

Features summary

- Easy Coating
- Fast Curing
- Excellent Performance
- Economic and Eco-friendly





Brief Introduction

- Epoxy powder coating is to preheat the strictly cleaned pipe to a certain temperature, and then spray the epoxy powder on the pipe, use the heat of the pipe wall to melt, level, solidify, and cool the powder to form a uniform, continuous and strong Anti-corrosion film. Due to its excellent performance, thermosetting epoxy powder coating is especially suitable for harsh environments, such as high-salt and high-alkali soils, high-salinity seawater and hot desert areas.

Features of fusion bonded epoxy powder

- 1) The coating has good **chemical resistance and solvent resistance**, can resist the chemical corrosion of H₂S, CO₂, O₂, acid, alkali, salt, organic matter and other substances in the transported medium, and can be exposed to salty ground water, sea water and soil containing corrosive substances such as various organic acids produced by microorganisms for a long time;
- 2) The coating is tough and **wear-resistant**, has excellent **impact resistance** and bending resistance, and has **excellent adhesion** to the steel pipe, which can effectively prevent mechanical damage during construction and damage to plant roots and soil environmental stress during use;

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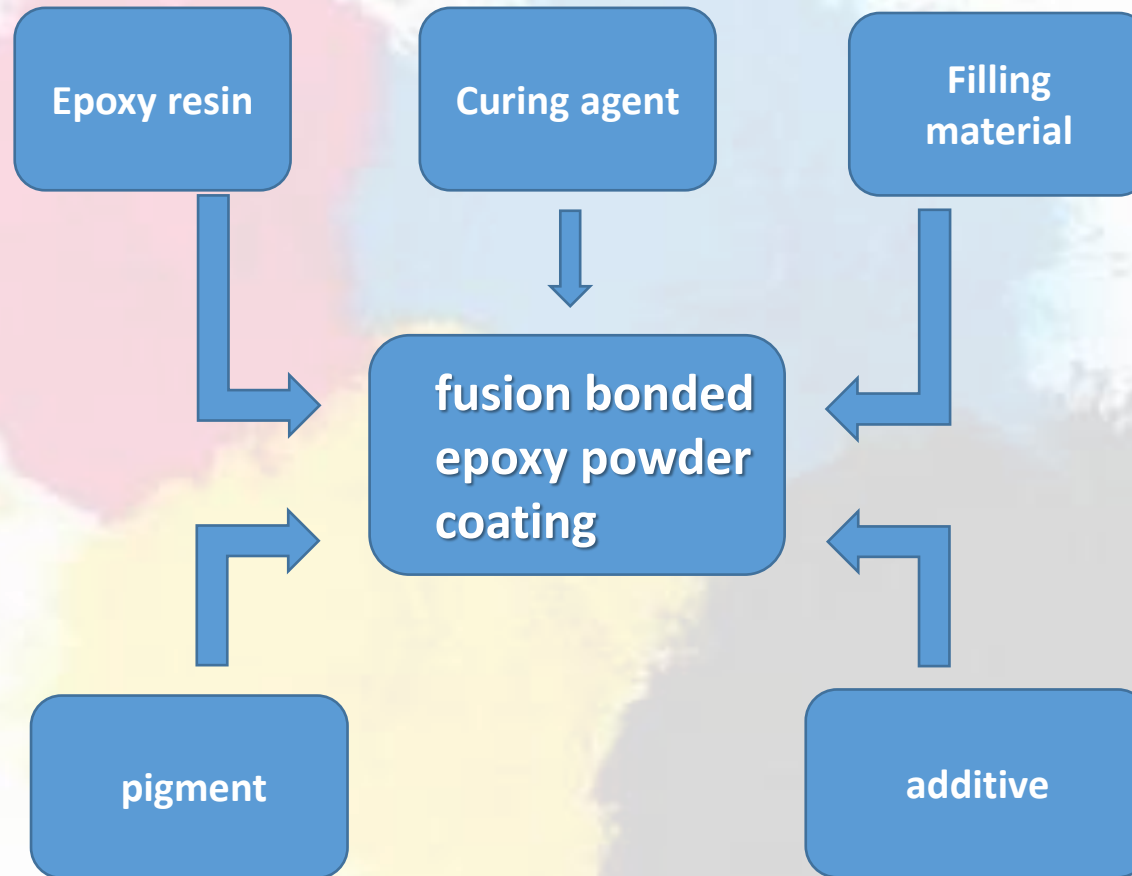
3) The coating has good **insulation properties**, can resist chemical corrosion under cathodic protection, and achieve the purpose of long-term protection;

