

Driver-side i-SRS Airbag System with Continuously Staged Inflation

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ABSTRACT

It is desirable for airbags to provide optimal occupant protection performance for vehicle occupants, who come with a variety of physiques and riding postures, in a variety of collision circumstances, among other variables.

However, in order to enable the bag to be inflated more quickly and to maintain occupant protection performance over a longer period under various circumstances, current driver-side airbag systems necessitate the use of dual stage inflators, occupant position detection systems, and the like, to enable the complex control necessary for the provision of optimal occupant protection performance without increasing the risk of inflation injury upon airbag deployment.

A driver-side airbag with continuously staged inflation was therefore developed using spiral sewing technology that tears at specified pressures together with vent timing control. Featuring a simpler system than that of the existing technology, this airbag is able to provide more tailored occupant protection for a wider range of differing physiques and collision circumstances and appears to do so without increasing inflation injury risks.

1. Introduction

The first Japan-produced driver-side airbag systems were introduced in 1987, and since then our efforts have continued to address the unchanging issue of achieving a high-level balance between providing optimal occupant protection performance while minimizing deployment injury risks when airbags inflate. This effort has yielded a variety of technologies, including the world's first dual stage inflator and occupant position detection system.

Airbag development has taken into account a variety of different occupant physiques and riding postures, types of collision, and other such parameters. In order to cover this variety of circumstances, for example, for shorter drivers, who are typically positioned closer to the steering wheel, it would be ideal in some crashes if the airbag could provide restraint sooner. For occupants whose seats are positioned further from the steering wheel, it would be ideal in some crashes if the occupant protection performance could be sustained over a longer time.

However, in order to enable the airbag to be inflated more quickly and to maintain occupant protection

performance over a longer period, current driver-side airbag systems necessitate the use of dual stage inflators, occupant position detection system, and the like, to enable the complex control necessary for the provision of optimal occupant protection performance without increasing the risk of deployment injury.

The objective of the technology described in this paper is to provide both the capability to have faster inflation and longer occupant protection performance, using a simpler system than that of the existing technology, and to do so without increasing inflation injury risk. For that purpose, driver-side airbags with two new technologies were developed. These were a sewing technology that makes it possible to change volume continuously at specified pressures, and a vent timing control technology that is able to effectively utilize the gas that is generated by the inflator.

This new structure airbag for driver-side use will be introduced here. It is the i-SRS (Supplemental Restraint System) airbag system with the continuously staged inflation.

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2. Continuously Staged Inflation and Vent Timing Control System

2.1. Continuously Staged Inflation Technology

The driver-side airbag with this new structure is shown in Fig. 1. The driver-side airbag with existing technology is shown in Fig. 2.

The driver-side airbag with this new structure allowed two new technologies to be introduced to existing driver-side airbag technology.

The first of these, a continuously-staged inflation technology, was realized through the development of a technology for sewing in a spiral pattern that will tear continuously if the pressure in the airbag reaches or exceeds a specified level.

This performs three functions: It rapidly generates an airbag reaction force, limits the degree of airbag protrusion toward the occupant, and controls the airbag pressure so that it stays within a specified level while also continuously varying the airbag volume.

2.2. Vent Timing Control Technology

The second function is technology for vent timing control to keep from venting the airbag gas until a freely selected amount of time has passed.

Driver-side airbags with existing technology have vent holes that are always open, and gas exhausts through the vents even as the gas is being generated and in response to occupant loading. On the other hand, this driver-side airbag with the new structure performs these two functions: Since it does not vent the gas until the airbag

is nearly at full volume, it more efficiently uses the gas generated by the inflator, extending the time of sustained airbag protective performance, and it allows for use of a reduced output inflator to mitigate the impact force on the occupant.

Figure 3 shows the structure of the vent timing control technology.

A vent hole flap is installed between the panel on the passenger side and the panel on the steering wheel side that make up the airbag. This flap closes the vent valve. By stitching it together with the spiral seams that tear, venting action is achieved by both the internal airbag pressure and volume changes.

