Technology Introduction

Development of PREGIO-HCPS (High-brightness Chemical Plating System)

OKAJIMA Noriyuki

1 Introduction

Metal is used in many key components that make up the products by KYB Motorcycle Suspension Co., Ltd. (hereinafter referred to as “KMS”). The surface treatment includes paint, alumite (anodic oxide coating), decorative chrome plating, etc. Each has advantages and disadvantages, and new surface treatment technologies that can be applied to KMS products were being anticipated. Therefore, we focused on silver mirror plating, which is characterized for its visual properties, to promote the development.

The development of silver mirror plating in KMS was started as technology to replace the decorative chrome plating, which is used in shock absorber components for motorcycles (aluminum outer tubes). Decorative chrome plating was outsourced to an affiliated company, and we had been troubled with high defect rate and high cost caused by the complex processes and the number of processes. Pin holes, which are representative defects, are caused by cavities. The chrome plating process enlarges pin holes, making them more visible (Fig. 1). This was causing the defect rate to increase.

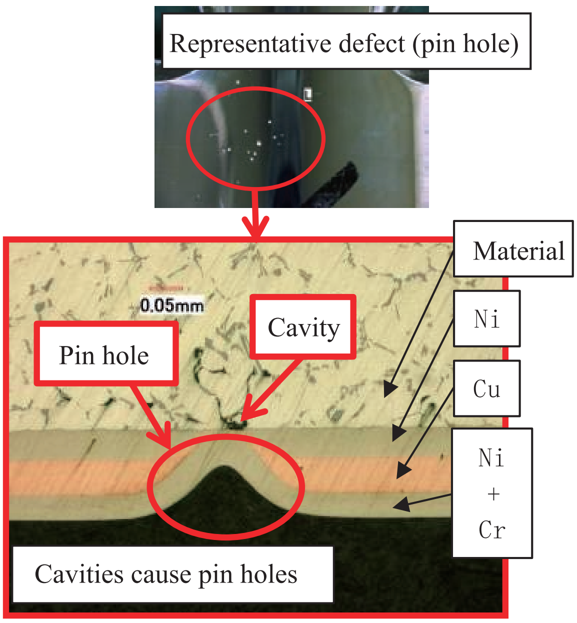

Fig. 1 Plating defect

There are 2 reasons that silver mirror plating was focused on as replacement technology for decorative chrome plating.

One is that silver mirror plating utilizes the painting technology. If we can cover faults, such as cavities, with a coating film, we may be able to reduce defects.

The second reason is that we could assimilate the appearance to chrome plating by coloring the coating film. We utilized the color variations and high brightness, which are the main characteristics of silver mirror plating. In order to fully utilize these characteristics, we shifted the direction away from mere development of technology to replace decorative chrome plating. We decided to establish new surface treatment technology with great added value and named this silver mirror plating technology “PREGIO-HCPS (High-brightness Chemical Plating System)”. PREGIO means “values” or “merit” in Italian.

2 Overview

Silver mirror plating is an application of the silver mirror reaction of the silver plating technology. This is existing technology used for resin materials as surface treatment to enclose a silver film, which is formed through a chemical reaction in a spray method, with undercoat and topcoat (Fig. 2).

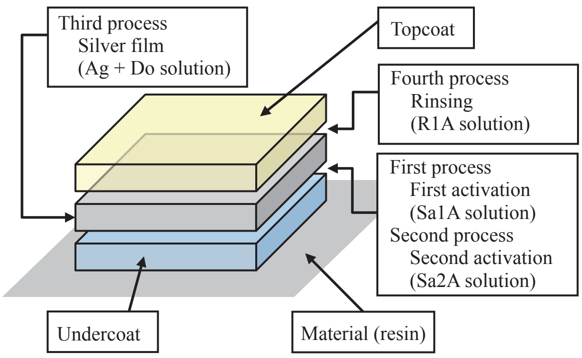

Fig. 2 Silver mirror plating structure

The silver mirror reaction is a chemical reaction in which ammoniacal silver nitrate solution is reduced by various reducing agents, extracting silver. This technology was discovered in the first half of the 19th century and has been used for many years. It is called the "silver mirror reaction" due to the fact that it is now industrially used as a manufacturing method for mirrors. The advantage of silver is that the reflectance of visible light is 98%, being the highest among metals. The disadvantages are that it is the second most expensive metal after gold and that it easily undergoes chemical reactions. Our affiliated manufacturer applied the silver salt processing know-how that they obtained through their work with photographic printing paper to silver mirror plating and developed silver mirror plating technology that can control chemical changes, such as **whitening, yellowing, and whitening unique to silver mirror plating** (refer to Glossary "Coating Defect" on P. 44), that had been considered the weakness of silver mirror plating.

