

Paint Film Technology for Automotive Exterior

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ABSTRACT

A metallic finish decorative film that is able to be applied to automotive exteriors has been developed. Following application using a vacuum forming method, the film is UV-cured. The top layer is a clear UV-cured layer.

General purpose aluminum flakes have been applied in the base coat, and the paint viscosity and coating conditions have been adjusted to enable the achievement of a metallic finish. In addition, embossing of the top layer enables various design expressions, such as a matte satin plating. The new film shows greater elongation during forming and superior adaptability to parts than conventional decorative films, and is also more flexible than metallic plating.

The new film has been applied on the front grille of the new Acura TSX.

1. Introduction

A variety of methods of achieving a decorative finish on plastic components in order to increase their texture are in general use, including molding in color, coating, and plating of, and application of decorative films to, the plastic materials. The use of films is known as a decorative technology that involves less use and discharge of solvents and harmful substances than coating and plating^{(1), (2)}, and which is also highly adaptable to design initiatives such as the use of printed patterns. Today, increasingly stringent environmental regulations and increasing demand for more attractive styling in automobiles are driving the invention and development of new automotive film decoration technologies.

These technologies are also extensively used by Honda, for example for wood grain patterned paneling for vehicle interiors. However, because there is little need to use the printed patterns as design initiatives on vehicle exteriors, the exterior use of these decorative film technologies has been limited to certain areas – for example, to match the color of the door protectors to the color of the body as a substitute of paint. This situation made it desirable to develop methods of exploiting the adaptability of decorative films to design initiatives for use on vehicle exteriors.

2. Concept of Exterior Decorative Film

2.1. Decorative Colors of Exterior Plastic Components

Figure 1 shows the decorative colors used on the front grilles of Honda vehicle for Japanese market models as

an example of the demand for decorative coloration of exterior components. There is a greater need for styling design of the front grille than for other exterior components, and there is a high level of demand for metallic finishes, with almost three-quarters of the decorative finishes on the front grilles being metallic finishes achieved by plating or metallic coatings.

2.2. Performance Requirements for Exterior Films

The achievement of high-intensity coloring using physical vapor deposition of indium and the use of films to color the side protectors can be indicated as examples of the types of decorative techniques applied to plastic components on vehicle exteriors. While side protector films perform well when they used as a substitute for the body color paint, there is some concern that the use of metallic finishes will make surface deterioration and pollution (from damage caused by washing the vehicle, adherence of chemicals, etc.) more obvious. In addition

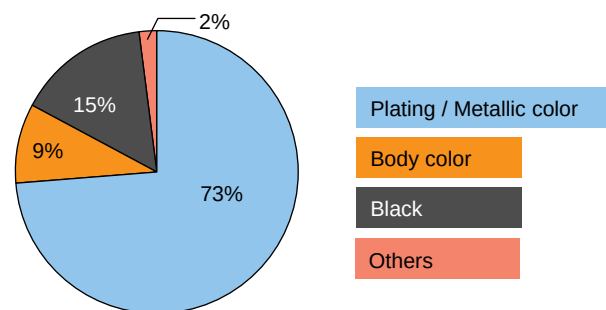


Fig. 1 Honda front grille color

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to meeting basic film performance requirements such as adhesion performance, a film used for a metallic finish would be expected to achieve a finish at least equivalent to that achieved by physical vapor deposition of indium in terms of external appearance following durability tests (resistance to damage, resistance to color change caused by chemicals, etc.).

In addition, because the shape of the front grille is more complex than that of the side protectors, the film would be expected to show a higher elongation rate in order to maintain both film performance and the correct color when the film was used on the grille.

3. Basic Specifications of Film

3.1. Layer Construction of Film

Figure 2 shows the layer construction of the film. The majority of standard automotive decorative films are applied using a sheet of a thermoplastic such as polymethyl methacrylate (PMMA), which is produced by extrusion. The project discussed here took a new approach and used a carrier film to form the coating. A clear layer, a color layer, and an adhesive layer are positioned in that order on a carrier film, and the adhesive layer is applied to the substratum plastic. This method offers the advantage of enabling the preforming and trimming procedures applied when using a thermoplastic backing sheet for a conventional decorative film to be discontinued, and releases a lower quantity of solvent during the production process than spray painting.

Because the film shows the metallic finish, a UV-cured layer with high scratch resistance and chemical resistance has been applied.