4) The coating has a high **glass transition temperature**, a wide application temperature range, and can maintain the best performance between -30 and 100° C;

5) FBE construction is convenient, no primer is needed, **fast curing**, assembly line operation, **high coating efficiency**; moreover, pipeline inspection and repair are simple, and the coating quality is easy to control.

6) The fusion bonded epoxy powder coating has poor weather resistance and is **not suitable** for the coating of **outdoor overhead pipelines**.

Composition of fusion bonded epoxy powder coating



环氧粉末涂料的组成

FBE Classifications

- Single layer epoxy powder
- Double layer epoxy powder
- Epoxy powder for 3-PE
- Epoxy powder for internal coating of pipeline
- Epoxy powder for steel bars
- Epoxy powder for prestressed steel strand
- Epoxy powder for encapsulation

How to use FBE

- FBE is only a kind of industrial semi-finished product. Only reasonable use can maximize its excellent characteristics. Therefore, using FBE is as important as making FBE.
 - 1. Adequate pretreatment**
 - 2. Reasonable curing**

Structure of Oxide Scale

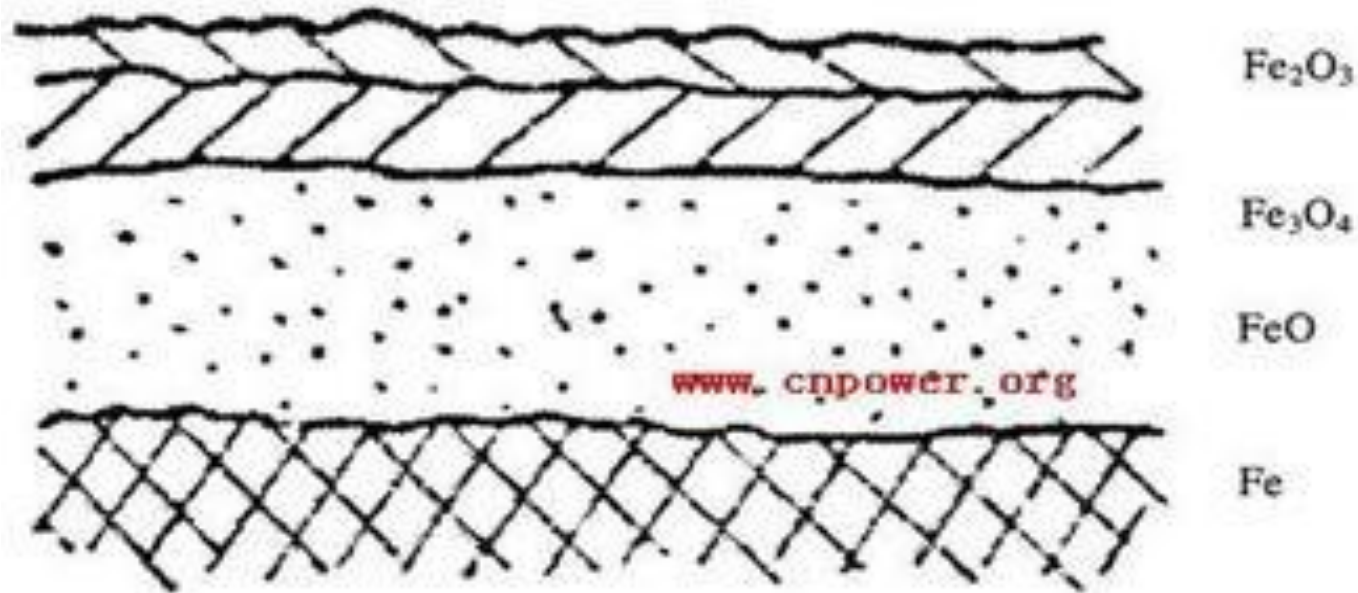


图 4 高于 570℃管内壁多层氧化膜结构

Oxide Scale

- It looks very tight, but there are actually many crevices, and these crevices can be easily permeated by water and oxygen. When the steel pipe just leaves the factory, the surface is completely covered with a layer of hard oxide skin.
- The oxide scale is basically composed of three layers of iron oxide, the surface layer is Fe_2O_3 , the middle layer is Fe_3O_4 , and the third layer composed of FeO comes in direct contact with the metal surface. Fe_2O_3 is chemically stable, while FeO is very unstable. Under the action of water and oxygen, FeO is easily hydrolyzed into iron hydroxide. In this way, the above-mentioned hydrolysis and corrosion will occur. This process slowly starts from the gap and deepens inward along the interface between the metal and the oxide scale, generating a larger volume of rust products on the interface, which will cause changes in the surface stress of the oxide scale, and the oxide scale itself has no ductility, so the oxide scale will soon peel off with the coating on the outside.

Oxide Scale

- In addition, physical factors such as temperature changes and mechanical effects can also cause the oxide scale to lift or peel off.
- From an electrochemical point of view, the electrode potential of the oxide scale is more positive than the metal iron itself by 0.15 ~ 0.20 V. When most of the surface of the steel plate is still attached by the oxide scale, the oxide scale in the corrosive medium constitutes a large cathode, and a small anode is formed on the surface of the steel pipe where the oxide scale is discontinuous, and thus causing serious electrochemical corrosion.

