

Development of Plastic Extra Window

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ABSTRACT

A large, extra window made of plastic with a complex 3-dimensional shape has been developed for use on the 2006 European CIVIC. The extra window was produced by a double-injection process using transparent and black resins and fixed to the tailgate panel with urethane adhesive. To ensure scratch resistance, the full outer and transparent inner surfaces of the extra window have a hard coating. The hard coating with the best weathering resistance was chosen from among polysiloxane hard coatings with good scratch resistance. Using an automated flow coat process to apply the hard coat mean the hard coat film thickness could be controlled within the appropriate range, ensuring superior durability of the coating. The new window provides the driver with an enhanced rear view and gives the car a whole new look.

1. Introduction

Conventionally, inorganic glass has been used for automotive windows. Compared to other materials used for exterior parts, such as steel plate, aluminum sheeting and plastic, there is less freedom in shaping and machining inorganic glass, so window design has been more limited than that of other exterior parts.

Recently, however, there has been more research into and development of alternative materials⁽¹⁾ that can be used in more complex window designs, and the application of these alternative materials to quarter windows and tailgate windows has begun^{(2), (3)}.

One design feature of the new European CIVIC is a tailgate spoiler located high on the tailgate that includes an integrated “extra window.” Figure 1 shows the extra window in the new European CIVIC. This window is large, with a complex 3-dimensional shape, and the transparent panel built into the extra window provides the driver with enhanced rear visibility.

This paper introduces the technologies involved in the plastic extra window that has been adopted in the new 2006 European CIVIC.



Fig. 1 Rear view of the new European CIVIC

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2. Basic Structure of the Extra Window

Figure 2 shows the shape of the extra window. The transparent panel is deeply curved, and there is no dividing line between the transparent panel and the spoiler.

Figure 3 shows the inside structure of the extra window. In attaching the extra window to the tailgate panel, urethane adhesive is applied around the entire edge to ensure a water tight seal. The inside of the extra window has clips that provide temporary support until the adhesive cures, and a high mount brake light must also be attached to the inside of the extra window.

To achieve this design and inside structure with the fewest number of parts, the extra window is formed using transparent and black plastics and a double injection process to create an integrated extra window. Specifically, after injection molding the entire extra window using transparent plastic, black plastic is used for injection molding at designated locations on the inside. The black plastic on the inside gives the appearance of black ceramic around the periphery of the transparent panel, and at the same time contributes to an overall increase in rigidity of the extra window.

Ordinarily, the scratch resistance of alternative materials is much lower than that of inorganic glass. Therefore, a hard coat was applied to the entire external surface, which must be scratch-resistant because of its exposure, and to the inside surface of the transparent panel.

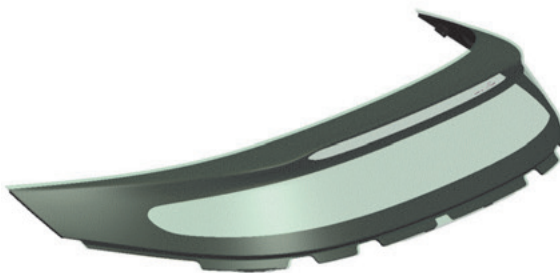


Fig. 2 Shape of extra window

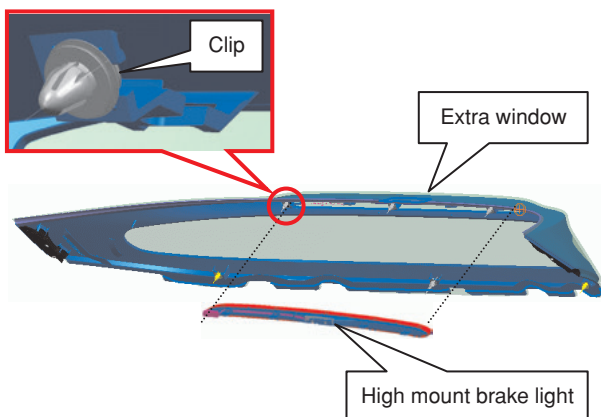


Fig. 3 Inside structure of extra window

3. Selection of Plastic Materials

A polycarbonate with advanced transparency and thermal stability was used for the transparent plastic. The transparent plastic was tinted green to match the colour of the rear window.

