Development of 'Relax Seat: Passenger Protection Airbag'

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ABSTRACT – With the advent of self-driving cars, significant changes are expected in the posture of occupants~~,~~ leaning back the seat or sleeping comfortably. In response to the consumers' needs, automobile manufacturers have recently mounted 'a Relax Seat' on the front passenger seat, which can be moved comfortably by reclining the chair back. However, in the event of a vehicle accident, passengers seated in a relax seat are generally known to be more seriously injured than occupants sitting in a typical seat position. Accordingly, in this paper, comparative data on the SLED test is presented to investigate the influence of a relaxed seat posture on the risk of injury of the occupants. Moreover, a dual-depth passenger airbag was also introduced as a countermeasure in the design and evaluation process.

INTRODUCTION

Several vehicle manufacturers are adopting indoor relax seats as an interior concept for the future autonomous driving vehicle. This enables drivers to lower the angle of seat back to relax when they do not drive to a destination as well as benefits non-driving passengers. Therefore, safety devices for vehicles with relaxed seating must be designed differently from existing safety devices that reflect normal seating. In general, the distance between the airbag and the passenger's head is longer in the case of a passenger seated on the relax seat than on the conventional seat, and the risk of injury may also increase for comfortable seating postures as seat belts are generally mounted on the B-pillar. A typical relax seat requires additional safety devices to support the occupant's lower extremities to prevent the occupant from submerging. In this study, the newly developed 'Relax Seat: Passenger Protection Airbag' which works in conjunction with BIS (Belt-in-Seat) and knee airbag, was designed and evaluated. We introduced the Dual-Depth Passenger Airbag newly developed to see how much these airbags and additional safety devices prevent the injury of passengers seated on the relax seat in the event of a frontal crash and to compare the performance with that of conventional airbag devices.

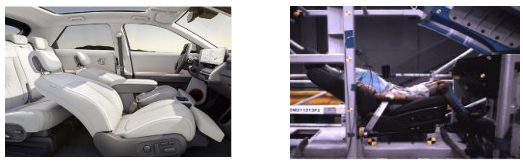

Figure 1 Relax seat and Seat with dummy

METHODS

A series of SLED tests were conducted in accordance with 35 mph US NCAP and 25 mph FMVSS208 scenario. Depending on the conditions, the BIS (Belt In Seat) belt mounted on the seat was used, and Passenger Knee Airbag and seat cushion airbags were also added to restrain the lower body. The angle of the seatback for the normal seat was 21 degrees, and the angle for the relax seat was set to a preset angle of 41 degrees by pressing 'the relax button' on the side of the seat. When passengers sat on the relax seat, the seat position was moved backwards by 100mm to secure enough space for passengers to comfortably stretch their legs, and the head position was also moved backwards by 100mm in the same way. In the case of PAB, existing mass-produced airbags and newly developed variable depth airbags were used. In the case of variable depth airbags, the depth of the cushion can be adjusted by utilizing a tether inside the cushion and a tether release device.

RESULTS

The dummy responses were compared for each of the four situations including sitting, cushion, and unbelted modes.

Case1: Comparison of dummy responses by seat
We checked how serious the risk of injury became when applying the existing mass-produced cushion to the normal seat and relax seat. As shown by the photo, the contact point was delayed, in the case of relax seat, by about 20 ms compared to the normal seat, and the acceleration applied to the head increased, so the head response was about twice as high, requiring early head restraint. In particular, when contacting a cushion in a relaxed-sitting position, the head was lifted and the

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chin was first contacted with the cushion, resulting in a large increase in Fz due to neck response.

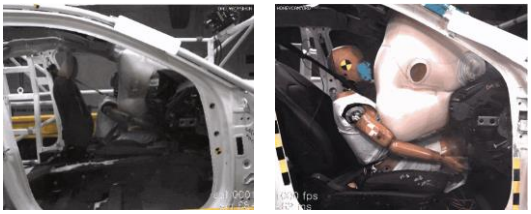

Figure 2 PAB Contact comparison

(Left: Normal seat, Right: Relax seat)

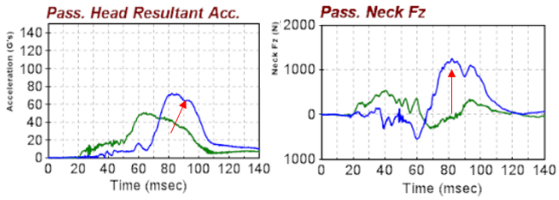

Figure 3 Response comparison

(Green: Normal seat, Blue : Relax seat)

Case2: Validation of modified airbag systems including Dual Depth Cushion PAB : Relax Seat

We checked how much the risk of injury would be prevented when applying the newly developed Dual Depth Cushion to the relax seat. As shown by the photo, when the dual depth cushion is mounted, the tether is released and the dummy head induces early contact with the cushion to prevent an increase in risk of injury. In addition, Seat Cushion Airbag and Passenger Knee Airbag were utilized to support the lower body, preventing the risk of injury more by restraining the head from lifting when the lower body was supported.

