Study on the long-lasting Anti-corrosion Construction Technology of Steel Structure of Service Tower in a Coastal Launching Site

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Abstract. In order to realize the long-lasting corrosion protection of the steel structure of service tower in a coastal launch site under C5-M corrosion environment, a five-layer heavy anti-corrosion system with hot spray zinc aluminum alloy as the base, and the supporting process and control requirements are put forward. And this paper studied on the difficult problems encountered in the site construction process, such as the high requirements of pre-treatment of substrate surfaces, difficulty of the protection of finished products and difficulty of coating process control. The actual construction shows that the proposed measures are limited, the coating effect is good, and the research results can guide the anti-corrosion construction.

1. Introduction
A coastal launch site is located in the northeast of Hainan island, near 20 degrees north latitude, east of the South China Sea, with high temperature, high humidity, high salt fog, as well as more thunderstorms, heavy rainfall, tropical cyclone landing and other climate characteristics, tropical marine atmospheric environment characteristics are obvious. A rocket launch service tower is less than one kilometer away from the coastline, and its corrosion environment has reached C5-M level. Since the tower was built and used in October 2014, its main steel structure has been seriously corroded under the influence of high temperature, high humidity and high salt fog. A large piece of coating peels off on the main steel structure column, obvious rust pits appear on the welding seam, and coating cracking or substrate corrosion occurs on the bolt coating, as shown in Figure 1.

In order to delay the corrosion rate of the steel structure, prolong the service life of the main body of the steel structure and eliminate hidden dangers, the overall corrosion of the service tower steel structure is carried out, covering an area of about 15000m². The anti-corrosion construction of tall and complex steel structure building is always the difficult point of anti-corrosion, and its construction technology and quality control method has become the hot spot of research. In 2008, Gao Sh. D. studied the anticorrosive painting technology of the steel structure of the National Stadium Bird's nest and the metal net frame of Yingdong Natatorium[1]. In 2009, Wang Y. D. studied the anti-corrosive construction cost control method of the steel pipe arch of Maocaoqie Bridge[2]. In 2011, Zhang D. L. and Chao Y., respectively studied the steel structure of Nanjing South Railway Station and the anti-corrosion technology of the steel box girder of Xihoumen Bridge[3, 4], and achieved good application results. In 2016, Japanese scholar Tuiki J. and others studied the anti-corrosion performance of Zn-Al alloy coating on steel bridges, and proved the good anti-corrosion effect of the coating system[5].

2017, Wang Sh. Y. studied the foundation anti-corrosion of UHV project, and put forward the anti-corrosion process and related quality control methods of HCPE combined epoxy coatings[6].

Figure 1. Corrosion of steel structure.

Compared with the above-mentioned steel structure anti-corrosion construction, the service tower steel structure anti-corrosion has a higher height, more complex structure, close to the South China Sea and is the second anti-corrosion after many years of use, sand blasting, Zn-Al alloy spraying and other anti-corrosion processes have to be constructed in the coastal environment tower site, and its painting construction and quality control are more difficult. Anti-corrosive construction is faced with the realistic problems of severe C5-M corrosion environment, high-altitude operation, complex tower space environment and finished product protection of various equipment and facilities on the tower. So this paper mainly focuses on the selection and control of anti corrosive technology of service tower steel structure in severe corrosion environment, and the analysis and countermeasures of construction difficulties in complex environment. In order to provide technical support for the smooth development of anti corrosion engineering.

2. Anti-corrosion process design and control

2.1. Anti-corrosion process design
In order to cope with the harsh corrosion environment of coastal C5-M and ensure the anti-corrosion design period of 15 years, combined with the test of various anti-corrosion systems in the launch site, the service tower steel structure anti-corrosion coating adopts a five-layer heavy anti-corrosion system with thermal spraying of zinc-aluminium alloy as the bottom.

The bottom of the first layer is sprayed with thermal spraying zinc-aluminum alloy, the purity of the zinc wire is not less than 99.9%, the purity of the aluminum wire is not less than 99.5%, the weight ratio of aluminum and zinc is 27-29%: 73-71%, and the total thickness is 150μm. The second layer is epoxy sealing paint, which is coated with one pass and has a thickness of 50μm. The third layer is an epoxy micaeous iron intermediate paint, which is coated with two passes and has a thickness of 120μm. The fourth layer is a polyurethane top coat, which is coated with one pass and has a thickness of 40μm. The fifth layer is a fluoro carbon top paint, which is coated with one pass and has a thickness of 40μm, wherein the fluorine content is not less than 24%. And the total thickness is more than 400μm.

