Study on Stiffness Characteristics of Driver Airbag Cover under Simulated Finger Pressing

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Abstract. The cover of driver airbag should not only satisfy the performance request of deployment, but also satisfy the sufficient stiffness while pressing on the horn. However, the stiffness of the cover is only evaluated by subjective pressure at present, and there is no quantitative test and data description. Through the subjective pressure evaluation and stiffness test of the driver airbag and other different models of the driver’s airbag cover, the assumption of the stiffness of the cover was obtained, and then the stiffener was used to increase the stiffness of the cover. The subjective press evaluation and the stiffness test were carried out, and the verification hypothesis was established, and the test method of the cover stiffness and the quantitative description method were obtained.

1. Introduction
Airbags is the supplement Restraint System (SRS), usually it is the supplement for the safety belts, which can reduce the injury of occupants in the collision. With the growing of automobiles in China, the installation rate and use of airbags are increasing year by year. At present, the Driver Airbag (DAB) has gradually become one of the indispensable parts of the automobile. Driver airbag is mounted inside the steering wheel. When the vehicle get a collision which is higher than the threshold value, the airbag can quickly produce a large amount of gas and inflate to form a certain shape of airbag, which can provide auxiliary protection for the driver in the collision. The surface of the driver's airbag is generally covered with plastic cover. The plastic cover needs to meet the requirements of not breaking and splashing when the airbag deploys. Now thermoplastic elastomer is the main material used for the driver airbag cover. Thermoplastic elastomers used as airbag cover mainly include polyolefin blend thermoplastic elastomer (TPO, TPV), polyurethane thermoplastic elastomer (TPU), polyester thermoplastic elastomer (TPEE) [1].

At the same time, the driver's airbag is also the carrier of the horn. By pressing the driver's airbag, it leads the horn loop and honks the horn. Therefore, it is necessary to meet the requirements of sufficient stiffness when pressing the horn without collapse. The stiffness of thermoplastic elastomer directly affects the comfort of pressing the horn. The problem is collapse of the cover at 6 o’clock when pressing on the horn. However, as it is subjective evaluation, it varies from person to person and cannot be quantitatively described. In this paper, we will discuss the establishment of simulated finger pressure test, study on the force-displacement relationship of the cover through the simulated finger pressure test, put forward the method to quantitatively describe the stiffness of the cover, and give the solution proposal of the cover collapse problem.
2. Stiffness test
The key to quantitatively describe the force-displacement relationship of the cover is the constantly recording between the force and the deformation. However, the force value recording is difficult, because the finger pressing cannot quantitatively record the force data, so we consider to use the simulated finger which installed on the force loading equipment, so we can read the force data constantly. The stiffness test method of cover come out after comprehensive consideration.

2.1. Test method
Test conditions: room temperature (23℃).
Test equipment:
(1) Load apparatus, as shown in Figure 1.

![Figure 1. The picture of load apparatus](image1)

(2) Analogue finger: the diameter is 19mm and there is a hemispherical head. As shown in Figure 2.

![Figure 2. The drawing of analogue finger](image2)

Parameters of analogue finger:
① length =83mm
② R=9.5mm
③ screw thread 5/8-11, deep =16mm
(3) Displacement inspection apparatus.
Test procedure:
(1) All samples are placed at room temperature 23℃.
(2) make the analogue finger and load apparatus perpendicular to the test point of the sample cover.
(3) Load a force of 80±2N to inspect the displacement of the test point of the cover.
(4) Visually check the deformation of the cover plate and the computer records displacement data.
2.1.1. Test samples. We select the driver airbag of 8 different brands and 2 models (Model 1 and Model 2) with collapse problem when pressing the 6 o'clock direction. A total of 10 models were tested for cover stiffness, and the materials of the 10 covers were all thermoplastic elastomers.

According to different styling of covers of 10 models, the amount of covers stretching out at 6 o'clock is different. In order to simulate the normal action of pressing the horn, the central point with the amount of cover stretching out from 2/3 of the wall is uniformly selected to verify the stiffness and deformation, as shown in Figure 3.