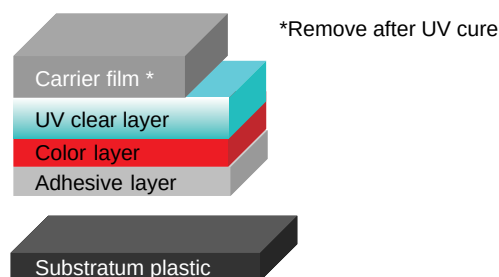


Fig. 2 Film layer construction

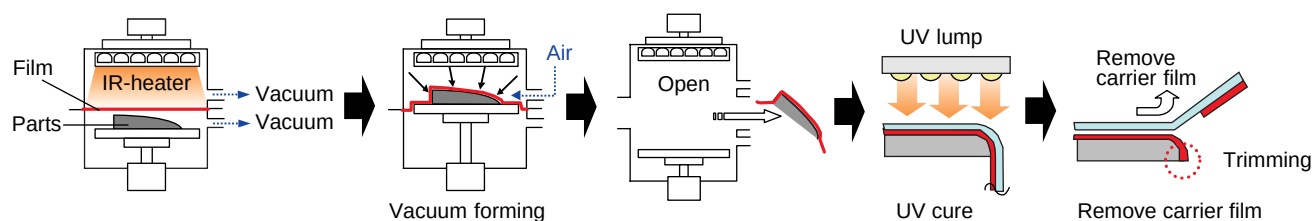


Fig. 3 Vacuum forming and UV cure process for paint film

In addition, from the perspective of repair costs, it is desirable for exterior plastic components to not be easily damaged by minor impacts. A highly impact-resistant alloy of polyamide and acrylonitrile butadiene styrene (PA+ABS), which has been used in front grilles and plastic front fenders, was therefore selected as the substratum plastic in this project, and an adhesive layer showing reliable adhesion with PA+ABS was developed.

3.2. Method of Overlay

A vacuum forming method is used to help ensure overlay of the film on the component. Figure 3 shows an overview of this method.

In a completely sealed vacuum chamber, the film is heated to render it flexible, and it is overlaid to the component in a vacuum forming procedure. At this stage, cross links have not formed in the UV clear layer, and it remains highly ductile. After the film has been overlaid to the substratum plastic, ultraviolet light is shined on it from above the carrier film in order to harden the UV clear layer. In the final procedure, the carrier layer is removed, leaving three paint layers on the surface of the component.

The use of UV curing following overlay of the film in this method helps ensure that the film can be formed onto the substratum when overlaid, and that a high cross-linking density is achieved in the top layer following the production process.

4. Metallic Finish

4.1. Achievement of a High-intensity Color Layer

Physical vapor deposition of metals to produce a laminated film is one example of the commercial use of metallic finish films. However, a larger number of procedures are involved in the manufacture of laminated films, and the films also have a higher number of layers. The project discussed here used general-purpose aluminum flakes as a simpler and lower-cost method of producing a metallic finish.

The color layer was applied over the UV-clear layer using a coater. Figure 4 shows a schematic of the film coating process.

Figure 5 shows the relationship between the paint viscosity of the color layer and intensity value (brightness

measured from the front of the component). Until a viscosity of about 5000 cps, the intensity value increases with viscosity. When this level of viscosity is exceeded, intensity values become saturated and basically constant. As the viscosity increases, imperfections such as streaks in the coating begin to appear. The range from 2000 to 6000 cps was therefore set as the appropriate viscosity for the achievement of a high intensity value.

Figure 6 shows the relationship between coating velocity and intensity value. The intensity value increases with coating velocity until a velocity of 10 m/min is exceeded, at which point the intensity value becomes saturated and basically constant. These results indicate that one point to be considered in achieving a high-intensity value finish using film coating is how to apply shear force to the base paint containing the aluminum flakes. It was conjectured that the application of a strong shear force to the base layer would generate a stronger alignment in the aluminum flakes, resulting in increased intensity value. Figure 7 shows a comparison between the intensity value

of a normal spray-painted metallic finish front grille and the film developed in this project. Film coating resulted in the achievement of a higher intensity value than spray-painting on the component used in the comparison. It is hypothesized that the alignment of the aluminum flakes is more easily enhanced when applying film coating than when applying spray-painting.

4.2. Embossing of the Surface Layer

Exploiting the characteristics of the laminate overlaying method, the use of embossing of the carrier film as a design element was examined. Figure 8 shows an image of the embossing procedure. Used in combination with the base layer that produces the metallic finish, this method enables the achievement of different designer finishes, such as a satin (matte) plating finish.