There are 4 processes to form a silver film (Fig. 3).

Resin material
↓
Undercoat
↓
Baking
↓
Silver film:
- Pure water wash
- ↓
- First process (First activation: Tin is added as a catalyst)
- ↓
- Pure water wash
- ↓
- Second process (Second activation: Silver nitrate is reduced by tin to form silver nuclei)
- ↓
- Pure water wash
- ↓
- Third process (Silver mirror reaction: Silver film is formed)
- ↓
- Pure water wash
- ↓
- Fourth process (Rinsing process: Stabilize silver, which is prone to corrosion reactions, to control the reaction)
- ↓
- Pure water wash

↓
Baking
↓
Topcoat
↓
Baking

Fig. 3 Silver mirror plating process

3 Target

The existing silver mirror plating was intended for indoor use, and plated materials were limited to resin. Due to this, the undercoat did not adhere to metal materials. Therefore, we decided to develop surface treatment technology that can respond to the coating quality standards that are applied to current articles by targeting metal material components of KMS with the cooperation of the manufacturer.

4 Preparation Test

We knew that the undercoat adhered to resin. Due to the fact that KMS components are coated components (resin coating), we thought we can make silver mirror plating on metal materials possible as long as the undercoat adheres to the coating.

First, we studied the undercoat's adherence with cathodic electrodeposition for rear cushion unit springs and with clear electrostatic spraying for aluminum outer tubes.

On the other hand, clear coating as basecoat can be used for aluminum and iron coating production lines in KMS. It had been used in the aluminum coating production line and demonstrated great adherence.

4.1 Result of the Square Grid Adherence Test

① Components with cathodic electrodeposition: Good

② Components with clear electrostatic spraying: Exfoliation occurred between the clear coating and the undercoat (Photo 1).

As a result of the investigation for the cause conducted by the affiliated manufacturer, it was presented that the cause was the overcuring of the clear coating and that clear coating was not suitable for the basecoat.

Clear coating for aluminum outer tubes is two-part curing acrylic silicon resin coating. Silicon resin doesn't have great adherence with other coating resin materials. The poor adherence becomes more prominent as the coating film's curing develops. Two-part curing coating has 2 agents of the coating material and curing agent. By injecting the curing agent into the coating material, the coating film cures. The curing develops along with baking heat and time, and this characteristic emphasized the poor adherence of silicon resin.

Due to this, we were unable to use the clear coating for aluminum outer tubes, which had been used in the past. We needed to develop new basecoat.

Photo 1 Exfoliation (aluminum material)

5 Development of Basecoat

To do this, we requested the affiliated manufacturer to select new basecoat, and they selected high temperature baking type acrylic resin coating and low temperature baking type polyester resin coating. Among coating materials by the affiliated manufacturer, these coating materials are primer materials that especially excel at the adherence to the base material. We decided to evaluate the advantages to make the selection.

5.1 Results of the Square Grid Adherence Test and Corrosion Resistance Test

(1) High temperature baking type acrylic resin coating

We manufactured testing plates (hereinafter referred to as “TPs”) and confirmed the adherence with square grid adherence tests. There was exfoliation between the basecoat and the undercoat, but the corrosion resistance performance was good.

According to the affiliated manufacturer, the cause of the exfoliation was overcuring of the high temperature baking type acrylic resin coating.

(2) Low temperature baking type polyester resin coating

When we manufactured TPs, foaming occurred (Photo 2). Due to this, we were unable to confirm the adherence, and the corrosion resistance was also poor.

According to the affiliated manufacturer, the foaming was caused by part of the solution within the low temperature baking type polyester resin coating vaporizing while the topcoat was being baked.

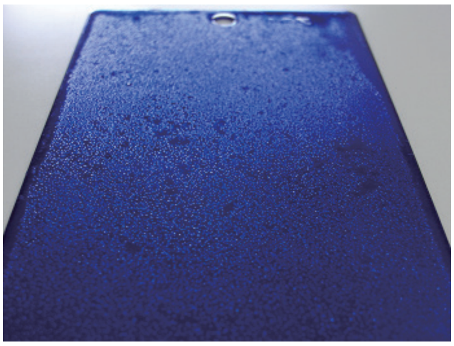

Photo 2 Foaming

Due to the above results, we selected high temperature baking type acrylic resin coating. This is because it was difficult to improve the corrosion resistance of the low temperature baking type coating in terms of coating material design and we decided that it was easier to respond to the defect, which is considered to be caused by the overcuring of high temperature baking type coating with good corrosion resistance.