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- FBE curing not only produces a polymer film, but it is also a good adhesive. A simple plastic film alone can not prevent metal corrosion. It must be tightly bonded to the steel surface to prevent the penetration of corrosive media. Usually the paint adheres to the steel surface due to the polar attraction of the secondary bonds between molecules, such as hydrogen bonds and van der Waals forces. The size of the attraction is inversely proportional to the 6th power of the distance between the molecules, and the closer it is, the greater the attraction; The range must be within 5\AA to be effective, that is, within 3 times the diameter of the oxygen atom. Therefore, if there is oil stain on the steel surface, even the single molecule oil stain will exceed 5\AA , which will cause the coating to lose adhesion, delamination and failure.

Substrate surface treatment

Contaminated steel pipe surfaces have an adverse effect on the performance of any coating, and the fusion bonded epoxy coating is no exception. Surface treatment generally refers to shot blasting. In special cases, chemical treatment can be added, but it is not common. Before shot blasting, if there is oil stain on the surface of the steel pipe, the oil stain should be washed off first. The so-called shot blasting is to use a centrifugal shot blasting machine to spray steel grit on the surface of the steel pipe at high speed to clean the rust layer, form the anchor pattern, and **remove the floating dust on the surface**. Generally it should reach the **Sa2.5 level**, and the depth of the **anchor pattern is 40-100 μ m**.



Reasonable curing

- FBE is a thermosetting powder coating. The processing technology mainly refers to the curing temperature and curing time of the powder coating. **Only when it is fully cured can the coating have good physical and chemical properties.** The large-diameter pipe to be coated is generally 12 meters long, and the residual heat is used to solidify it. The gel time must be fast enough to completely solidify before cooling; at the same time, the solidification speed must be slow enough to properly wet and level the surface and to infiltrate into the depth of the anchor pattern. It is a pair of contradictions. Because the fusion-bonded epoxy powder coating FBE is a thermosetting coating, after coating, it not only must be leveled, but also fully cured, and a series of chemical reactions will occur to form a three-dimensional network of macromolecules with similar structure.

