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Optimization Design of Workshop Painting Parameter Process

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Abstract: Through the analysis of the actual situation and process of painting industrial steel components in Hechang Company, we have modified the mixing ratio of paint, thinner, and curing agent. Additionally, we have effectively adjusted the drying time of various paint types under different seasons and temperatures. Eventually, a painting solution suitable for our company has been developed. According to this process, the painting quality has been significantly improved, costs have been saved, the labor intensity has been reduced, and production efficiency has been remarkably enhanced.

Keywords: Painting process; Mixing ratio; Adjustment; Production efficiency

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1. Introduction

With the development of society, the types of paints have increased. Industrial paint, a category of paint, has been highly regarded since its appearance [1]. Paint is composed of pigments suspended in a liquid. It was not until the Industrial Revolution that the paint industry was recognized as a part of China's economy.

2. Types of industrial paints

Industrial paints are mainly used on the equipment produced by industrial enterprises. Let's take a look at the types of industrial paints:

(1) Steel structure paints, these mainly include anti-rust paints for steel structures, anti-corrosion primers, intermediate paints, and anti-corrosion topcoats for steel structures [2]. Common varieties such as epoxy zinc-rich primers, epoxy micaceous iron intermediate paints, aliphatic polyurethane topcoats, polyurethane topcoats, fluorocarbon topcoats, and alkyd paints are all collectively referred to as industrial paints [3].

(2) Industrial paints are mainly used on mechanical equipment, the surfaces of various machine tools, lathes, and equipment to achieve decorative, anti-corrosion, and anti-rust effects.

(3) Ship paints are a high-tech field in industrial paints, including deck paints, waterline paints, ballast tank coatings, anti-fouling paints, and ship hull paints [4].

(4) Exterior wall paints, industrial exterior wall paints are different from civil exterior wall coatings. They are often applied in special fields such as surface buildings and chemical anti-corrosion, with requirements for service life, appearance, and anti-corrosion [5].

(5) Baked enamels and plastic powders, these products can be used for pipeline spraying [6]. They are commonly used in the coating of auto parts, bicycle frames, chassis cabinets, etc.

(6) High-temperature-resistant paints, some industrial equipment needs to be used in high-temperature environments. Therefore, high-temperature-resistant industrial paints can be used in environments above 300°C. The main varieties are silicone high-temperature-resistant paints and aluminum powder paints [7].

(7) Underground pipeline anti-corrosion paints, underground water supply pipelines, oil pipelines, etc., all require the application of special underground pipeline anti-corrosion coatings. The main varieties are bituminous paints and epoxy coal tar pitch paints.

(8) Anti-corrosion paints for above-ground equipment: In chemical fields, coal mines, factories, etc., these environments often have various corrosive substances such as acid-base gases and humid steam [8]. Industrial anti-corrosion paints include acid-resistant paints, alkali-resistant paints, humidity-resistant paints, solvent-resistant paints, and other special varieties [9].

(9) Paints for special substrates: For example, stainless steel and galvanized steel require special primers to have good adhesion [10]. Special paints are also needed for plastic materials such as PVC and ABS to ensure coating without damaging the substrate. Fiberglass-reinforced plastic is also a special substrate for industrial paint coating.

Combined with the equipment produced by Hechang Company (**Figure 1**), such as drilling rigs, towers, CNPC liquid storage tanks, and skid frames, the main types of paints we use include:

Topcoats: Polyurethane, alkyd paint, chlorinated rubber, etc.

Intermediate paints: Gray epoxy paint;

Primers: Epoxy zinc-rich primer, alkyd primer, etc.

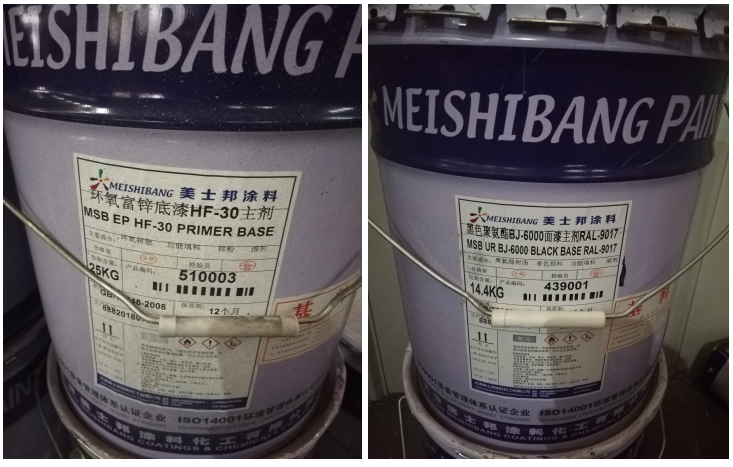


Figure 1. Commonly used paint models

The advantages of various paints are as follows:

(1) Polyurethane paint has excellent weather resistance, gloss retention, color retention, good chemical

resistance, salt-spray resistance, strong adhesion, tough film, full and bright appearance, good impact resistance and wear resistance, and excellent decorative properties [11,12].

(2) Alkyd paint is mainly composed of alkyd resin and is currently the largest-produced type of coatings in China. It has advantages such as low cost, simple construction, low requirements for the construction environment, full and hard film, good durability and weather resistance, and good decorative and protective properties.

