ABSTRACT

North America crash regulations established regulations that require airbags mounted in 1994, and began to emphasize the need for a secondary safety device. But over time, the pressure due to the strong airbag fatalities had been occurring. So, airbag supplier and car maker had developed 30% reduction de-powered airbags compared with full-power airbag. But, An adequacy of airbag pressure in infants on the front seat and for unbelted small women had been discussed by NHTSA. Finally NHTSA released the FMVSS208 Advanced airbag regulation for out of position small female driver, unbelted small occupant and infants on the front seat.

To satisfy the Advanced airbag regulations, car makers have applied dual-stage inflator airbag, driver seat track position sensor and occupant detection and classification sensor for passenger. Especially for static deployment fatalities about out-of-positioned driver, dual stage inflator must have been applied to driver airbag.

The research and development method satisfying the FMVSS208 advanced airbag regulation with single stage inflator driver airbag will be discussed in this paper.

This paper does not change the operating strategy applying dual stage inflator in North America and I want expect you to understand the On the other hand the improvement of performance through diverse attempts.

Introduction

The standard for abnormal seating the driver's seat defined by FMVSS208 is moving driver's seat with the middle height to the front-end of the track, and seating a 5% female dummy close to the steering wheel. There are two positions of seating the dummy close to the steering wheel.

Position #1 is chin-on-module positioning the dummy's chin right above the DAB.

Position #2 is chin-on-rim positioning the dummy's chin in the 12 o'clock direction of the steering wheel.
Injuries regulated by FMVSS208 are those on the head, neck, chest and knees. The injury on the head is expressed in the injury value of HIC. The injury on the neck is expressed in Nij and ±Fz. Nij consists of Nte (tension-extension), Ntf (tension-flexion), Nce (compression-extension) and Ncf (compression-flexion), which is an item that evaluates the vertical force and moment on the neck simultaneously. For example, Nte evaluates tension on the neck and the moment (extension) in which the neck bends back. ±Fz refers to the tension and compression applied to the neck directly. Chest injury is expressed in acceleration (Chest Acc.) and deformation (Cd). For knees injury, the load applied to the knees is measured (femur load).

Knees injury amounts to nothing in an actual OOP TEST, with a very low injury value, so it is excluded from the injury values dealt with in this study. You may want to see FMVSS208 for detailed information about injury factors.

**Body**

To satisfy LRD performances using a single stage inflator, the following parts should be considered:

1) Selecting inflator
2) Selecting DAB cover tear line
3) Cushion folding method
4) Position of DAB module in STRG WHL
5) Relationship between the seating position of dummy and vehicle layout

A design meeting the optimum condition for the above is necessary.

1) **INFLATOR SELECTION**

Inflator performances may be represented by pressure, mass flow rate, gas emission amount and gas emission duration.

1) Pressure: raw data acturally measured by tank test
2) Mass flow rate: the pattern can be estimated by the incline of the pressure curve actually measured, and the actual data is drawn out by formula
3) Gas emission amount: mass flow rate integral value
4) Gas emission duration: The time of reaching the peak of the pressure curve or the mass flow rate zero point

The number of moles and temperature among the inflator performances are relative concepts, which cannot be used as comparative data.

The number of moles is affected by the type generated by the inflator and the lighter the molecular weight of gas is emitted, the greater the number of mol may get. In other words, hybrid type that emits gas with a relatively large molecular weight shows much practical gas emissions but the fewer number of moles. Thus, the number of moles is effective only in comparison between inflators in the same series.

**Figure 3. Inflator Performance Correlation**

1-1) **Pressure Properties**

Till now, inflator properties have been defined only by maximum pressure. In this case, it is impossible to express accurate inflator properties. In other words, overall graph pattern and maximum pressure value should be considered simultaneously.
① The final peak pressures of the red graph and the blue graph are the same.

② Compared to the red graph, in the blue graph, the time of inflection point occurrence comes after → The time of mass emission gets longer as much as the delay time of the inflection point.

③ For the blue graph, the increase of additional pressure after the inflection point continues → the additional emission of mass is continuously occurring.

④ The initial incline of the red graph is great → the initial mass amount is great.

⇒ Showing the same peak pressure, but having different gas emission extent.

⇒ In other words, pressure value cannot represent the entire properties of the inflator.

1-2) MASS FLOW RATE

Mass flow rate can be estimated in the differential form of the pressure graph from the actual measurement, and mass flow rate peak time can be checked by the inflection point of the initial pressure curve while mass flow rate duration time by the time of reaching the pressure maximum.
1-3) Gas Emission
Gas emission is a value of integrating mass flow rate.

\[
\text{Total Mass} = \int m \, dt
\]

1-4) Number of Moles
Mole is a kind of unit (in other words, it is not a physical phenomenon but weights and measures artificially made by chemists).

\[
\text{TOTAL Mole} = \sum \left( \frac{\text{TOTAL Gas Quantity} \times \text{PORTION Gas component } j}{\text{WEIGHT CORRESPONDING GAS}} \right) \frac{1}{\text{GAS MOLECULAR WEIGHT}}
\]

For inflators in the same series, relative comparison is possible, but for each different series, the molecular weight of gas emitted are different, so it does not have a meaning.

