# Analysis of Dummy Injury with respect to Vehicle Pitching

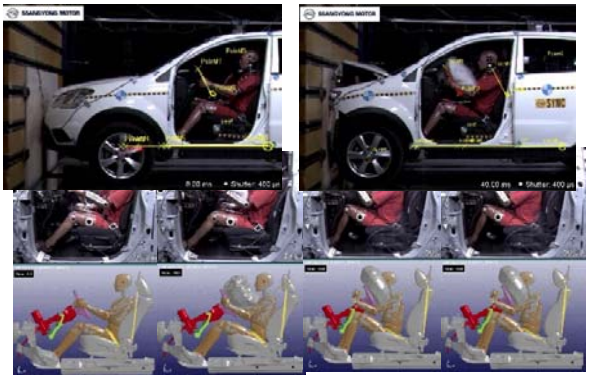
Hwan-Jun Choi, Min-Seung Seo, Jaeheon Jeong*

## I. INTRODUCTION

In a vehicle frontal collision, pitching occurs and we found that there was little difference in the degree of pitching in each test.

## II. METHODS

We constructed CAE models to evaluate the effects of pitching on injury in a 56 kph frontal collision. Considering the pitch angle of the vehicle, we created four CAE models with different steering-wheel angles from the original model. Through an analysis model we studied the pitching impact on the injuries to head, neck and chest.



| Mode type | | | STRG 각도 | Seat 구조 | 비고 |
|---|---|---|---|---|---|
| A type Model | case 1 | Base model | 28.5deg | Rigid Seat | - |
| | case 2 | Base model + | 31 deg | | 2.5deg up |
| | case 3 | Base model + | 33.5deg | | 5deg up |
| | case 4 | Base model + | 26 deg | | 2.5deg Down |
| B type Model | case 5 | Base model | 28.5deg | Deformable Seat | - |
| | case 6 | Base model + | 31 deg | | 2.5deg up |
| | case 7 | Base model + | 33.5deg | | 5deg up |
| | case 8 | Base model + | 26 deg | | 2.5deg Down |

| Mode type | | STRG 각도 | Seat 구조 | HIC 값(36) |
|---|---|---|---|---|
| A type Model | case 1 | 28.5deg | Rigid Seat | 681 |
| | case 2 | 31 deg | | 708 |
| | case 3 | 33.5deg | | 866 |
| | case 4 | 26 deg | | 560 |
| B type Model | case 5 | 28.5deg | Deformable Seat | 690 |
| | case 6 | 31 deg | | 721 |
| | case 7 | 33.5deg | | 886 |
| | case 8 | 26 deg | | 662 |

Fig. 1. Vehicle collision test tracking, CAE model setting table and Head injury results.

### Head part

The head injury result of the 5 degree case model shows the highest HIC. The HIC result of each case is shown in Fig. 1. The head injury of Case 5 was HIC 690, Case 6 was HIC 721 and Case 7, the worst result, was HIC 886. In comparison to the best case, injury increased 28% in the worst case. From these CAE results we determined that the higher the vehicle's pitching angle, the harder is the impact of the airbag with the dummy's my head.

### Neck part

The CAE result shows that the injuries to the dummy's neck part in the 5 degree case model were the most severe. Neck - Fx and - My, shown on the graph in Fig. 2, show the highest value in Case 8. But Mocy, which is an evaluation item of NCAP, was highest in Case 7. For more information concerning the Mocy, see below at the Conclusion.

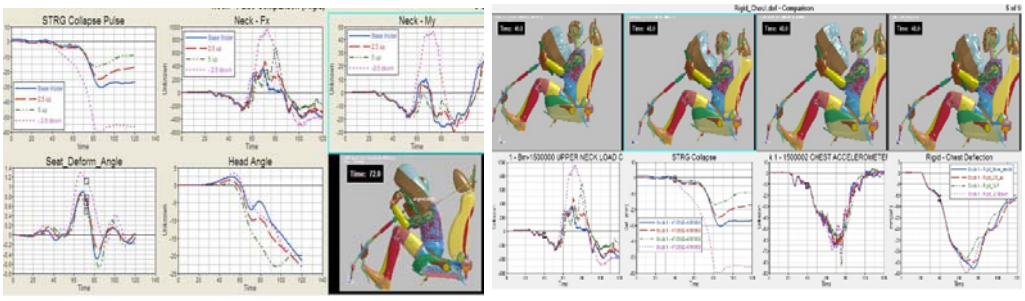



Fig. 2. Neck and chest injuries graphs and CAE models.