To prevent delamination of the black and transparent plastics after the double injection process, it was necessary to select a black plastic similar in type to the transparent plastic. In addition, to ensure the adhesiveness of the urethane adhesive, it was necessary to apply a solvent primer for plastics to the black plastic's adhesive surface. Therefore, a polycarbonate alloy was selected for the black plastic, providing chemical resistance superior to that of polycarbonate alone.

To confirm adhesion when the urethane adhesive was used with the black plastic, a shear adhesive test was performed. The results confirmed that the urethane adhesive had cohesive failure across the adhesive surface, and that there was sufficient adhesion. It was also confirmed that there were no plastic primer application irregularities caused by dissolution of the black plastic surface.

4. Selection of the Hard Coat Material

To qualify as providing enhanced rear visibility, the extra window's transparent panel must satisfy the abrasion resistance test stipulated in European regulations (ECE 43) on automotive safety glass material. To do this, the material had to have even higher scratch resistance than that of headlight lenses. Therefore, a polysiloxane hard coat was selected for the extra window rather than a conventional acrylic urethane hard coat often used for headlight lenses.

Moreover, because the extra window is designed with a comparatively large horizontal surface, it is exposed to more UV radiation than headlight lenses. Accordingly, the extra window's hard coat must have greater weathering resistance. Accelerated weathering tests were carried out on five types of polysiloxane hard coats, using a Sunshine Weather-O-Meter (SWOM) and a QUV Weather Tester (QUV). A durability comparison was made by timing the period until cracks appeared on the hard coat surface. The SWOM accelerated weather test conditions and test results are given in Table 1 and Fig. 4, and the QUV accelerated weathering test conditions and test results are given in Table 2 and Fig. 5. Compared to conventional polysiloxane hard coats (hard coats 1 – 4) used on headlight lenses, hard coat 5 had weathering adhesive resistance that was 4.5 times greater than that of the others in the SWOM tests, and 5 times greater than that of the others in the QUV tests. Therefore, hard coat 5 was selected for the extra window.

Hard coat 5 has a double layer structure, with a top layer and a primer layer. Each layer receives a thermal curing treatment, creating a 2-coat, 2-bake specification. Hard coat 5 has the two features, (1) and (2) below, and these features provide both the scratch resistance and weathering adhesive resistance required by the extra window.

- (1) By adding a UV absorber to the primer layer, it was possible to add a lot of UV absorber without any drop in the top layer's surface hardness.
- (2) By carrying out thermal curing treatment of the primer layer independently, it was easier to control the primer layer's film thickness and to obtain a stable hard coat adhesiveness.

Table 1 SWOM accelerating weathering test conditions

	Item	Test condition
Test subject condition	Substrate	Flat piece of black polycarbonate
	Coating thickness	Proposal thickness of hard coat supplier
	Coating condition	Proposal condition of hard coat supplier
SWOM condition	Basic condition	In compliance with JIS D 0205
	Back panel temp.	63±3°C
	Rain shower time	12 min. during 60 min.

Table 2 QUV accelerating weathering test conditions

	Item	Test condition
Test subject condition	Substrate	Flat piece of black polycarbonate
	Coating thickness	Proposal thickness of hard coat supplier
	Coating condition	Proposal condition of hard coat supplier
QUV condition	Basic condition	In compliance with JIS D 0205
	Light exposure temp.	63±3°C
	Condensation temp.	50±2°C
	Operating condition	Repetition of light exposure for 4 hours - condensation for 4 hours

Hard coat 5 is only produced in North America and because it has a short shelf life, supplying Europe from North America presented logistical difficulties. Therefore, in combination with the development of the extra window, European localization of hard coat 5 production was carried out, making a stable supply possible.