5.2 Measures against Defects and Their Results

In order to prevent the overcuring of the basecoat and ensure good adherence with the undercoat, it is advantageous to set the baking temperature for the basecoat lower than that of the undercoat so that curing of the undercoat and curing of the basecoat can complete at the same time when the undercoat is being baked. Furthermore, in order to prevent the basecoat and the undercoat from being affected by the baking temperature while the topcoat is being baked, it is desirable to have the same baking temperature for the undercoat and the topcoat.

As a result, the basecoat curing method was changed from the heat-curing method using high temperature baking to the two-part curing method. Since two-part curing coating materials are cured by adding curing agents, the basecoat baking temperature can be set lower than that of the undercoat baking temperature. It was considered that it would also work better with the undercoat, which uses the same curing method. As a result of manufacturing TPs, no foaming was found, and adherence performance was secured through the grid adherence tests. Due to the above, silver mirror plating on metal materials was made possible by enclosing basecoat (cathodic electrodeposition or modified high temperature baking type acrylic resin coating) between the metal material and undercoat.

6 Evaluation according to the Coating Quality Standards and Measures

To evaluate according to the coating quality standards, we removed the re-coating performance test from the evaluation items. The objective of this test is to re-coat the same coating material over the baked coating film to confirm the adherence performance when the second coat is baked. We omitted this part because silver mirror plating uses Color Clear for the topcoat, meaning that re-coating deepens the color and changes the appearance. Since appearance changes affect product values, we decided that we cannot re-coat the coating material.

6.1 Evaluation Result according to the Coating Quality Standards

The coating standards were not satisfied for the weather resistance and flexibility (Photos 3 and 4).

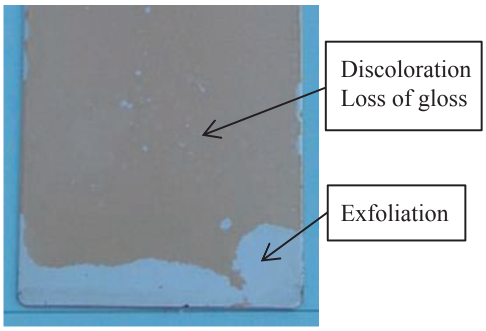

Photo 3 Weather resistance test result

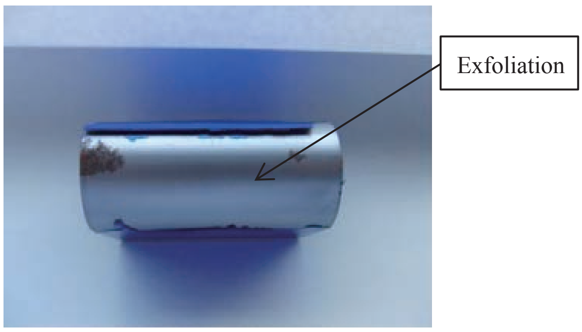

Photo 4 Flexibility test result

6.2 Measures against Defects and Their Results

(1) Defect description for the weather resistance test [Note 1)]

The topcoat for silver mirror plating is more prone to discoloration and whitening compared to common colored coating. Common colored coating films reflect part of incident light, such as UV rays, on the coating film surface, so the coating film deteriorates due to the incident light. On the other hand, the topcoat for silver mirror plating uses Color Clear, which is colored but allows incident light to penetrate. The incident light that passes the coating film is reflected on the silver film, and it passes the topcoat again, meaning that the topcoat is affected by both the incident light and the reflecting light, accelerating the coating film deterioration (Fig. 4).

Note 1) The test sample is set in a sunshine carbon arc-type weatherometer (JIS B 7753), and the test is conducted for the specified duration of time. The sample passes the test if no cracking or abnormality in the shine/color, etc. is found in the visual evaluation.

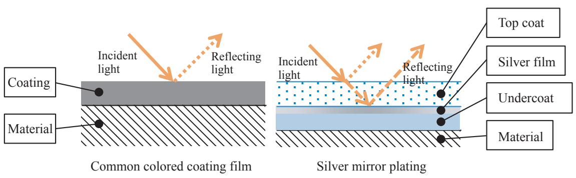

Fig. 4 Difference in light reflections

(2) Defect description for the flexibility test [Note 2)]

This was caused by the fact that the coating film thickness between the basecoat and the topcoat is approximately 50 µm, which is thicker than common coating films.

Note 2) The test sample is set on a bend test device (JIS K 5600-5-1) so that the tested surface would be on the outside when it's bent. The surface is bent 180 degrees over a period of approximately 1 second. The sample passes the test if no cracking or exfoliation is seen in the coating film.