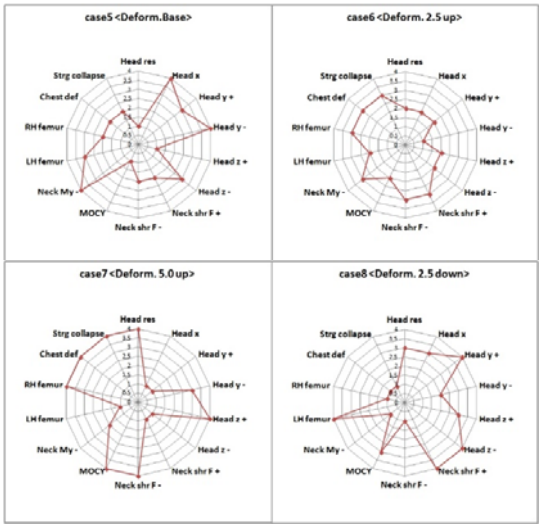
*Hwan-Jun Choi, Min-Seung Seo, Jaeheon Jeong all work at the Ssangyong Motor Company.

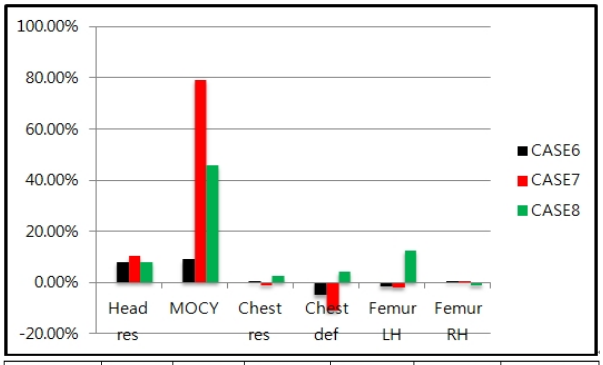
**Chest part**

From the CAE results, it is clear that the chest deflections of the 2.5 degree model were the highest. The dummy chest injuries were inverse proportional to the vehicle pitching angle and were caused by the airbag impacting. As the angle of the airbag goes down, there is a higher probability of it hitting the thorax. The chest deflection value of Case 5 was 45 mm and of Case 6 was 41 mm, while the value of Case 7 was 38 mm. Therefore, chest deflection, compared to the original value, was improved by more than 16% in Case 7. However, the variation in chest deflection did not affect the NCAP star rating.

## III. CONCLUSION

The injuries of the head and neck were proportional to an increase in the vehicle pitching angle increase, while the chest deflection value was inversely proportional to it. In order to study these injuries further, we compared the injuries of all cases (a radial graph is shown in Fig. 3). The worst case was Case 7, in which the vehicle pitching angle was greatest. When we compared the Mocy values of Case 5 and Case 7, we found the biggest increase of the total injury values, at 78.93%. We can determine, therefore, that the Mocy is the value most affected by vehicle pitching when testing the 56 kph frontal collision.




| DEFORMABLE | Head res | MOCY | Chest res | Chest def | Femur LH | Femur RH |
|---|---|---|---|---|---|---|
| case5 (Base) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| case6 (2.5° ↑) | 7.86% | 8.80% | 0.09% | -5.13% | -1.70% | 0.23% |
| case7 (5° ↑) | 10.10% | 78.93% | -1.12% | -11.16% | -1.98% | 0.56% |
| case8 (5° ↓) | 7.90% | 45.52% | 2.25% | 4.11% | 12.48% | -1.17% |

Fig. 3. Radial graphs and vehicle pitching influence checking table.

## IV. References

[1] Ministry of Land, Infrastructure and Transport, New Car Assessment Program protocol, 2014.
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[5] SYMC, 56 kph Frontal Impact Test, Final Report, RT00019293/RT00019294RT00021455/RT00022928.
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