Reasonable curing

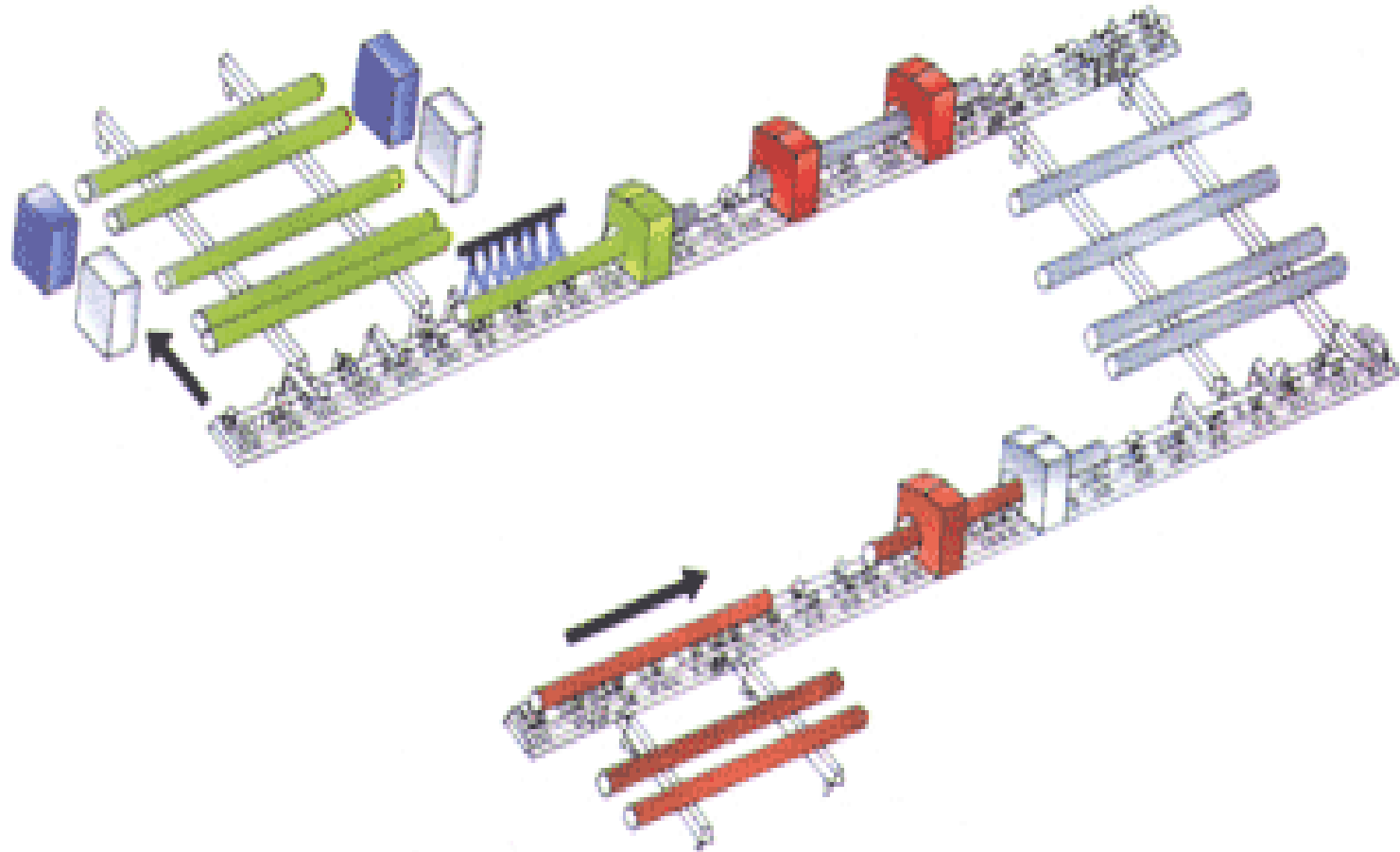
- It needs to be kept at a certain temperature for a period of time to completely react and mature. If the curing percentage is not more than 95%, the physical and chemical properties of the coating cannot be achieved. The resin in the film is still a brittle prepolymer without strength and resistance, not to mention the protection of the steel pipe. This is very important in the use of fusion-bonded epoxy powder. **Only a curing rate reaching 95% or more will be considered as a complete curing.** An incomplete curing or over curing is harmful to the quality of the coating. When the curing temperature is higher than 260°C, the molecular chain of the coating is easy to break, causing side reactions such as degradation and decomposition, the coating is scorched, and the performance cannot be achieved, and the metallographic structure of the substrate may also change, and thus affecting the main strength of the pipeline.

