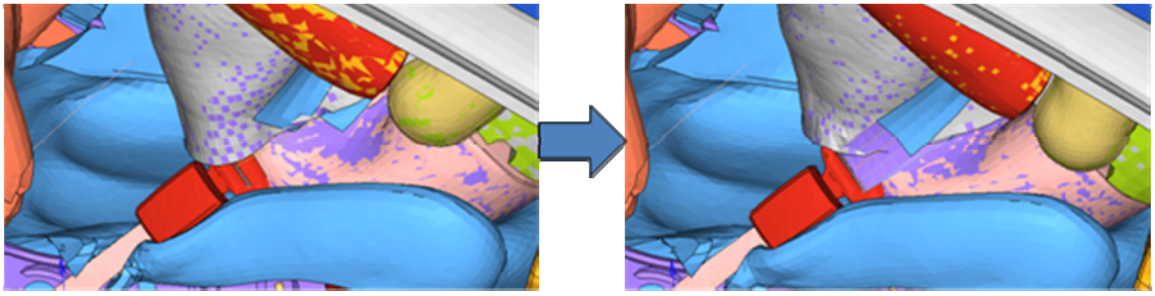


Figure 6 Correct the contact between dummy and seatbelt near buckle by 2D slipring

MPP decomposition

Dummy and airbag are the most running-time-consuming models. In order to reduce the running time, distributing dummy and airbag parts to all processors is recommended. Distributing dummy and airbag parts to all processors can be achieved by *CONTROL_MPP_DECOMPOSITION_BAGREF and *CONTROL_MPP_DECOMPOSITION_PARTSET_DISTRIBUTE.
*CONTROL_MPP_DECOMPOSITION_BAGREF distributes the airbag parts base on reference geometry. Without this keyword card, LS-DYNA will distribute the parts of airbag base on folded geometry. The elements will not be adjacent when distributing the parts base on folded geometry , and the computing efficiency is no good. Included the parts of dummy and airbag respectively to *CONTROL_MPP_DECOMPOSITION_PARTSET_DISTRIBUTE as shows in Figure 7. The average time-saving is about 0.5~1 hour on 12 processors by user define MPP decomposition.

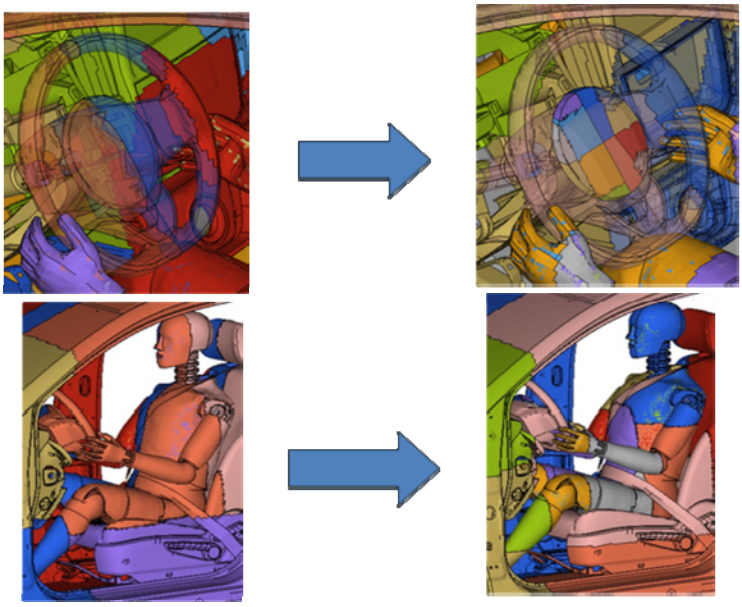


Figure 7 MPP decomposition

Correlation Results

The final correlation results are described as following two sections:

Dummy Kinematics

The first step is to check the dummy kinematics. The kinematics shows similar behavior between real crash test and simulation, as Figure 8 .