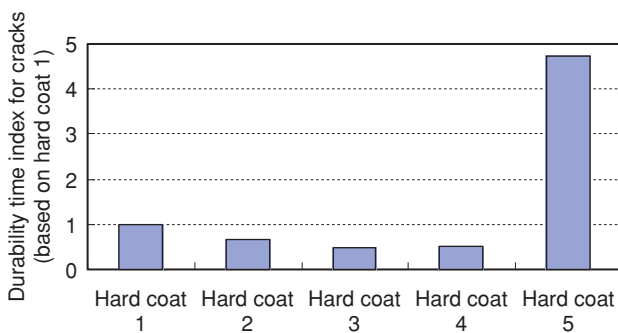


Fig. 4 SWOM accelerating weathering test results

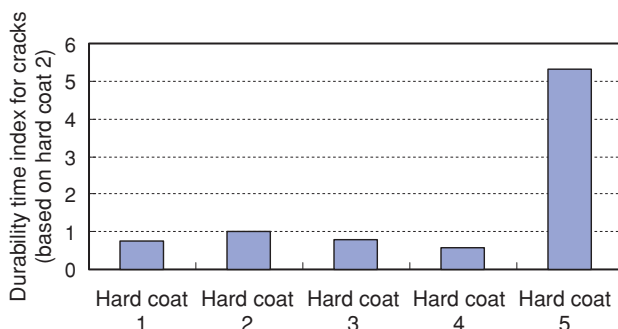


Fig. 5 QUV accelerating weathering test results

5. Hard Coat Film Thickness Control

To prevent scratching and environmentally induced deterioration under operating environment conditions, it was important to be able to control hard coat film thickness, as well as hard coat material selection. A flow coat process was used as the extra window's hard coat coating method, allowing comparatively uniform coating over complex shapes. In the flow coat process, the coating film is produced by having the coating liquid discharged from a nozzle and flow over the object being coated.

Furthermore, by optimizing the coating liquid parameters, coating liquid application conditions, and position in which the extra window was held during the flow coat process, the hard coat film thickness was controlled within the desired range. Automating the flow coat process also stabilized the hard coat film thickness.

Durability tests have confirmed that, under external factors and environmental conditions assumed for the operating environment, extra windows coated in this way are not subject to scratches, hard coat cracks, or yellowing of the transparent panel.

6. Dimension Accuracy and Appearance Quality Controls

Figure 6 shows the extra window's production flow.

In the hard coat's thermal curing treatment, the extra window is exposed to high temperatures for an extended period of time. To obtain the correct part dimensions after hard coat coating, it is necessary to control deformation due to residual stress during the thermal curing treatment or due to the window's own weight. By optimizing injection molding parameters in the double injection process, residual stress of parts after molding is controlled at a low level. Furthermore, by optimizing the shape of the jig that holds the extra window, deformation caused by the extra window's own weight is controlled.

In addition, the hard coat process is carried out entirely in a clean room to provide the high-quality appearance required of an exterior part.

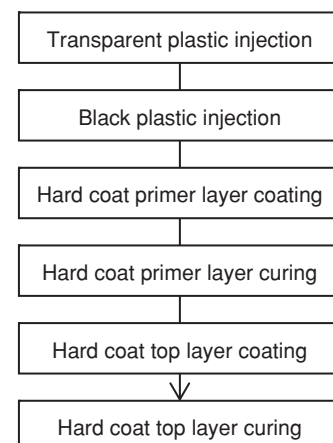


Fig. 6 Manufacturing flow for extra window

7. Conclusion

We have developed a plastic extra window that integrates the tailgate spoiler and window by using a polycarbonate coated with a polysiloxane hard coat. The extra window has been adopted in the new 2006 European CIVIC.

- (1) A double injection molding process using transparent and black plastics allowed for a distinctive design and inside structure. Use of a polycarbonate for the transparent plastic and a polycarbonate alloy for the black plastic ensured superior adhesion between the plastic layers, as well as good performance with the urethane adhesive.
- (2) A hard coat was applied to the entire external surface, which has to be scratch-resistant, and to the inside surface of the transparent panel. Among polysiloxane hard coats that are highly scratch-resistant, the hard coat with superior weathering resistance was selected.
- (3) Using an automated flow coat process to apply the hard coat meant the hard coat film thickness could be controlled within the appropriate range, ensuring superior durability of the coating under actual operating conditions.
- (4) To ensure correct dimensions, hard coat deformation during thermal curing treatment was controlled by optimizing the injection molding parameters and jig shape. In addition, an excellent appearance was achieved by carrying out the entire hard coat process in a clean room.

The adoption of this extra window enhances driver rear visibility, and at the same time, gives the car a whole new look.

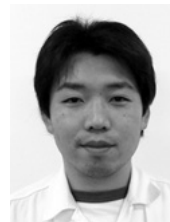
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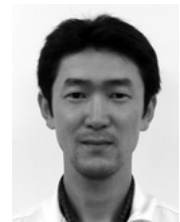
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