Make the best use of everything

- There are many varieties of FBE, each of which has its own characteristics and performance indicators. The construction and application are not the same. Our principle of choosing FBE is "make the best use of everything." Different workpieces use different FBE and construction techniques. For example: FBE inside the pipeline requires the coating to be dense, hard and wear-resistant, to reduce secondary pollution of the conveying medium, to reduce friction resistance, to extend the service life of steel pipelines, and to improve pipeline transportation efficiency; while the outer coating of the pipeline focuses on the coating toughness and impact resistance, surface leveling is second, after all, protection is the most important. If the two are used in reverse, the intended purpose will not be achieved. Another example: The toughness of the steel bar coating is the first because of the requirements of on-site bending, while the FBE coating in the pipe puts the adhesion first, and the two materials cannot be mixed. Therefore, choosing FBE reasonably is as important as producing FBE.

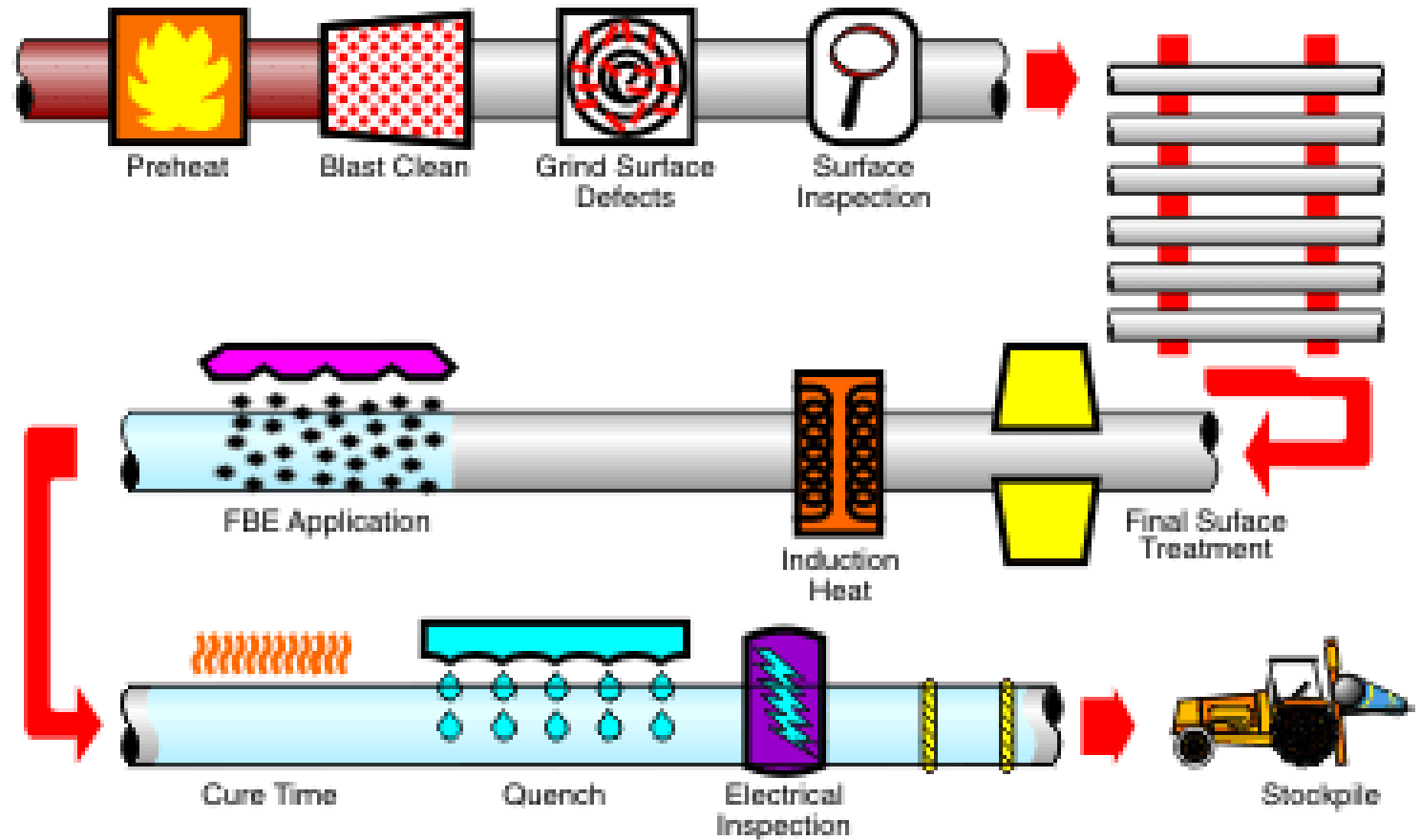
Coating process of anticorrosive epoxy powder coating