(3) Chlorinated rubber is made of chlorinated rubber, plasticizers, pigments, etc. The film is tough, dries quickly, and has excellent weather resistance and chemical resistance. It also has excellent water-resistance and mildew-resistance. It has excellent low-temperature construction performance and can be constructed in an environment of 20–50°C [13]. It has good wet-dry alternation performance. When repairing the chlorinated rubber film, there is no need to remove the old film, which is convenient for maintenance.

3. Problems encountered in workshop painting

3.1. Previous painting process method

In industrial painting, generally, the paint is mixed according to the ratio parameters of paint, curing agent, and thinner provided by the paint manufacturer. The paint, curing agent, and corresponding thinner are purchased according to the color required by the manufacturer [14]. Regardless of the time, whether it is summer or winter, sunny or rainy, the paint ratio relationship is based on the parameters provided by the paint manufacturer. Corresponding curing agents, thinners, or other auxiliary materials are used for different types of paint. At that time, there was no corresponding painting technical guidance document, and paint was only regarded as a simple anti-corrosion coating material [15].

3.2. Problems encountered in painting

Affected by climate, temperature, and humidity, we found that the surfaces of many sprayed equipment could not dry within the specified time. Quality defects such as flow marks, wrinkled surfaces, and peeling paint skins occurred on the paint surface.

With the expansion of production scale, we found that the painted production equipment had problems such as wrinkled paint surfaces (**Figures 2**, **3**, and **4**), peeling paint skins, and sometimes paint bubbles and rust even before leaving the factory.

Many customers who purchased the equipment also reported serious paint peeling and a large number of rusty areas, which had a great impact on the production accuracy of important parts.



Figure 2. Defect 1 in painting

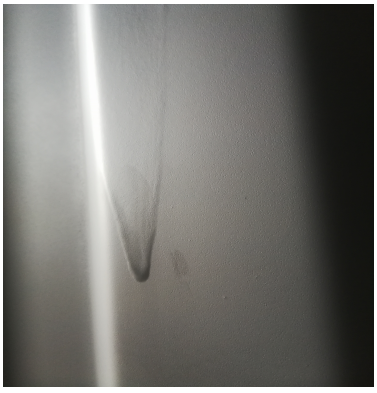


Figure 3. Defect 2 in painting



Figure 4. Defect 3 in painting

4. Problem analysis

Subsequently, we conducted a key inspection of the rusty and peeling areas. Through consultations with paint manufacturers and investigations of local environmental factors, we found that the problems in painting were closely related to the painting process and methods. Therefore, we made improvements. We optimized the ratio based on the original parameters and redesigned the process parameters, such as the drying time of different paints.

5. Solutions

With the coordination of the technical department and the workshop production department, we conducted multiple tests on the new painting process, recorded the data many times, and made repeated improvements. Finally, a painting solution that suits the company's environment was developed. The final improved painting process plan is as follows:

(1) Painting in summer: In summer painting, the ratio of a bucket of paint to a bucket of curing agent is 1:1, and the mixing ratio of thinner to paint is approximately (0.2–0.3):1. The actual painting effect is good. When the temperature is high, using a slow-drying curing agent can extend the usage time, increase the leveling time, and prevent pimples and orange peel.

(2) Painting in winter: In winter painting, the ratio of a bucket of paint to a bucket of curing agent is 1:1, and the mixing ratio of thinner to paint is approximately (0.1–0.2):1. The paint viscosity should be slightly higher than that in summer. The painting interval is about 10–15 minutes, and the actual painting effect is good, reducing sagging.

(3) Painting on sunny days: The ratio of paint to curing agent is the same as above, but the ratio of thinner to paint is slightly different, which is (0.2–0.3):1.

(4) It is generally not recommended to carry out outdoor painting on rainy or cloudy days. Due to the influence of air humidity, it is generally recommended to carry out indoor construction and increase the painting interval.

(5) The shot-blasted workpieces must be sprayed with primer within 2–4 hours; otherwise, rust reversion is likely to occur, affecting the subsequent anti-corrosion performance.

(6) The time required for the paint to dry completely after painting is as follows:

In summer (with curing agent):
Fast-drying paint: T > 1 hour
Slow-drying paint: T > 5 hours
General paint: T > 4 hours
In winter (with curing agent):
Fast-drying paint: T > 5 hours (rarely used)
Slow-drying paint: T > 24 hours
General paint: T > 24 hours
For alkyd paint (without curing agent):
In winter: T > 2 days
In summer: T > 1 day

6. Effects after process improvement and comparison of effects

Table 1 presents a comparative analysis between old-style and improved painting processes, highlighting signif-icant advancements in smoothness, drying time, paint efficiency, and overall cost-effectiveness. **Figures 5** and **6** show the effect diagram of painting improvement.

Table 1. Comparison of old-style and improved painting processes

Process method	Smoothness	Drying time	Mark- remaining situation	Paint-peeling situation	Paint consumption	Cost
Old-style	High roughness	Long	Many	Many	High	High
Improved	Reduced roughness, smooth surface	Reduced by 50%	Significantly reduced	Significantly reduced	Low	Significantly de-creased



Figure 5. The first effect diagram of painting improvement



Figure 6. The second effect diagram of painting improvement

7. Conclusion

By optimizing the ratio parameters of paint, thinner, and curing agent in the painting process and adjusting the drying time after painting, the painting quality of industrial equipment can be effectively improved. Moreover, by arranging the time reasonably, the painting time can be greatly saved, and the painting efficiency and quality in the workshop have been significantly enhanced.

Disclosure statement

The authors declare no conflict of interest.

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