<table>
<thead>
<tr>
<th>GAS</th>
<th>CONTENT</th>
<th>ACTUAL EMISSION</th>
<th>Molecular weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2O</td>
<td>37.34%</td>
<td>11.2</td>
<td>18</td>
</tr>
<tr>
<td>N2</td>
<td>35.64%</td>
<td>10.7</td>
<td>28</td>
</tr>
<tr>
<td>CO2</td>
<td>26.88%</td>
<td>8.1</td>
<td>44</td>
</tr>
</tbody>
</table>

Table1. Example of Calculation of the Number of Moles by Type

1-5) Molar Fraction Curve
Applying a graph of the changes of gas generation composition ratio by time as interpretation input data can obtain a very powerful result.

Fig.8 Molar Fraction Curve

1-6) Definition of Inflator Performance
Considering the inflator performance properties examined in Chapter 2, the inflator properties defined with existing maximum pressure only are subdivided into the below five properties.
1) Maximum pressure
2) Mass flow rate
3) Gas generation duration time
4) Maximum gas generation time
5) Gas emissions

Figure9. inflator performance definition
1-7) Correlation between Inflator and Collision Performance

To analyze injuries by existing mass produced vehicles, the worst injury is Nte in neck injuries, and to examine the correlation between the worst injury and inflator performance, for mass flow peak 1g/sec↑, the neck FZ injury increases at the latter part, and accordingly, Nte occurs in 25 ~ 35ms, and some target injury performance (within 70% of the regulations) is not satisfactory.

For mass flow peak 1g/sec↓, Nte occurs around 10ms, and it all satisfies the goal.

Figure 10. Position 1 Nte (by inflator properties)

In other words, regardless of the final pressure, it is linked to the size of mass flow rate, and if mass flow rate peak is over 1.0, in the latter part (25 ~ 35ms), as Nte reaches the maximum with the tensil force and the resulting action of moment, some models do not satisfy the goal, and if mass flow rate peak is below 1.0, in the initial part (before 10ms), it reaches the peak of the tensile force and Nte reaches the maximum, but both show a satisfactory level.

To analyze injuries by existing mass produced vehicles, the worst injuries are CHEST d and CHEST g injuries, and to examine the correlation between the worst injury and the inflator performance, the time of mass flow rate peak and the time of chest injury peak tend to be consistent. At this time, if mass flow peak is 1g/sec↑, chest injury rapidly increases, and accordingly, the target injury performance (within 70% of regulations) is not satisfactory.

For mass flow peak 1g/sec↓, all chest injuries satisfy the goal.

Figure 11. Position 2 Chest g (by inflator properties)
In other words, regardless of the final pressure, it is linked to the time of reaching the peak of mass flow rate and its amount, and when mass flow rate peak is over 1.0 and reaches within 10ms, chest injury does not satisfy the goal, and if mass flow rate peak is below 1.0 and the time of reaching the peak is around 10~15ms, all chest injuries satisfy the goal.

That is, the inflator properties requested through analysis on LRD performance are as follows:

<table>
<thead>
<tr>
<th>구분</th>
<th>Primary</th>
</tr>
</thead>
<tbody>
<tr>
<td>최대 Mass flow rate</td>
<td>1.0g/s ↓</td>
</tr>
<tr>
<td>Mass peak 시간</td>
<td>10 ~ 15ms</td>
</tr>
</tbody>
</table>

*Table2. Requirements for inflator*

**DAB Tear Line Selection**

DAB cover pattern can be designed in various specifications, but for LRD performance, it is most advantageous to decide the specifications in which the additional reaction applied to the cushion after unfolding is minimized.

*Figure13. tear line pattern*

**Cushion Folding Method**

The difference of the cushion shape in unfolding because of the cushion folding is very clear. To optimize LRD performance, it is advantageous to unfold it in a radial unfolding method by which the punch-out force applied to the dummy in unfolding decreases.

*Figure14. test result according to folding pattern*

**Mounting Location of DAB Module**

The degree of position of DAB module on STRG WHL, also, may greatly affect LRD performance. When DAB unfolds, to make DAB cover pass over the visible space at the top of STRG WHL, it is good to be positioned downward if possible, and in terms of chest injury value, it is good for DAB module to be positioned below the plane of STRG WHL REFERENCE.
Distance between the bottom of the Sun Visor and the center of STRG WHL

In LRD unfolding, the dummy flies to the sheet because of the reaction of DAB cushion, and at this time, if the space from the sun visor is narrow, the back of the head directly contacts the sun visor, which may adversely affect the head injury, sufficient space should be secured.

Conclusions

1) DAB applying a Single Stage Inflator that meets North American LRD performance may be overcome only by the detailed analysis on the element design technology of each component part and sufficient understanding about the vehicle layout.

2) Our company is working on the mass production of two models based on the details mentioned in the body.

3) We ask you for understanding about the parts about which we may not present guide figures of each item except inflator since they are our company's know-how.

Reference list