2.2. Anti-corrosion process control
In the process of anti-corrosion construction, the construction party is required to install the process as follows, and complete the process and quality control of each stage according to the procedure. Party A and the construction party shall establish a quality supervision group to supervise and check all aspects of the process and quality in the construction process.

1) Protection of finished products. Because there are many equipment and facilities on the tower, such as water pipe, fire pipe, gas pipe, propellant filling pipeline, valve control box and aluminium alloy shutter, sand blasting and coating will cause pollution or damage to them, and the protection measures for the finished products on the tower should be done first before construction.
2) Substrate pretreatment. The rust removal grade of steel structure substrate pretreatment should reach Sa3.0, and the roughness requirement is Rz 60-100μm. For some inconvenient places for sandblasting, manual grinding is used, and the rust removal grade reaches ST3. Before painting, ensure that the content of soluble chloride on the surface of steel should not be greater than $7\mu g/cm^2$. The cleanliness requirement of cleaned pipeline surface dust is not greater than grade 3.

3) Adhesion requirements. For flat surfaces such as columns, crossbeams and cross columns, the drawing force should be greater than 5MPa, and the location of measuring points should be determined by consultation according to the site conditions. For irregular surfaces such as climbing ladders and railings, the measurement by means of grid method should reach grade 0.

4) Coating thickness control. Thermal spray coating thickness measurements are performed. For other coatings, wet film thickness gauge should be used frequently in the construction process, so as to control the dry film thickness more accurately. Dry film thickness measurement and testing requires that there are at least 3-6 points for each column, cross column and crossbeam on each floor. The average thickness of each point measured at each point shall not be less than 90% of the prescribed coating thickness and not more than twice the prescribed value. The allowable value of 15% of the thickness measured at each point is less than the prescribed thickness value, and the minimum value should not be less than 85% of the total thickness of the coating.

5) Environmental requirements for construction. Temperature and humidity meters must be hung on the construction site, requiring that the construction environment temperature is 5℃~38℃, and the relative humidity of the air is not more than 85%. Under the conditions of rain, fog, strong wind and large dust, outdoor painting operations are prohibited.

3. Analysis of construction difficulties

The service tower has the characteristics of high building, complex structure, many gas-liquid pipelines and equipment on the tower, which makes the anti-corrosion construction of the tower have many difficulties, such as high altitude work, many dead corners of painting, and difficult protection of finished products. In this paper, the tower anti-corrosion construction in the face of the important and difficult issues in-depth analysis, put forward measures to ensure the quality and progress of construction site.

3.1. High requirements for substrate pretreatment

1) High requirements for surface rust removal. In order to ensure the adhesion of thermal spraying zinc-aluminum coating and the overall anti-corrosion effect, the substrate surface rust removal grade requires Sa3.0, and some parts that are not easy to blast sand are polished to ST3 by hand, Sa3.0 and ST3 are the highest level required for substrate surface treatment. Because the corrosion of steel structure belongs to the second corrosion of substrate, it is necessary to clean all the original coating system and rust by sandblasting, especially some crevices and seriously corroded parts, which is difficult to reach Sa3.0.

2) It is difficult to control the salt content of the substrate surface. The technical requirement is that the soluble chloride on the surface of the substrate before painting is less than $7\mu g/cm^2$. The service tower is less than 1 kilometer away from the coastline, the air salt spray content is high, and the chloride ion carried by the sand used for sand blasting will cause the salt content of the substrate surface to exceed the standard, which is difficult to control.

3.2. There are many dead corners in construction.

There are a large number of dead parts in tower steel structure, such as joint plate cracks, stiffened plate bolts, louvers and steel structure cracks, fire hydrant box and distribution box, which are difficult to sand blast rust removal and paint spraying, so it is difficult to deal with them.
3.3. It is difficult to construct the outer side of the tower.
Anti-corrosion construction is required for service tower columns, inclined beams, beams and columns outside the tower. High altitude operation, construction workers have no safe stress surface, the quality of base material sandblasting treatment, thermal spraying zinc and aluminum and other coatings is difficult to guarantee, and the construction object is interlaced with louvers, pipelines, pipelines and other facilities, so the construction is more difficult.

3.4. The protection of finished products is difficult.
Each floor of the service tower is equipped with a large number of fire fighting, rainwater, domestic water pipes, hydraulic oil pipes, gas supply pipes, filling pipes, cable bridges, structural safety online monitoring system sensors and pipelines, blinds and other equipment and facilities. If the protective measures are not in place, sand blasting and painting construction are likely to cause damage or pollution to the above equipment and facilities.