Figure 9 shows a prototype front grille using a satin plating finish film. Table 1 shows appearance data on satin plating and the satin plating finished film. Optimization of the intensity value of the base layer and

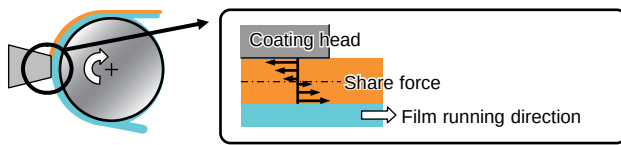


Fig. 4 Image of base paint coating

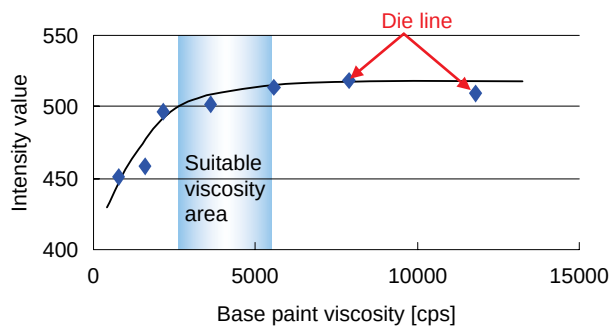


Fig. 5 Relationship between paint viscosity and brilliance

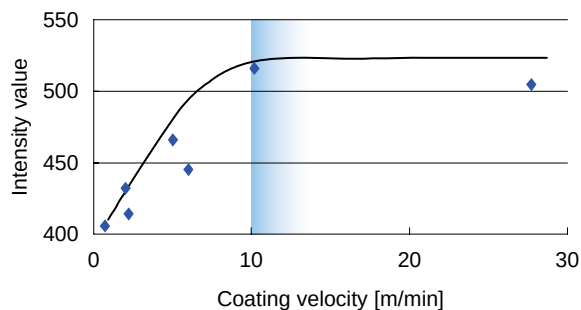


Fig. 6 Relationship between coating velocity and brilliance

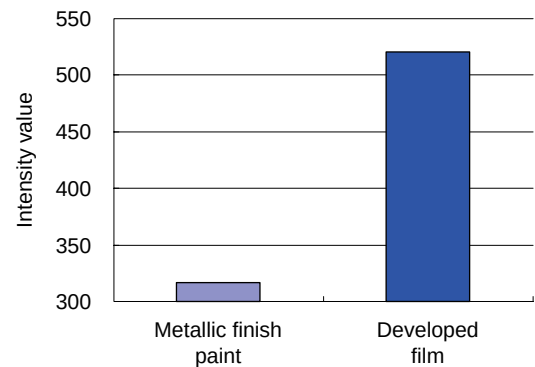


Fig. 7 Comparison between spray paint and film

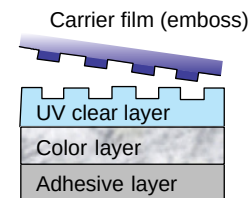


Fig. 8 Image of embossing

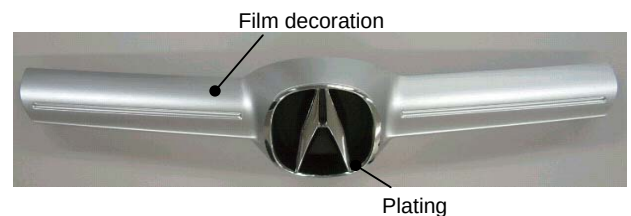
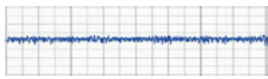
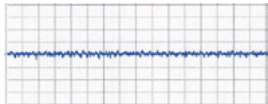


Fig. 9 Satin film proto-part

Table 1 Comparison between satin plating and developed satin film

	Surface roughness chart	Intensity value	Gross
Satin plating		450	55
Developed satin film		480	58

the embossing procedure has enabled the achievement of appearance close to those of the satin plating. In addition, the type of pigment used in the base layer and the type of embossing applied to the carrier layer can be changed, increasing the range of design variations available for the metal plating.

5. Product Performance

5.1. Flexibility

The flexibility of films can be indicated as one factor making film decoration superior to metallic plating. However, the standard UV-cured paints used for applications such as vehicle headlight lenses have low flexibility, and are therefore not superior to metallic platings without modification. Taking its use on flexible substratum plastics into consideration, the project therefore modified the UV-cured film to increase its flexibility. Flexibility was evaluated by bending tests conducted with the film overlaid to the substratum plastic. The bending test method is shown in Fig. 10. Test pieces coated with films were bent at 90° across a steel pipe of 1/2 inch in diameter for approximately 1 second, and the film was checked for breakage. The results of the tests are shown in Table 2. As comparisons, a UV hard coat and a standard plastic paint were tested at the same time. The substratum plastic in all cases was PA+ABS. The results indicate that the developed film shows sufficient flexibility for use on exterior components.

