Study on abnormal noise of leather of car shift mask based on FAT

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Abstract—Shift cover problem is one of the hot issues of car interior trim. Based on the theory of fault tree analysis, a fault tree model of a family car was established, and various influencing factors were analyzed in detail. By optimizing the leather production process, the NVH performance of the whole vehicle is improved, which provides a reference basis for solving similar problems in engineering.

1. INTRODUCTION
With the increase of car parc year by year, people pay more and more attention to the feeling of "humanized design" of the car, and the performance requirements of the vehicle NVH are also getting higher and higher[1,2]. The noise of automobile interior decoration is one of the focus of increasing attention[3]. For a certain family car in the actual use process, the "squeaking" abnormal sound caused by the shift shield (as shown in Figure 1.) : the abnormal sound is most obvious when shifting between D/N gears. When the real car is confirmed, the abnormal sound is caused by the extrusion friction of the leather surface in the red circle. In this paper, based on the fault tree analysis (FTA) theory[4-6], a systematic fault tree model is established, and various influencing factors are analyzed in detail.

2. ANALYSIS
The fault tree analysis (FTA) in the quality management tool was used to make a multi-level detailed analysis of the possible causes of abnormal sound in leather. The fault tree analysis was shown in FIG.

FIG. 1 Abnormal leather sound
According to FTA, carry out special analysis on each factor, find out the key influencing factors and solve them.

1) Leather materials

At present, the shift cover is mainly made of PVC, PU and genuine leather. PVC is currently used by some Japanese cars and some independent brands (JAC), and PU is used by American and German brands as well as most independent brands (Geely and Chery). Leather is mainly used in the top grade car cover and handball surface skin. The material distinction of PVC and PU is shown in Table 1 below:

| Leather   | Process | Thickness, embossed         | Material | Base cloth                  | Treating agent                        |
|-----------|---------|-----------------------------|----------|----------------------------|---------------------------------------|
| PVC       | rolling | Die clearance control thickness, roller embossing | PVC + plasticizer + base cloth | Thin, leather physical properties are determined by PVC | Individual process coating            |
| PU        | coating |                                                            |          |                            |                                       |

The leather cover of the model of the joint venture brand/independent brand was investigated. The sound of PU material was almost the same, while the sound of PVC material was abnormal for some models. The cost of PU is twice that of PVC. The protective leather material studied in this paper is PVC.

2) Production process

Calendering process is used for PVC leather and coating process is used for PU leather. The process comparison is shown in Table 2. Leather processing process needs to add a variety of different treatment agents (including brightener, anti-abnormal sound agent, etc.), to improve the performance of leather.
In the process of PU production, leather primer is directly added into PU slurry without separate application process (refer to Geely, Chery, Volkswagen, etc.), as shown in Figure 3:

![PU production process flow](image)

**Figure 3 PU production process flow**

Common PVC production process Leather is provided with solvent-based and water-based treatment agents. Different treatment agents require different production processes, namely, post-treatment process + solvent-based treatment agent and pre-treatment process + water-based treatment agent. Post-treatment process: Apply solvent-based surface treatment agent to leather products; Pretreatment process: Apply water-based surface treatment agent before heating knurling, as shown in FIG 4:

![PVC production process](image)

**FIG.4 PVC production process**

Water-based treating agent is more wear-resistant and environmentally friendly than solvent treating agent (water-based treating agent is slightly more expensive than solvent treating agent). The
pretreatment process is to apply the treating agent before knurling after the leather is heated. The treating agent will penetrate into the leather more fully and have better wear resistance.

The post-treatment process + solvent-treating agent used in the shield leather studied in this paper has some problems, such as insufficient application of solvent-treating agent on the surface and failure of anti-abnormal sound function.

(3) Leather texture
Leather texture contrast is shown in Figure 5:

![Leather texture contrast](image1)

FIG. 5 Leather texture contrast

Compared with the coarse and fine grain texture, the friction abnormal sound appears after wiping with wet cloth, and the texture has little influence on the abnormal sound. The leather in this paper is fine grain texture.

(4) Shape and size of shield frame
Comparison of the shape of the cover frame of different car types is shown in Figure 6:

![Comparison of shield frame shapes](image2)

FIG. 6 Comparison of shield frame shapes

Compared with the shape figure 6 of the benchmarking car cover frame, the leather cover frame should be as square as possible to avoid the appearance of the sharp Angle inner frame of the cover in
this paper, which causes the leather to appear double convex in this area, reducing the appearance of mutual extrusion and friction on the cover surface, so as to avoid the occurrence of abnormal sound.

Table 3 Clearance between shifter bar and cover frame

| Specifications(mm) | L  | TAYRON | lavida | this project |
|--------------------|----|--------|--------|--------------|
| panel              | 160| 180    | 120    | 135          |
| W                  | 100| 110    | 60     | 75           |
| Minimum clearance between joystick and cover frame(mm) | Front | 16 | 50 | 20 | 10 |
|                   | back | 18 | 30 | 17 | 8 |
|                   | left | 18 | 20 | 18 | 15 |
|                   | right| 18 | 20 | 16 | 13 |

See Table 3 for the gap between the gear shift bar and the cover frame of the benchmarking car. In this paper, the gap between the gear shift bar and the cover frame is obviously small, which is easy to cause leather folds.

(5) Number and position of leather stitches
The comparison of stitch number and position of different molded leather is shown in Figure 7:

FIG. 7 Comparison of guard stitches

The comparison of benchmark models is shown in Figure 7. The number and position of stitching lines mainly depend on the shape and modeling requirements of the shield frame. It is not found that the number and position of stitching lines have an impact on abnormal sound.

3. IMPROVED VERIFICATION
As the model in this paper is a mass-produced model in the market, considering the factors such as
shape and unchangeable cost, it is preferred to optimize the processing technology of leather to solve the problem of abnormal sound. The main optimization measure is the use of water-based treatment agent + pretreatment process, as shown in Figure 8. After verification by test, the optimized leather has no difference.

FIG. 8 Flow chart of optimized production process

4. CONCLUSION
In this paper, a fault tree analysis model of the system was established based on the abnormal sound of the shifting cover of a family car. Various influencing factors were analyzed in detail and an optimization scheme was formulated to improve the VEHICLE’S NVH performance. The following conclusions were drawn:

(1) Through in-depth analysis of leather materials, production technology, texture modeling, etc., the optimization scheme was determined.

(2) After the improvement, the leather abnormal sound problem was solved, and the NVH performance of the car was improved.

ACKNOWLEDGMENTS
The project was supported from the Intelligent Robot Research Team of Anhui Xinhua University (NO: kytd201903), Natural Science Fund of Anhui Xinhua University (grant NO. 2018zr013), and Natural Science Fund of Education Department of Anhui province (Grant No.KJ2018A0591, KJ2018A0592).

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