FBE Construction sketch



Coating process

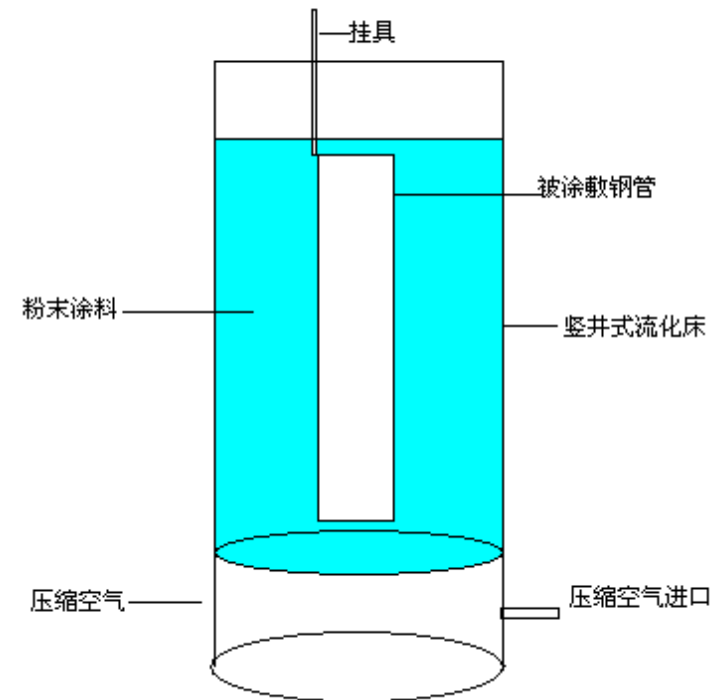
FBE is a thermosetting powder coating. The processing technology mainly refers to the **curing temperature and curing time** of the powder coating. Only when it is fully cured can the coating have good physical and chemical properties. Only when the curing rate reaches 95% or more, it is considered to be fully cured. **Incomplete curing** or **over curing** is harmful to the quality of the coating.



涂敷工艺示意图

Coating process of fusion bonded epoxy powder coating

The coating methods of anticorrosive epoxy powder coatings mainly include: **electrostatic spraying method, thermal spraying method, suction method, fluidized bed method, roller coating method**, etc. The coating inside the pipeline generally adopts friction electrostatic spraying, suction or thermal spraying. The outer coating of the pipeline generally adopts the electrostatic spraying method. For the special-shaped parts the fluidized bed method or the electrostatic spraying method will be adopted.



Schematic diagram of fluidized bed hot dip coating

Intermediate frequency heating and spraying



Intermediate frequency heating

- Intermediate frequency heating furnace is a power supply device that converts 50HZ power frequency alternating current into intermediate frequency (above 300HZ to 1000HZ). It converts three-phase power frequency alternating current into direct current after rectification, and then converts the direct current into adjustable intermediate frequency current, which is supplied to the medium frequency alternating current flowing in the capacitor and the induction coil, generates high-density magnetic lines of force in the induction coil, and cuts the metal material contained in the induction coil, which generates a large eddy current in the metal material. Due to the fast heating rate of this heating method, there is very little oxidation. The oxidation burning loss of intermediate frequency heating forgings is only 0.5%, while the oxidation burning loss of gas furnace heating is 2%, and that of coal-fired furnaces is 3%.