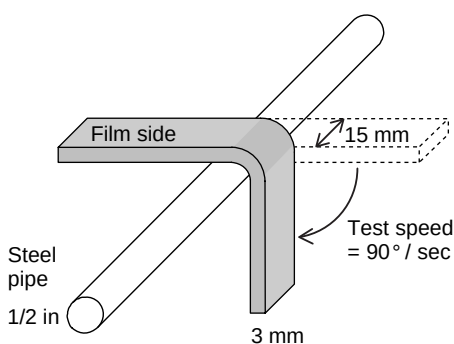


Fig. 10 Bending test method

Table 2 Bending test result

Test temp.	Criteria	UV hard coat	Painted front grille	Developed film
Room temperature	Film non-break	Break	Non-break	Non-break
-30°C	Base resin non-break	Break	Non-break	Non-break

Table 3 Car wash machine test result

		Top layer material	Rating point of car wash resistance
Film	Developed	UV cure type acrylic resin	1
	Body color film for door molding	PVDF / PMMA	5
Spray paint		Polyurethane	1

Rating point: GOOD ← 1 2 3 4 5 → POOR

Table 4 Film elongation and property

Item	Film elongation rate		
	100% (initial)	150%	200%
Color retention	Initial	$\Delta E \leq 1.5$	$\Delta E \leq 3.0$
Adhesion	100/100	100/100	100/100
Chemical resistance	No change	No change	No change
Gasohol resistance	≥ 60 min	≥ 60 min	≥ 60 min
Rating point of car wash resistance	1 point	1 point	1 point
Bending resistance	Non-break	Non-break	Non-break
Weatherability	No problem	No problem	No problem

5.2. Film Performance

Table 3 shows the results of a test of damage in a car wash machine. A rating of 1 represents the highest level of resistance to damage. The use of a UV-cured clear layer has increased the resistance of the film to car wash damage against a standard film for exterior use, and has enabled the achievement of the target, an equivalent level of damage-resistance to a vapor-deposited decoration of indium. The film also satisfies other performance requirements for decorative films used on vehicle exteriors, including gasohol resistance.

Table 4 provides an overview of the properties of the film at different elongation rates. The film satisfies requirements, including color retention and durability, up to its maximum elongation rate of 200%.

5.3. Use on Components

The developed film has been applied on the front grille of the new Acura TSX. In addition, because the film has the properties listed below, it is expected to be used on a wide range of components in future.

- (1) The developed film is more flexible than metallic platings, and film breakage will not result from a certain degree of deformation, e.g. as a result of minor impacts,

and a reduction in repair costs can therefore be expected. The film is also expected to be used in applications in which there are restrictions on the use of metal platings, for example at the outer edge of the transmission area of millimeter wave radar. In addition, no harmful substances such as heavy metals are used in the manufacture of the film.

- (2) Less solvent is emitted in the application of the film to components than in spray painting, and the film enables the realization of designs that would be difficult to achieve using spray painting.
- (3) Compared to a conventional film, the developed film achieves a reliable balance between elongation during the forming process and surface performance on the component. In addition, because no backing sheets are used, the pre-forming and trimming procedures can be discontinued or abbreviated.

6. Conclusion

- (1) A decorative film featuring a UV-cured clear layer that is UV-cured following lamination to the component in a vacuum forming method has been developed.
- (2) The developed film enables the achievement of metallic finishes (satin plating finishes, etc.), and satisfies the performance requirements for use on exterior components, including resistance to damage in car wash machines.
- (3) The developed film has reliable bendability, and a low level of harmful substances is discharged during its manufacture.
- (4) The developed decorative film has been applied on the front grille of the new Acura TSX. It is expected to be used on a wide range of components in future as one method enabling a metallic finish to be achieved on exterior plastic components.

References

- (1) Kasahara, H.: Yuki Haiki Shori Shisutemu, Kankyo Taiougata Hyoumenshorigijutsu, Tekunoshisutemu, p. 389-392 (2005) (in Japanese)
- (2) Nakamura, T.: Purasutikkumetaraijingu Gijutsu to Kankyou Taiou, Kankyo Taiougata Hyoumenshorigijutsu, Tekunoshisutemu, p. 571-575 (2005) (in Japanese)

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