2.3. Deployment Process

The Japan New Car Assessment Program (JNCAP) provides a domestic standard for evaluating automobile safety performance in Japan. Figure 4 shows the deployment process and comparison of airbag internal pressure properties of the driver-side airbag with the new structure and that of a single stage driver-side airbag with existing technology. These two airbags received similar ratings for occupant protection performance on the JNCAP frontal collision test using an AM50% dummy (50 percentile adult male dummy). (The inflator is a domestic single-ignition specification product.)

At 17 ms after airbag ignition, the driver-side airbag with the new structure has generated a reaction force [Fig. 4(a)]. At this point, it is not venting gas. However, the driver-side airbag with the existing technology begins to vent gas at the same time the airbag begins to fill. A deployment reaction force is generated at an earlier time in this way in the case of the driver-side airbag with the new structure because the volume is smaller at the time of initial deployment. This effect also reduces the airbag stroke in the thickness direction, thereby reducing the likelihood of interaction with the occupants during inflation. The comparison of the new driver-side airbag and driver-side airbag with existing technology shown in Fig. 5 makes it apparent that the new driver-side airbag can reduce the degree of airbag protrusion toward the occupant.

At 27 ms, when the deployment has proceeded further,

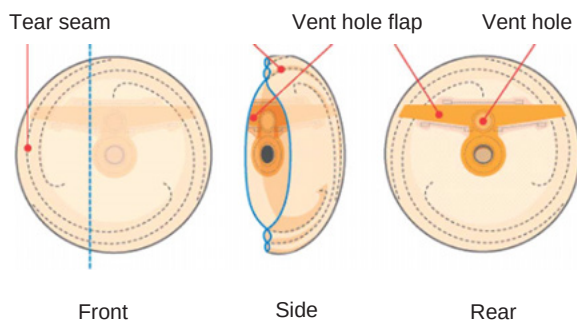


Fig. 1 New airbag structure

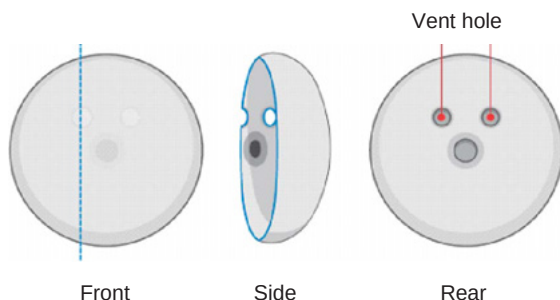


Fig. 2 Existing airbag structure

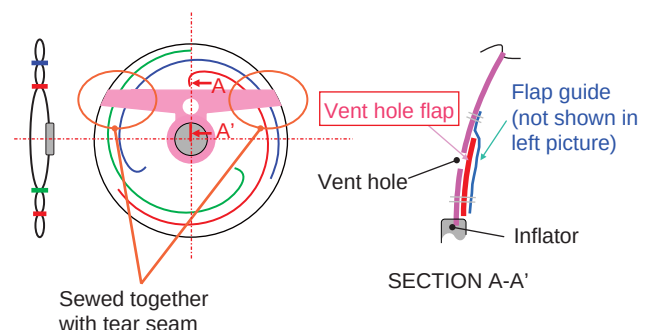


Fig. 3 Structure for control of venting

the airbag with existing technology generates a deployment reaction force [Fig. 4(b)]. When the internal pressure in the new airbag rises to the specified pressure, the spiral seam is torn continuously from inside the airbag, and inflation of the volumetric capacity continues with control applied so that internal pressure will not rise to or above the specified level.

When deployment has proceeded still further, at 40 ms, the internal pressure of the driver-side airbag with existing technology reaches its peak value [Fig. 4(c)]. On the other

hand, in the new driver-side airbag, the vent hole flap is freed and the airbag begins its gas venting operation.

Then, at 50 ms, the vent hole flap is pushed out of the vent valve by the pressure of the airbag, and gas venting takes place [Fig. 4(d)].