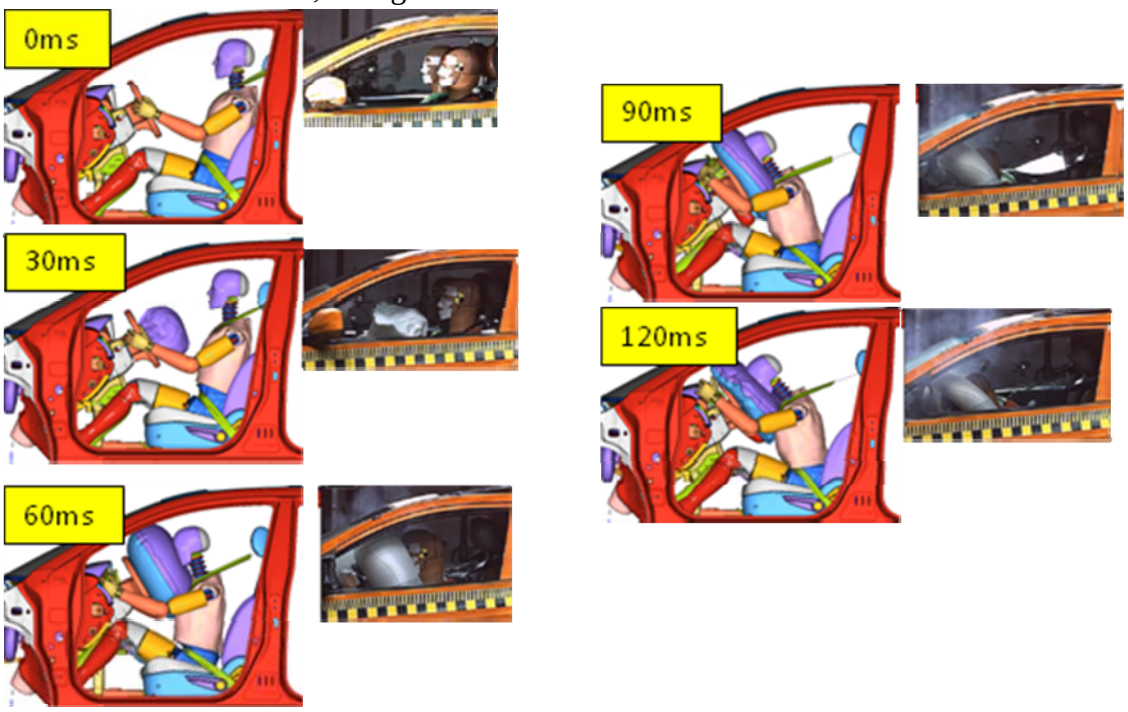


Figure 8 Dummy kinematics comparison

Injury Curves

The dummy injury curves are shown in Figure 9, which shows acceptable correlation between real crash test and simulation.

Noticed Issue

The LSTC HybridIII 50th dummy model has one apparent problem, which causes many unstable condition during simulation running. There are many in-dummy mesh penetrations. These penetrations sometime introduce unrealistic contact force, result in out-of-range velocities, severe hourglass deformation, severe deformation in a few elements. It is difficult for user to eliminate all penetrations, because it will dramatically change the geometry of dummy. Besides, user doesn't know the exactly dimension. The only way to solve this issue is to eliminate the penetration after unexpected results or termination happened, then run the case again. This method is not so good because takes more time to repeat running.

