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Analysis of Paint Film Cracking on PVC Surface after Secondary Baking

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Abstract: *Two-tone car needs to go through the oven twice, PVC and the film on the PVC surface due to shrinkage difference, secondary baking, paint film will produce cracking problem; the interval between two baking times, ambient temperature and humidity, PVC material and film thickness will affect the cracking situation. This paper analyzes several influencing factors through experiments and solves the problem by taking relevant measures.*

Keywords: *Film Crack on PVC, Interval Time between Two Baking, Ambient Temperature and Humidity, PVC Material and Paint Film Thickness*

1. Introduction

Statistics show that the group with a high interest in cars is young people, who are becoming increasingly demanding of the uniqueness of cars due to their pursuit of individuality. The two-tone vehicle is popular among young people, resulting in an increased production of two-tone vehicles every year and bringing new challenges to the painting work. [1-2] The two-tone vehicle needs painting twice, so needs baking twice. [3]Before the second baking process, the PVC fine sealing surface will absorb moisture due to the long dwell time and high ambient temperature and humidity, and the high coefficient of thermal expansion of PVC sealing material will cause paint film cracking on the PVC surface. [4]The cracking of the paint film seriously affects the visual aesthetics and requires polishing and spot repair, which not only affects the quality but also increases the workload of the production personnel. There are many reasons for the cracking of paint film on the PVC surface, including the interval time between the two baking processes, ambient temperature and humidity, PVC material and paint film thickness, etc., which will all affect the cracking of the paint film. [5] This article analyses these impact factors by laboratory tests and simulates the cracking of PVC surface paint film after re-baking under different temperature and humidity conditions and dwell times in a salt spray chamber. By analyzing the cracking of the paint film, we can determine which factors affect cracking and take response measures to avoid it.

2. Analysis of Characteristics and Causes of Cracking of PVC Sealing Glue and Paint Film

2.1 Function of PVC sealing glue

PVC seam sealing glue is a paste sealing glue composed of polyvinyl chloride resin agglomerated by the emulsion method or micro-suspension method, phthalate plasticizers, solvents, thickening agents, tackifiers, inorganic fillers, and pigments. [6-7] It has good tackiness and after heating and plasticization, it becomes an elastic body with a certain adhesion strength, with excellent abrasion resistance, flexibility, and chemical resistance. It has good bonding with electroplating primer and epoxy polyamide primer and is widely used to seal the inner and outer seams of car bodies. PVC type seam sealing glue is an ideal material for sealing car body seams due to its low cost, odorless, non-toxic, good construction technology, and excellent sealing effect. It is the most widely used and researched seam-sealing glue.

However, PVC still has deformation during baking and will cause moisture absorption during storage, which will affect the cracking performance of PVC. [8]

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2.2 Analysis of Causes of Paint Film Cracking

There are many reasons for cracking of the paint film on PVC, both material and external factors. In this article, the internal cause of PVC surface paint film cracking is the inherent property of the PVC sealing glue. [9] As stated in Section 1.1, PVC sealing glue is a chemical mixture composed of various organic and inorganic substances, with a complex formula, and therefore different formulas of PVC sealing glue will inevitably have an impact on the surface paint film, and the main external causes of cracking of PVC surface paint film are temperature, humidity, interval between the first and second baking, paint thickness, etc.

The interval between the two baking, humidity and environmental temperature, PVC material and coating thickness, etc. will all have an impact on the cracking of the coating. By the following tests, the impact of these factors on the cracking of the coating is analyzed and corresponding measures are formulated based on the test results.

During June and July of each year, the high temperature and humidity environment in the Yangtze River Delta region, with temperatures reaching 35-40℃ and humidity reaching 80-100%, will affect the painting construction. For the two-tone body spraying, after the first coat is finished, due to shutdowns, etc., the black roof is unable to complete the spraying and baking in time, and the PVC will absorb moisture in high temperature and high humidity environment. The longer the time, the higher the temperature and humidity outside, the more serious the moisture absorption, and during the second baking process, the PVC surface coating will crack, as shown in Figure 1. [10] This cracking seriously affects product quality and causes a large amount of repair work, and puts higher requirements on the production schedule.

Figure 1: Crack status of paint on PVC surface

3. Experiment

3.1 Sample Preparation

Prepare 150mm x 70mm tinplate sheets, coat PVC on the tinplate sheet through a GAD robot, and dry the PVC in the PVC oven. Then place the tinplate sheet on the debugging car and spray different thicknesses of paint film by painting robot. Dry the samples in an oven. Through this method, test samples with different PVC thicknesses (1500um, 2500um) and paint film thicknesses (80um, 110um) are made[11].

3.2 Experiment Process

Place the prepared samples in a salt spray chamber with different temperatures and humidity (30°C/60% humidity and 40°C/90% humidity) for 1-6 days. Deionized water is used as a moistening and heating medium in the salt spray chamber. Then place the prepared samples in a paint oven for baking, observe the cracking state of the paint film after baking, and analyze the factors affecting cracking to formulate corresponding measures to solve the cracking problem[12].