The time taken to generate the deployment reaction force with the new driver-side airbag is shown as T_N , while the time taken to generate the deployment reaction force with the driver-side airbag with existing technology is shown as T_E .

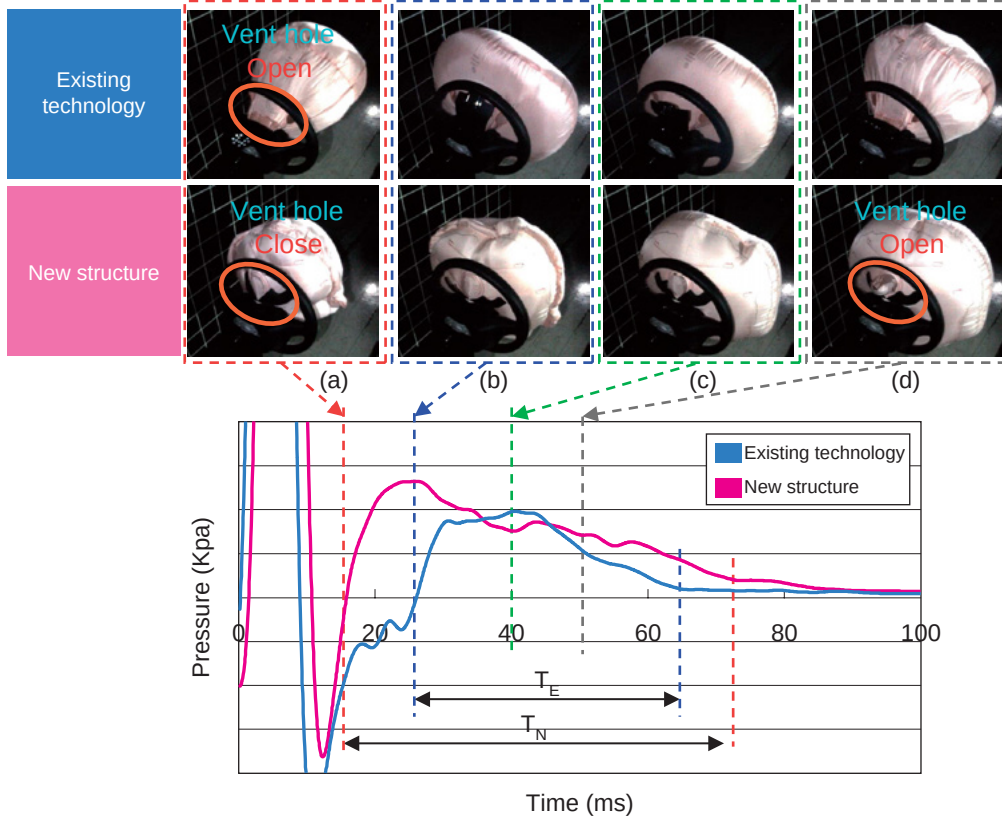


Fig. 4 Airbag pressure time histories: existing technology versus new structure with air bag deployment behaviors