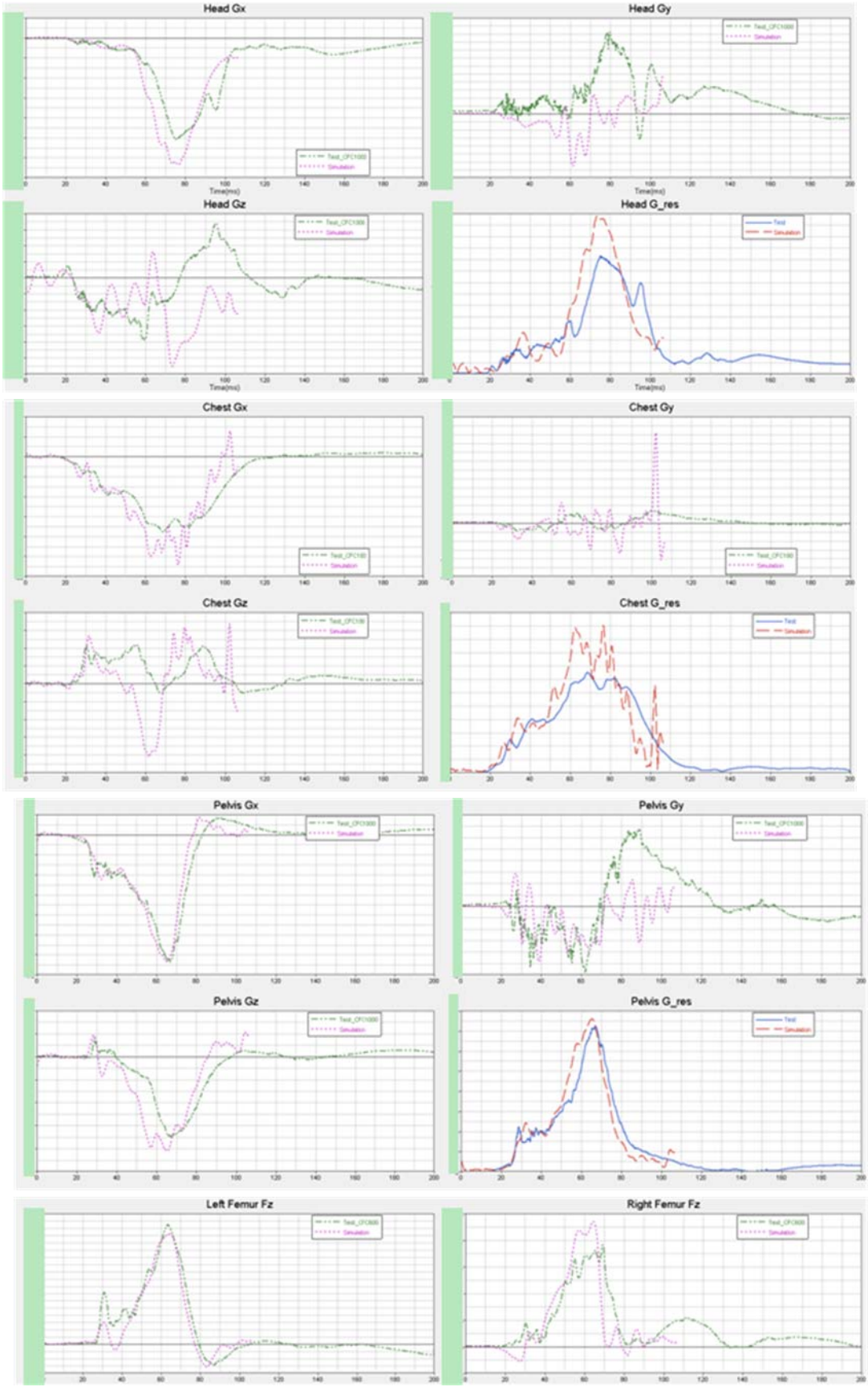


Figure 9 Injury curves comparison

Summary

This article describes the usage of LSTC_NCAC Hybrid III 50th dummy in frontal occupant simulation, and try to give a preliminary guideline of usage it. In summary, LSTC_NCAC Hybrid III 50th dummy is a acceptable alternative tool in vehicle development, though there are some drawbacks have to pay attention to, which describes as following:

- Dummy positioning should be performed by LS-PrePost.
- Some restriction of dummy joints are nonphysical, which keep the dummy position from real crash test condition. Release joint stop angle is one way to solve this problem.
- Dummy renumbering should be performed by LS-PrePost.
- The pelvis block of LSTC_NCAC Hybrid III 50th dummy is much thicker than others. This may cause the seatbelt have a lot of slack in case the preprocessor considering thickness. Changing the thickness of pelvis when seatbelt fitting, and recovering the thickness afterward is one solution.
- Some null shells of dummy cannot produce enough contact force to prevent penetration during running. Increasing the thickness and Young's modules of the null shell is recommended.
- 2D slipring is recommended in buckle area to avoid unrealistic behavior and penetration.
- User defined MPP decomposition is a good way to reduce running time.
- There are many in-dummy mesh penetrations. These penetrations sometime introduce unrealistic behavior. The only way to solve this issue is to eliminate the penetration after unexpected results or termination happened, then run the case again.

References

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