3.5. Difficult control of coating process
This anti-corrosion is the first time to carry out the field construction of five-layer heavy anti-corrosion system based on thermal spraying zinc-aluminum coating in the launch site, the coating thickness, coating adhesion and coating time interval are the difficulties of process control, especially the thermal spraying zinc-aluminum coating is prone to problems such as thickness is not up to the standard or flatness is not enough, which requires high construction experience and spraying techniques of workers. In addition, high-altitude work and construction in toxic and closed environment have a negative impact on the control of painting process.

4. Research on response measures

4.1. Superhard abrasive and water cleaning to solve the substrate treatment
1) Rust removal grade guarantee. In order to remove the original coating and rust on the substrate, the abrasive ratio of super-hardness steel wire cutting shot (50%), water chestnut sand (40%) and a small amount of steel shot (10%) and 0.7MPa high-pressure buffer gas cylinder were used to ensure that the surface rust removal grade reached Sa3.0. In order to prevent excessive rust removal leading to excessive roughness of the surface, it is required to move to the next area immediately after the metal color of the steel structure leaks out, so as to avoid staying for a long time. The actual effect is shown in Figure 2.

2) Surface chloride ion control. Before sandblasting, the chloride ion content of the steel sand is detected, and then it can be used. After the completion of sand blasting on the substrate surface salt detection, if exceeded, then wash with high-pressure water until the standard. In the construction process, the construction environment is sealed by a closed canopy to prevent the external chloride ions from entering.

4.2. Elbow sand blasting and cold spraying zinc brush to solve dead corner construction
In view of the problem of incomplete derusting in the inner side of bolts, connecting plate and other dead corners, the corner sandblasting gun head is used in sandblasting, which can directly hit the inner corner. In addition, a small closed box is made when blasting, which can make the abrasive eject repeatedly inside, thus solving the problem of incomplete rust removal in the dead corner position. Due to the large size of thermal spraying gun, it is difficult to spray at the dead corner. After the comparative test with epoxy zinc-rich primer, the cold spraying of zinc with brush is selected to replace it.

4.3. Construction of outer side of tower in closed warehouse with external hoisting room
In view of the difficult construction problem of the large flow water spraying pipe derrick steel structure on the south side of the tower, the whole steel truss closed warehouse and hanging basket are
used to solve the problem. The closed warehouse is equipped with dehumidifier, dust collector, abrasive recycler and other equipment, which on the one hand provides a stable, reliable and relatively comfortable construction environment for workers, on the other hand plays a closed role in sandblasting abrasive and paint, preventing the wind from polluting other finished products. The closed warehouse is shown in figure 3.

4.4. Multi-layer coating with wooden boards to protect the finished products
In view of the gas-liquid pipeline, hydraulic pipeline and all kinds of water pipes and electric pipes on the tower, the fresh-keeping film is wrapped to prevent paint spraying pollution, and then the silicon tape is wrapped and tied with iron wire to prevent the damage of high-pressure sandblasting. For the blue louvers on both sides of the tower, the template is used to shield them, and then the silica gel seal is used to protect them. For other equipment on the tower, such as valve control box, it is directly protected by silicone tape and canvas wrapping.

4.5. Inspection and improvement while spraying to control painting process
It is difficult to control the thickness of thermal spraying Zinc-Aluminum coating, so workers are required to strictly follow the following spraying technology during construction: air pressure: 0.55-0.7MPa. Compressed air flow: ≥16m³/min, spraying distance: 100-300mm. Spray track overlap range: 1/4-1/3. The moving speed of the lance is 10-20cm/s. The wire feeding speed is generally controlled at 120-150cm/min. In addition, it is required to self-check the thickness while spraying, so as to know the thickness well.

5. Verification of application effect
After the actual painting verification, the above construction difficulties have been effectively solved, the protection of finished products, the treatment of base materials in front of the table, the construction environment control and the final painting process all meet the requirements. The final painting effect is as follows:
6. Conclusion
Aiming at the steel structure anti-corrosion technology control strategy in the complex environment of coastal launching site, and aiming at the heavy and difficult problems such as high requirement of substrate pretreatment, construction of dead corner, difficulty of finished product protection and difficulty of painting technology control encountered in the construction process, the corresponding countermeasures are put forward to solve them. Through the actual construction verification, the response measures are effective, and the research results have a good guiding significance for the final painting construction.

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