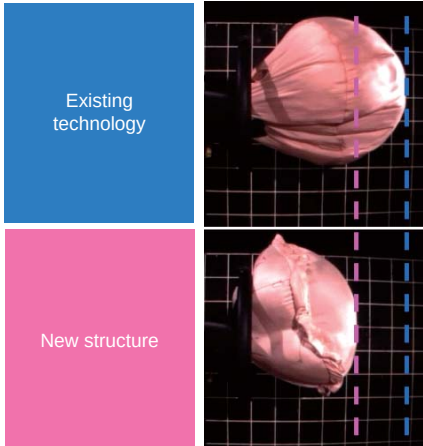


Fig. 5 Air bag shape at initial deployment stage

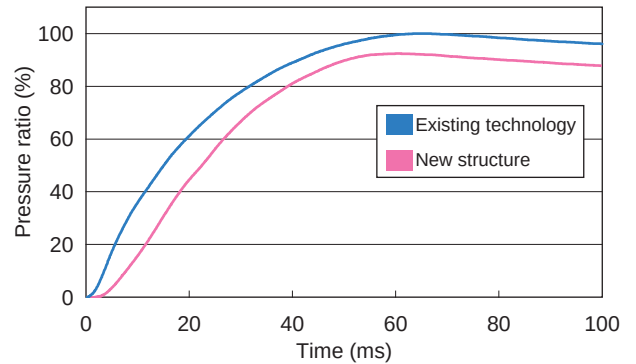


Fig. 6 Tank pressure-ratio time histories

The new driver-side airbag was able to generate a deployment reaction force (internal pressure ≥ 0 kPa) for a period about 1.5 times longer than that of the driver-side airbag with the existing technology.

The inflator output can also be reduced in order to efficiently utilize the gas generated by the inflator.

Figure 6 shows the ratio between the inflator pressure used in the driver-side airbag with the existing technology and the inflator tank pressure in the new driver-side airbag.

3. Performance Evaluation

3.1. Occupant Protection Performance

Figure 7 shows an injury ratio comparison in the JNCAP frontal barrier collision test for the new driver-side airbag and driver-side airbag with existing technology. (The inflator is a domestic single-ignition specification product.) The new driver-side airbag and driver-side airbag with existing technology that have

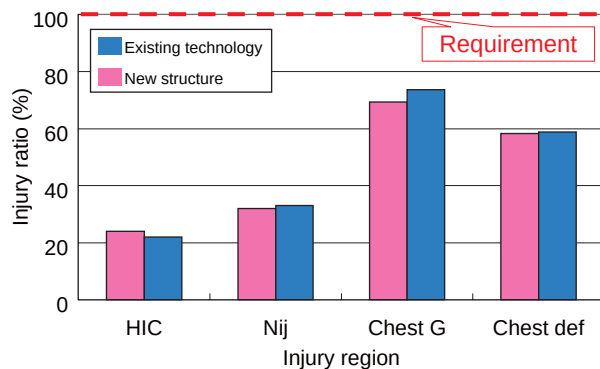


Fig. 7 Comparison of injury ratio of AM50% dummy in various injury measurement regions between existing technology and new structure

equivalent occupant protection performance on the JNCAP frontal barrier collision test were also subjected to the full-wrap frontal barrier collision testing at 55 km/h with the seat adjusted to the farthest forward point and an AF5% dummy (5 percentile adult female dummy) seated wearing a seatbelt. Figure 8 shows the airbag deployment behavior during the occupant protection time history.

This allows confirmation that at 20 ms the new driver-side airbag has taken on a shape that allows generation of airbag deployment reaction force more quickly than the driver-side airbag with existing technology.

Figure 9 shows the injury ratios relative to the driver-side airbag with existing technology for each injury measurement region in the results of this testing. (The inflator is a domestic single-ignition specification product.)

The injury levels were lower in all injury regions than with the single stage driver-side airbag with existing technology. Especially, in the neck region, the injury ratio was about 30% lower.

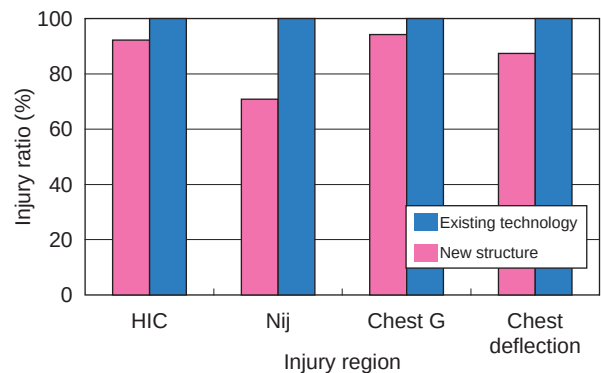


Fig. 9 Comparison of injury ratio of AF5% dummy in various injury measurement regions between existing technology and new structure