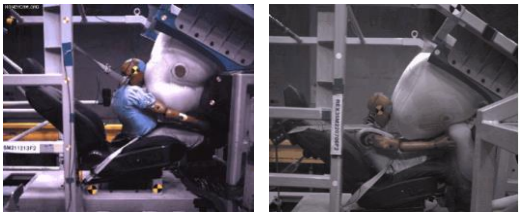

Figure 4 PAB Contact comparison

(Left: Normal cushion, Right: Dual Depth cushion)

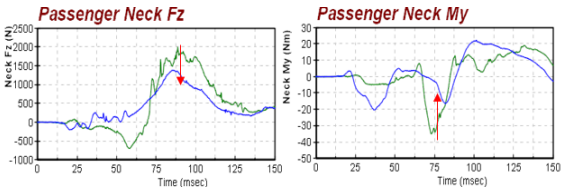

Figure 5 Response comparison

(Left: Normal cushion, Right: Dual Depth cushion)

Case3: Validation of modified airbag systems including Dual Depth Cushion PAB : Normal Seat

We checked whether risk of injury would occur as much as the existing cushion if the tether was not released, in the case of the newly developed Dual Depth Cushion mounted in the same normal seat. As shown by the photo, the tether was holding the cushion, so the cushion depth was the same as the exsiting mass-produced cushion. It meant the time when the dummy contacted the cushion was similar, so the actual dummy response was less serious than the existing cushion.

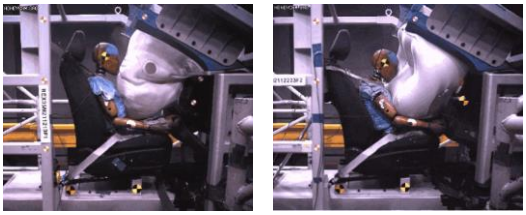

Figure 6 PAB Contact comparison

(Left: Normal cushion, Right: Dual Depth cushion)

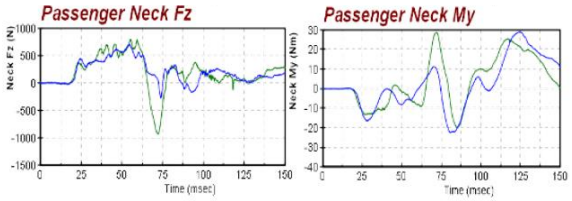

Figure 7 Response comparison

(Left: Normal cushion, Right: Dual Depth cushion)

Case4: Verification of modified airbag systems including Dual Depth Cushion PAB : Unbelted Mode

We checked whether risk of injury would occur as much as the existing cushion if the tether was not released, in the case of the newly developed Dual Depth Cushion mounted in the Unbelted Mode of the same normal seat. As shown by the photo, the tether

was holding the cushion, so the cushion depth is the same as the existing mass-produced cushion, and the timing of the dummy's contact with the cushion was similar, so the dummy response was less serious than the existing cushion.

Figure 8 PAB Contact comparison

(Left: Normal cushion, Right: Dual Depth cushion)

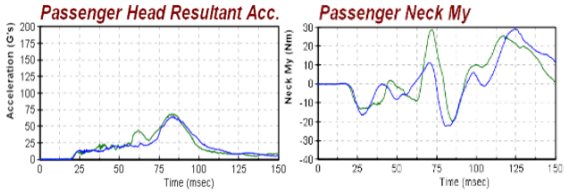

Figure 9 Response comparison

(Left: Normal cushion, Right: Dual Depth cushion)

DISCUSSION

In general, the risk of injuries increase in relax seats rather than normal seats, and when Dual Depth Cushions are mounted, injuries can be prevented compared to existing mass-produced cushions in NCAP mode and legal modes in North America. The conclusion section provides a simple summary of all that was learned or accomplished by the study. The reader must be able to find supporting evidence in the Results section for each conclusion.

CONCLUSION

The study results showed when the existing mass-produced cushion was mounted on the relax seat, the head response increased by 240% and the neck response by 130%. However, when the newly developed dual depth cushion was mounted, head response reduced by 13% and neck response by 13% compared to mass-produced cushions. In addition, when the tether was not released from the dual depth cushion mounted on the normal seat, it was confirmed that head response decreased by 11% and neck response by 21% compared to mass-produced cushions. In the case of unbelted mode, the mass-produced cushion was evaluated with the actual cockpit, and the dual depth cushion was assessed with the steel buck, so direct comparison was difficult. However, in general, given the fact that the risk injuries triggered by the steel buck are generally more serious, it was confirmed that the dual depth cushion had a function that reduced head response by 50% and neck response by equivalent value.

In the future, we will additionally check the LRD performance of the dual depth cushion, which was evaluated in this study, and we will also check the module reliability.

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