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3.3 Experiment Results

3.3.1 Effect of Different PVC Thickness on Paint Film Cracking

The two painted tinplate sheets of different PVC thicknesses (2500um and 1500um) were placed in the salt spray chamber with a test condition of 40℃/90% humidity for 1-6 days and then baked again. The specific cracking situation is shown in Figure 2. As shown in Figure 2, paint films of different PVC thicknesses produced partial cracking on the 4th to 5th days. There was no obvious difference in cracking, so PVC thickness does not have an obvious effect on the cracking of the paint film after the second baking and is not an important factor. The main reason may be that the PVC shrinkage and expansion rate is low, and the difference in PVC thickness is not enough to cause different states of paint film cracking[13].

Figure 2: Crack status of different PVC thickness

3.3.2 The Effect of Different Paint Thickness on the Cracking of the Paint Film

Two samples with film thicknesses of 80um and 110um were placed in a salt spray chamber, with the test conditions being 40℃/90% humidity, and were placed for 1-6 days and then baked again. The cracking of the samples with different paint thickness is shown in Figure 3. As can be seen from Figure 3, as time increases, the cracking becomes more serious, and the 110um film thickness sample cracks more seriously. It is therefore concluded that as the paint film thickness increases, the degree of cracking becomes more serious. The flexibility of the paint film is much lower than that of PVC, and the thicker the paint film on the PVC surface after the second bake, the more serious the cracking status.

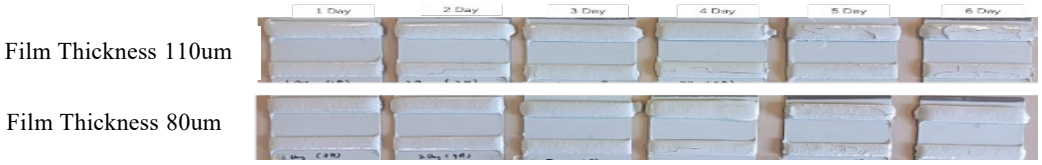

Figure 3: Crack status of different film thickness

3.3.3 Impact of Different Environmental Temperatures and Humidity on Paint Film Cracking

Two samples with a paint film thickness of 110um were placed in a salt spray chamber with different temperature and humidity environments, respectively at 30℃/60% humidity and 40℃/90% humidity for 1-6 days. Then carry out the second baking, and study the impact of temperature and humidity on the cracking of PVC surface paint film based on the cracking status shown in Figure 4. As shown in Figure 4, the PVC surface paint film gradually cracks with the increasing storage time under the temperature and humidity of 40℃/90%, and the cracking becomes more serious. However, under the temperature and humidity of 30℃/60%, the surface of the paint film does not crack during the storage of 1-6 days. The results show that the higher the temperature and humidity, the more easily the PVC surface paint film cracks, and the more serious the cracking becomes with the prolonging of the storage time before the second baking. In the Yangtze River Delta region, in June and July when the weather is high temperature and humidity, if the production is stopped for a long time and the black roof car is not completed with the second coating and baking, PVC will absorb a large amount of water vapor. If spraying is performed after a period of time, it will cause film cracking on the PVC surface, affecting the quality of the car.

Figure 4: Crack status of different temperatures and humidity

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3.3.4 Impact of Different Dwelling Time on the Cracking of Paint Film

Place the PVC samples with a thickness of 2500um and paint film thickness of 110um in the salt spray chamber, with test conditions of 40℃/90% humidity, and take them out after 1-6 days. Then, bake them again in the oven. As the storage time in the salt spray chamber increases, the paint film gradually cracks, as shown in Figure 5. From Figure 5, it can be seen that after the dwelling time reaches 5 days, the cracking of the paint film begins to appear and gradually becomes more serious as time goes on

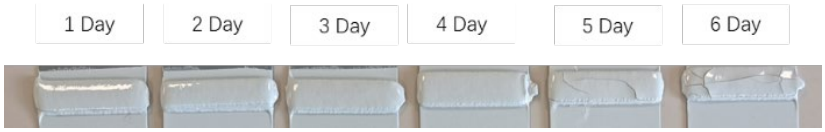

Figure 5: Crack status of different dwelling time

3.3.5 The Impact of Different PVC Formulations on Cracking Conditions

Two PVC formulations were selected to compare their cracking conditions. The test conditions were 40°C/90% humidity, with a residence time of 1-6 days in the salt spray chamber, followed by baking in the oven, and the cracking conditions were evaluated. The specific cracking conditions are shown in Figure 6. As time increases, the paint film gradually cracks, but sample 1 cracks more seriously. Sample 1 is the original formula, while sample 2 is an optimized sample, optimized by reducing the PVC expansion rate. This test confirms that the optimized PVC reduces the PVC expansion rate, which can improve the cracking condition of the PVC surface paint film.