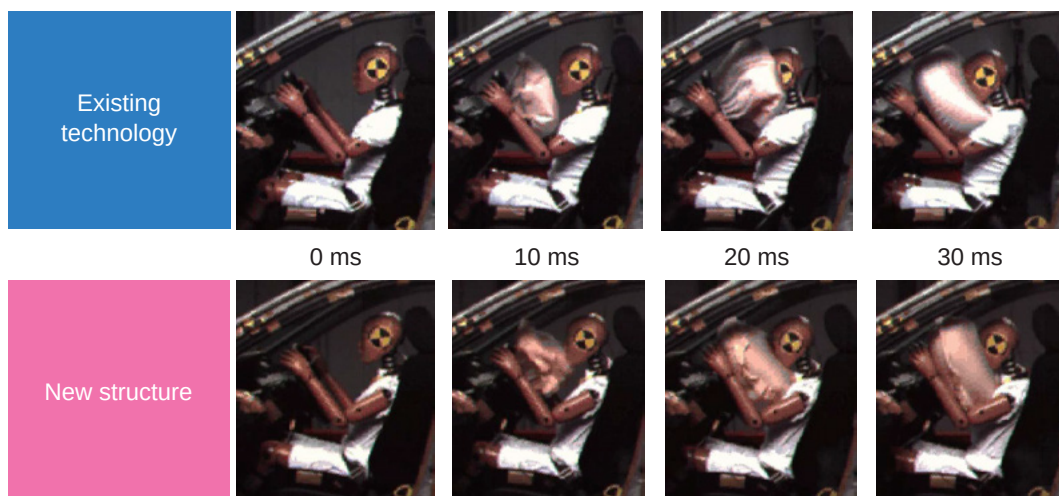


Fig. 8 Comparisons of behavior of air bag and AF5% dummy at frontmost seating position between existing technology and new structure



Fig. 10 AF 5 % dummy set for measuring impact force of air bag

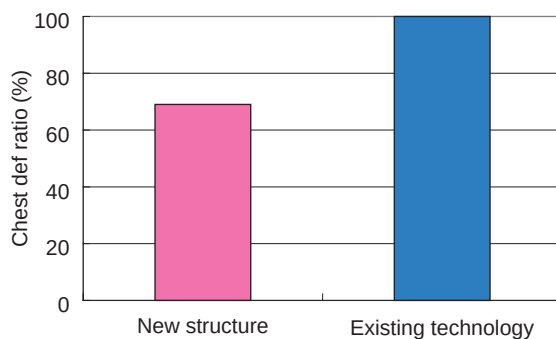


Fig. 11 Chest deflection ratio

4. Conclusion

The following two technologies were developed to enable a driver-side airbag to offer occupant protection performance in response to a wider range of occupant physiques and collision circumstances.

(1) Continuously staged inflation technology

(2) Vent timing control technology

These technologies have enabled a new driver-side airbag that can be deployed more rapidly and can provide occupant protection performance for a longer period of time, without increasing the deployment injury risk.

The aim from this point forward will be to continue to develop this technology, including phenomena that can occur in the real world while achieving a higher level balance between the further enhancement of airbag performance in occupant protection and impact force reduction.

3.2. Reduced Impact

Figure 8 shows that the new driver-side airbag at first fills to a smaller volume and then inflates in a radial pattern. It therefore allows limitation of the degree of airbag protrusion toward the occupant and reduction of the impact force on the occupant. This can be verified at the 20 ms point in Fig. 8.

One method of evaluating the impact force of the airbag is to conduct testing with an AF5% dummy positioned so its chest is in contact with the airbag module. Figure 10 shows a dummy in the position used for this evaluation method, and Fig. 11 compares the chest deflection ratio of the driver-side airbags with the new structure with that of the driver-side airbags with the existing technology.

The new driver-side airbag was able to reduce the inflator output by making more efficient use of the generated gas as shown in Fig. 6. This was able to reduce the impact force on the occupant.

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