![Figure 3. The illustration of cover protruded](image)

Test samples illustrate in the table 1

| Models   | Material | the distance of cover stretching out at 6 o'clock | Subjective assessment |
|----------|----------|--------------------------------------------------|-----------------------|
| Model 1  | TPO      | 38mm                                             | Collapse              |
| Mode 2   | TPO      | 31mm                                             | Collapse              |
| Model 3  | TPO      | 31mm                                             | No collapsing         |
| Model 4  | TPO      | 37mm                                             | No collapsing         |
| Model 5  | TPU      | 45mm                                             | No collapsing         |
| Model 6  | TPO      | 38mm                                             | No collapsing         |
| Model 7  | TPO      | 51mm                                             | No collapsing         |
| Model 8  | TPU      | 25mm                                             | No collapsing         |
| Model 10 | TPU      | 46mm                                             | No collapsing         |

2.2. Test data

Test data is shown in the table 2 and figure 4.

| Models   | Load (N) | Displacement (mm) | Performance    |
|----------|----------|-------------------|----------------|
| Model1   | 65       | 11                | Bending, no function |
| Model2   | 80       | 3.5               | Bending        |
| Model3   | 80       | 2.6               | No bending     |
| Model4   | 80       | 2.5               | No bending     |
| Model5   | 80       | 1.8               | No bending     |
| Model6   | 80       | 1.7               | No bending     |
| Model7   | 80       | 2.7               | No bending     |
| Model8   | 80       | 1.5               | No bending     |
| Model10  | 80       | 1.2               | No bending     |
2.3. Test data discussion
Model 1 the amount displacement is 11mm which far exceeded the others when the load is only 65N, and the cover has no function at all.

Model 2 the amount displacement is 3.5mm when the load is 80N, the cover has a little bending, but the function is OK.

From Model3 to Model10, the amount displacement is 1.2mm—2.7mm when the load is 80N, the average of displacement is 2.015mm. As shown in figure 5.

When the load is greater than 100N, some models have bending phenomenon, and considering that actual force which can be applied by human pressing the horn will not exceed 80N, so 80N is determined as the maximum load in the simulated finger test.

Based on the above, we assume that the driver airbag cover will not collapse when the deformation of the cover is less than 3mm when the load is 80N where is in the direction of 6 o’clock.

3. Proposal of improving the cover stiffness
According to the cover stiffness assumption, we carried out a stiffness lifting design for the Model 1 driver airbag cover. There are two proposal of improving stiffness:

(1) change the cover material from soft to harder material;

(2) keep the cover material same, but increase bars in the structure to reinforce the cover;

Based on the requirements of airbag initiation, the cover cannot be broken or splashed when it deployed. At present, only thermoplastic elastomer is suitable for the airbag cover, and other plastics (such as: PP, PVC, etc.) cannot meet the requirements of airbag deployment. Therefore, the proposal 1
which change the material of cover is not good. Only proposal 2 can be realized directly from mold modification, which is to add bars into the 6 o'clock direction of the cover. This is shown in Figure 6.

![Figure 6. The difference between no-strengthen (L) and improving (R)](image)

The improving cover was assessed by subjective evaluation, the assessment results are shown in Table 3.

| Model          | Material | the distance of covers stretching out at 6 o'clock | Subjective assessment |
|----------------|----------|--------------------------------------------------|-----------------------|
| Model 1 before | TPO      | 38mm                                             | Collapsing            |
| Model 1 after  | TPO      | 38mm                                             | No collapsing         |

### 4. Verification of simulated finger test

The improving cover was assessed by simulated finger test, the assessment results are shown in Table 4.

| Model          | Load (N) | Movement (mm) | Performance          |
|----------------|----------|---------------|----------------------|
| Model 1 before | 70       | 11            | Bending, no function |
| Model 1 after  | 80       | 2.02          | No collapsing        |

Test data is shown in figure 7.

![Figure 7. The difference between no-strengthen (orange) and improving (purple)](image)

According to comparison of subjective pressing evaluation and simulated finger test results, it can be concluded that:

1. The increase of stiffeners has a significant effect on the improving of cover stiffness
2. Assume that the deformation of the driver airbag cover is less than 3mm when the 80N load is on the driver airbag cover 6 o'clock direction, this assumption can quantitatively describe the subjective press evaluation which the driver's airbag cover will not collapse
5. Conclusion
In this paper, we carried out the subjective pressing assessment and simulated finger test between the collapsing driver airbag cover and other different Model covers, draw an assumption that a quantitative description for cover stiffness. Subjective pressing evaluation and simulated finger test were carried out on the added bars into the structure of cover which is to improving the stiffness of the collapsed cover, verified the validity of the assumption.

We can quantitatively describe the subjective pressing evaluation whether the driver airbag cover is soft and collapsing by the deformation of the driver airbag cover when the stiffness in the 6 o’clock direction is applied to load 80N. If the deformation is less than 3mm when 80N is applied, we can sure that the driver's airbag cover can meet the requirements of subjective pressing.

References
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