Development of the Instrument Panel Design Method Adaptable to Multiple Manufacturing Processes for the New X-TRAIL

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Abstract

Instrument panels to be installed in New X-TRAIL, a globally produced model (called ROGUE in North America and QASHQAI in Europe), are being produced at multiple bases including new plants. Since these plants have different equipment, skins of the instrument panels will be produced by both of these two methods: negative vacuum forming with dedicated equipment at existing plants and injection molding with general machines at new plants (“injection molding skin manufacturing”). This paper describes development of the instrument panel that can meet two types of production requirements for skin manufacturing, which can lead to reduction in equipment investment and streamlining of the development activities.

Key Words: Instrument panel, Skin, Negative vacuum forming, Injection molding

1. Introduction

In the middle of current emphases on globalization, efficient investment control and development, one of the recent examples of such effort is New X-TRAIL shown in Fig. 1. In the Nissan’s product lineup, this model is considered to be a typical example in the perspective of globalization. Its production was initially started in North America, and that of Japan, China, EU, and Russia have been followed (Fig. 2). Needless to mention, the sales deployment is also on a global basis, yet the cockpit module (“CPM”) should be identical in design for all markets. Besides such standard components as meter, audio, A/C panel, glove box and ventilator, instrument panel is the most substantial part.

The instrument panel is a soft instrument panel, which consists of a urethane foam layer covered with skin on top of a plastic core layer.

As for the selection of manufacturing method, in the existing plants, the negative vacuum forming method used also for the previous models’ production was inherited as the skin manufacturing method in view of the equipment investment efficiency. On the other hand, in newly set up plants, the world’s first molding method with versatile injection molding machines, was adopted instead of just introducing the same conventional method. The challenge is then to develop an instrument panel which meets both of the two types of manufacturing requirements in order to control the total investment and to maintain the development efficiency at the same time.

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2. The Soft Instrument Panel Structure

The soft instrument panel is structured with three layers; a core plastic, urethane foam and skin layers (Fig. 3).

Fig. 3 Structure of instrument panel

As mentioned above, two kinds of manufacturing methods are selected for molding the most upper skin layer. Details of these two, the negative vacuum forming and the injection molding methods.

2.1. The Negative Vacuum Forming Method

The process of the forming by this method is shown in Fig. 4.

(1) Soften the skin sheet with heat.
(2) Set the heated skin sheet in between the Plug and the Cavity.
(3) Close the Plug and the Cavity.
(4) Evacuate the in-Cavity space to mold and transfer the grain pattern.

Skin forming is completed through the above steps.

Fig. 4 Process of negative vacuum forming

2.2 Injection Molding Method

Fig. 5 shows the process of the injection molding method.

(1) Slide the Core to close the metal mold.
(2) Inject thermoplastic resin to mold.
(3) Open the metal molds to demold the remaining workpiece out of the Cavity.

In this method the high versatile injection molding machine can be used for the skin manufacturing.

3. The Difference in the Production Requirements

As described in 2.1, the negative vacuum forming method has restriction of skin elongation, whereas the injection molding method has constraint regarding die direction. There are technical issues to be met for both of the production requirements.

(1) Undercut portion configuration
(2) Minimum corner radius
(3) Ease of demolding
(4) Die direction

The both methods are compared on the restrictions with each item above to clarify which method has stricter condition, thus to be reflected to the design configuration.

Each requirement is shown below.

3.1 Undercut Portion Configuration

Undercut portion configuration is shown in Fig. 6. This part cannot be pulled out by simply sliding the Core in
the die opening direction. In the process of the injection molding method, an additional Slide structure with the metal mold is necessary for forming the undercut portion.

**Fig. 6 Movement of injection mold**

This technical issue of both methods, that the molding product cannot be demolded from the metal mold without a Slide structure, could basically be avoided if the molding product is relatively soft. However, the further research clarifies the following restrictions in each method.

In the negative vacuum forming method shown in Fig. 7, the height (H), depth (D) and angle (θ) have to be controlled to suppress local elongation of the skin at the undercut portion. In the injection molding method shown in Fig. 8, although the undercut portion should be relatively thicker, the dimension (T) has certain limit to curb the shrinkage issue.

Consequently the restriction is determined by (H), (D), (θ) and (T), but the injection molding method with stricter condition is selected because the tolerance of (T) is relatively smaller than (D).

### 3.2 Minimum corner radius

As a requirement of the injection molding method, the minimum corner radius is generally set to 1 mm.

On the other hand the radius for the general configuration of the negative vacuum forming is 1.5 mm. It may, however, need even larger radius in the case of U-shaped cross-sectional configuration shown in Fig. 9 since the radius R is also determined by the ratio of depth (D): width (W) in view of the skin elongation. Thus the negative vacuum forming with stricter condition was selected.

### 3.3 Ease of demolding

After molding, the skin should be demold smoothly. As shown in Fig. 10, the molding should be designed that the undercut portion against the die direction, which is shown in terms of length (L) and angle (θ), should come within the OK area.

Comparing the negative vacuum forming and the injection molding methods, in the latter case, the OK area is narrower than that of the negative vacuum forming method since the undercut portion is thicker. Thus, the injection molding method with stricter condition was selected.
3.4 Die direction

As shown in Fig. 11, the die direction for the injection molded skin is determined based on the undercut amount restriction.

On the other hand, the die direction of the negative vacuum forming method has restrictions by the skin elongation ratio, so the length (L) along the surface against the width (W) should be set within the OK area as shown in Fig. 12.

Accordingly respective die-direction for each method can be determined.

4. The Challenge for the Solution

The above mentioned manufacturing requirements have then been reflected to the design. As a concrete examples of 3.1, the configuration of the undercut portion at the mating surface between the instrument panel side and the door, shown in Fig. 13, is introduced as below.

In the initial design, the undercut surface angle (θ) and depth (D) met the requirements of the negative vacuum forming method shown in Fig. 14. In the case of the injection molding method, however, the thick portion (T) of the undercut portion could not satisfy its requirement.

Thus, the requirements of injection molding methods with stricter condition needed to be applied, and the configuration was modified to thinner one as shown in Fig. 15.

The subsequent studies from 3.2 to 3.4 have been ap-
plied to conduct the design feedbacks that satisfy both methods' restrictions. Consequently we have realized the skin manufacturing production in the global plants with different production facilities.

5. Closing Remarks

In the global model production, the challenge is to make effective use of the existing plants to optimize equipment investment in view of the total cost delivery. In order to address the challenge of the global model production, we have established a design method, enabling us to select the best skin manufacturing method for each region plant. Furthermore, we have also realized the development efficiency by unifying the design configurations that can enable identical fitting structures between the instrument panel and the peripheral parts.

References

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