Coating process of fusion bonded epoxy powder coating

Single-layer

Ordinary level: 300~400 μ m

Enhanced level: 400~500 μ m

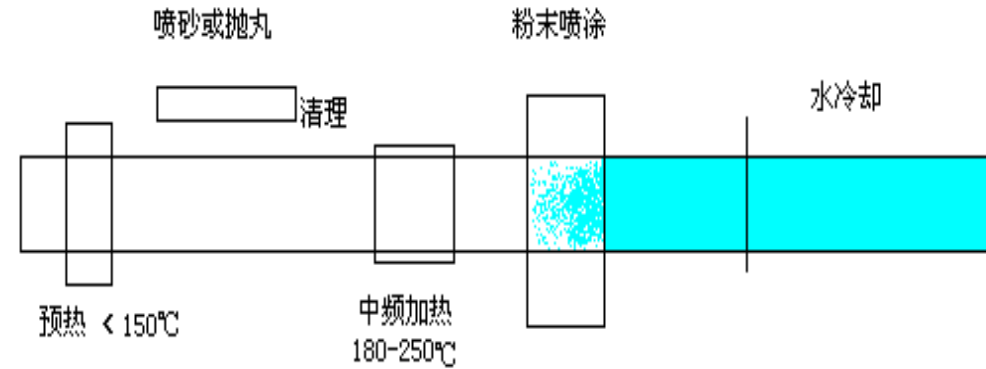


图7 单层熔结环氧粉末涂料涂装示意图



Coating process of fusion bonded epoxy powder coating

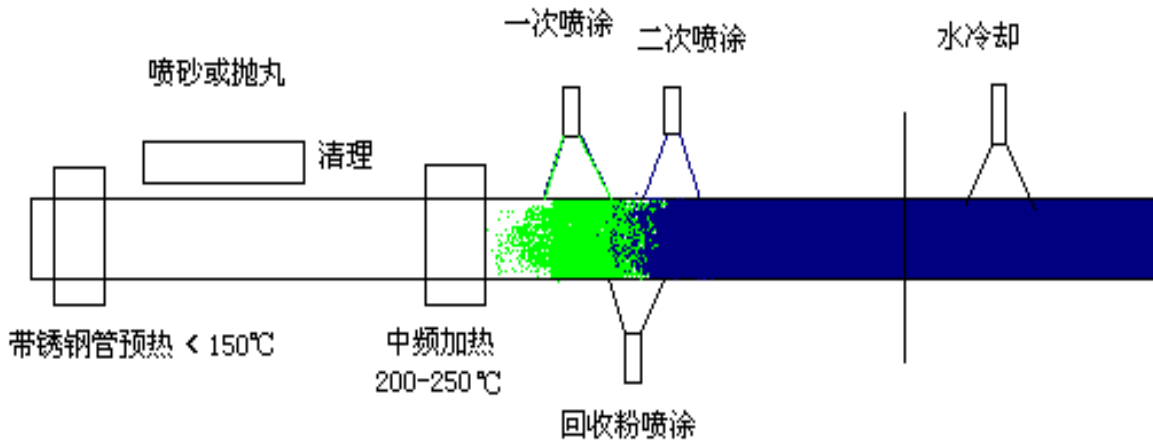
Single-layer

1. Preheat the steel pipe. This process can remove the sundries, loose oxide scale and oil stains on the surface of the steel pipe.
2. Carry out sandblasting treatment to make the surface reach the Sa2.5 level required by the standard GB/T8923-2011, the anchor pattern depth of the surface is in the range of 50~100 μ m, and the appearance is silver gray.
3. Cleaning. The residual sand remaining on the surface must be removed before the intermediate frequency heating, otherwise it will affect the appearance and adhesion of the coating film after coating. Generally, compressed air or a portable dust collector can be used to blow off the remaining sand and dust.
4. Intermediate frequency heating to make the temperature reach 180~250 $^{\circ}$ C, and determine the specific temperature according to the specific situation.
5. Electrostatic spraying, coating is carried out on the electrostatic powder automatic coating line, the thickness of the coating film is determined according to the use, ordinary grade \geq 300~400 μ m, reinforced grade \geq 400~500 μ m; curing time and curing temperature are based on specific process conditions set.
6. Cool with cooling water.