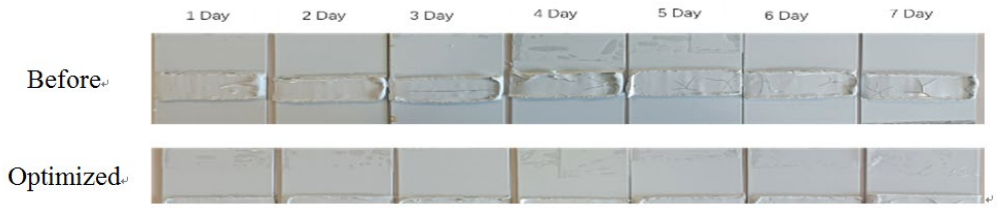

Figure 6: Crack status of different PVC formulations

4. Measures to Improve Paint Film Cracking

Through the above analysis, we have come to the following conclusions: the thicker the paint film, the more serious the cracking after secondary baking; the longer the interval between the first and second baking of the PVC surface paint film, the more serious the cracking; the higher the temperature and humidity of the environment where the sample is stored, the more easily the film will absorb moisture, the more serious the cracking after secondary baking; the higher the shrinkage expansion coefficient of PVC, the more serious the cracking after secondary baking[14].

In response to these factors, we have made corresponding optimization measures to solve the problem of paint film cracking on the surface of PVC.

First, we need to optimize and reduce the expansion coefficient of PVC, reduce the shrinkage and expansion rate of PVC during secondary baking, reduce the difference with the paint film, and effectively reduce the risk of cracking of the paint film.

Second, for high temperature and humidity weather, if the production stop time exceeds two days, timely completion of the black roof second spray is necessary to reduce the interval between the two bakes. We need to guide the production and solve the problem of cracking of the paint film.

Finally, the optimization of the paint film thickness in the inner cavity location is carried out, especially in the position where the paint film is thicker, which not only reduces the risk of paint cracking after the second baking but also reduces material consumption while meeting quality requirements[15].

With these measures, the cracking problem after the second baking of the two-tone car has been basically solved.

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5. Conclusion

The application of a new process will inevitably result in new problems. To solve these new problems, a comprehensive analysis of the affecting factors must be conducted in order to find effective solutions. Through experiments, this article has identified the factors that influence the cracking of the paint film during the second baking of the two-tone car and has formulated corresponding measures to resolve the problem.

References

[1] Dong Yue (2022). Optimization of manufacturing cost of two-color body painting Electroplating and finishing, 41 (6), 6
[2] Wan Song. (2019) Advanced Two Tone Paint Process Study. Automobile Applied Technology.
[3] Zhou Junpeng, Xu Kang, Zhang Zhengye. (2020) The Mechanism Analysis and Solution Method of Foaming/Glue Hole of Automobile Coating Sealant. Automobile Applied Technology.
[4] Li Liang, Xu Sheng. (2020) Cause Analysis and Improvement Air Bubbles of Door Folding PVC Sealant in Automobile Painting. Shanghai Coatings.
[5] Yang Kai. (2022) The Prevention and Treatment Technology of Paint Film Defect in Automobile Spray Paint. Automobile Applied Technology.
[6] Liu Hualin, Xie Chuanyong, Wang Liang. (2014) Cracking Problem of PVC Fine Sealing Belton Auto Door and Its Solution Thereto. Coating Technology & Abstracts.
[7] Gan Zhengxian, Chen Xinting. (2020) Application and Optimization of Double-color Process Technology. Modern Finishing.
[8] Jiang Ronghua, Fan Feng. (2018) Analysis and Prevention of Cracking of Automotive Sealing PVC Sealant. Automobile Applied Technology.
[9] Liao Meidong, Xi Zhongmin, Zhong Jian, Su He, Zhang Rui. (2017) Analysis of the Film Cracking for PVC Sealant Paint Sealing Adhesive Colored Paint Film Cracking Defects. Modern Finishing.
[10] Chen Guilin, Liu Lidong, Chen Wenquan. (2022) Optimization Practice of Placing Cracks in PVC Sealant for Automobiles. Shanghai Coatings.
[11] Wang Hekun, & Yang Guang (2018). Solution to the blistering problem of the paint film on the surface of the weld sealant caused by the reduction of air temperature Electroplating and finishing, 37 (20), 4
[12] Zhang Xinguo, Deng Liexiong, Liao Zhanglong (2021). Analysis and solution of the crack problem of the seam sealant on the roof of the car body Times Motor, 000 (012), 140-141146
[13] Wang Gang, Wang Ming, Yang Feng, Huang Lili (2020). Study on the cracking, bulging and bubbling of pvc sealant in the weld of car body roof Modern Coatings and Painting, 023 (009), 17-19
[14] Liang Rong, Dong Bing & Xue Jiangduan (2017). Research on cracking of automobile pvc weld sealant Modern Coatings and Painting, 20 (12), 4
[15] Jiang Ronghua, Fan Feng (2018). Analysis and prevention of cracking of pvc sealant in automobile coating Automotive Practical Technology, 000 (021), 251-253