(3) Measures

In order to satisfy the coating standards, the affiliated manufacturer has promoted efforts to improve the performance by repeating studies and tests for various additives for the basecoat, undercoat, and topcoat. In order to confirm the extent of the improvement for this performance, we decided to evaluate the actual values of two basecoat materials.

(4) Result

We were able to confirm that the performance was clearly improved in terms of weather resistance and flexibility, which did not satisfy the coating standards in the previous evaluation. However, we were unable to satisfy the target coating standards (Photos 5 and 6). The coating standards were satisfied with other evaluation items.

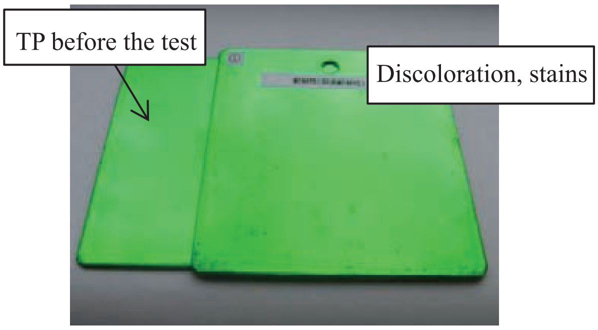

Photo 5 Weather resistance test result

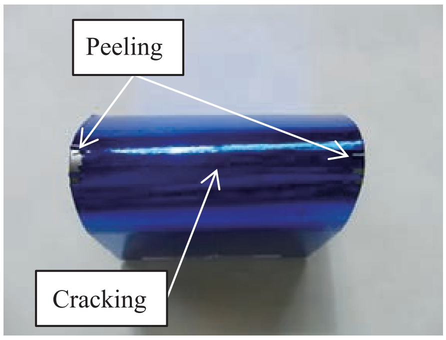

Photo 6 Flexibility test result

7 Conclusion

Our affiliated manufacturer has developed stabilization technology to overcome the 3 major defects of silver (whitening unique to silver mirror plating, yellowing, and adherence defect), undercoat required to form the silver film, and the topcoat to protect and brighten the silver film. Enclosing the basecoat that was developed in this project between the metal material and the undercoat in addition to the above technologies enabled us to use silver mirror plating on metal materials. This in turn has enabled us to establish a new surface treatment technology system and its basic technology to respond to outdoor environments in which KMS products are used (Fig. 5 and 6).

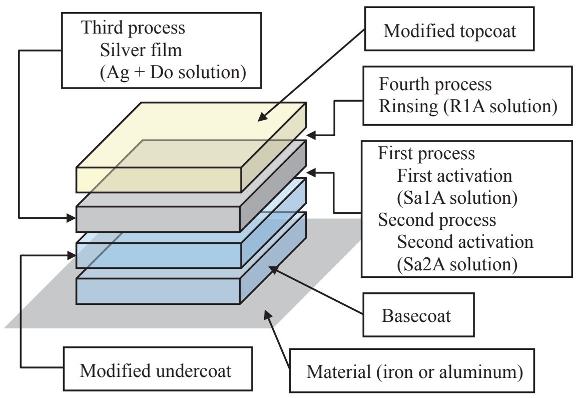

Fig. 5 Structure of PREGIO-HCPS

Metal material (iron or aluminum)
↓
Basecoat
↓
Modified undercoat
↓
Baking
↓
Silver film:
- Pure water wash
↓
- First process
(First activation: Tin is added as a catalyst)
↓
- Pure water wash
↓
- Second process
(Second activation: Silver nitrate is reduced by tin to form silver nuclei)
↓
- Pure water wash
↓
- Third process
(Silver mirror reaction: Silver film is formed)
↓
- Pure water wash
↓
- Fourth process
(Rinsing process: Stabilize silver, which is prone to corrosion reactions, to control the reaction)
↓
- Pure water wash

↓
Baking
↓
Modified topcoat
↓
Baking

Fig. 6 Process of PREGIO-HCPS

8 In Closing

Although the silver mirror plating technology has existed for a long time, its use is limited. We hear that multiple companies have attempted developing this but gave up without achieving the result.

While part of the performance was not achieved in this development, we were able to achieve good results. I believe this is largely because the affiliated manufacturer and KMS collaborated with each other.

In the future, we intend to consider the sales channels by using the above evaluation results as the actual values of PREGIO-HCPS.

Photo 7 Spring treated with PREGIO-HCPS

*「PREGIO-HCPS (logo)」 are registered trademarks of KYB Corporation in Japan and other country.

Author

OKAJIMA Noriyuki

Joined the company in 1992.
3rd Production Engineering Dept., KYB Motorcycle Suspension Co., Ltd.
Mainly engaged in safety/environment management work.