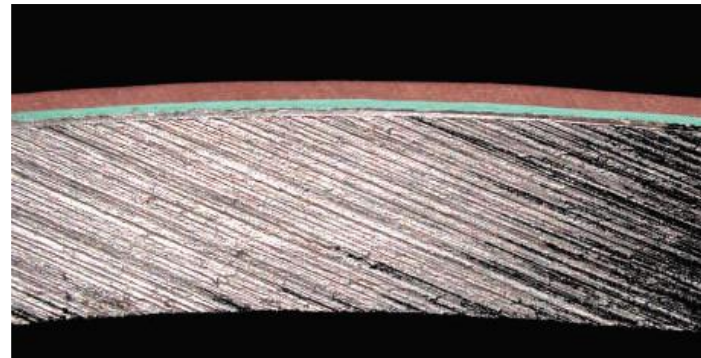
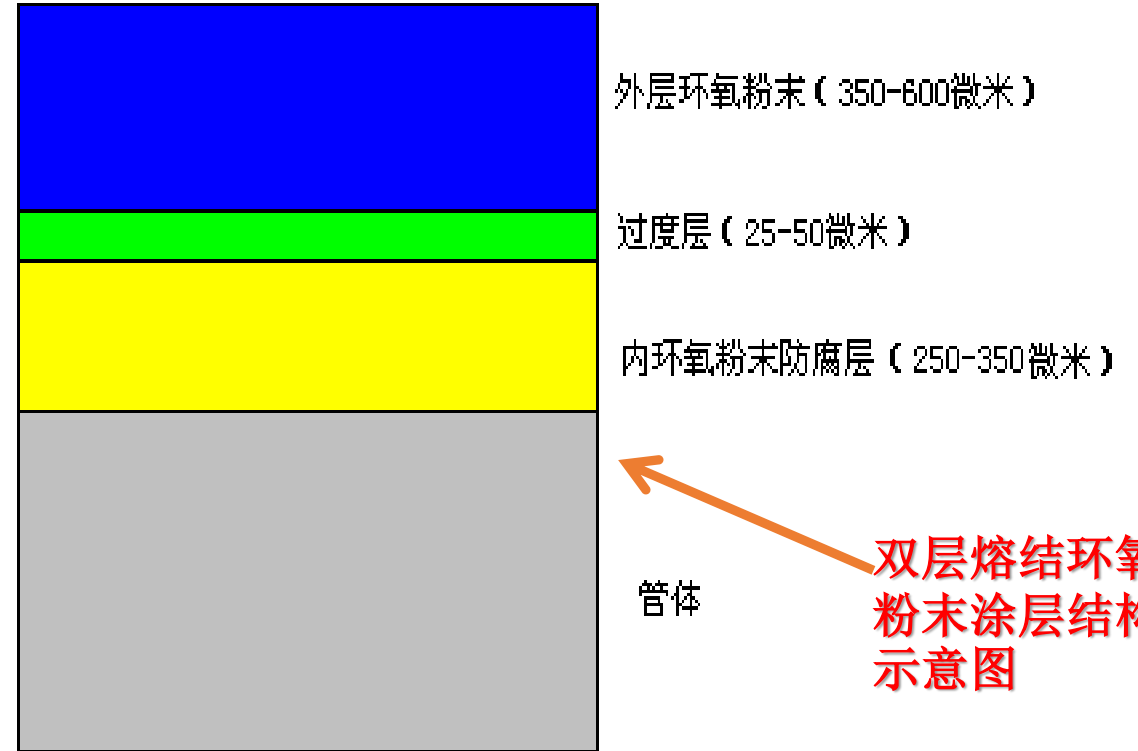
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Coating process of fusion bonded epoxy powder coating

Double layer



双层熔结环氧粉末涂料涂装示意图



Coating process of fusion bonded epoxy powder coating

Double layer

1. Preheat the steel pipe. This process can remove the sundries, loose oxide scale and oil stains on the surface of the steel pipe.
2. Carry out sandblasting treatment to make the surface reach the Sa2.5 level required by the standard GB/T8923-2011, the anchor pattern depth of the surface is in the range of 50~100 μ m, and the appearance is silver gray.
3. Cleaning. The residual sand remaining on the surface must be removed before the intermediate frequency heating, otherwise it will affect the appearance and adhesion of the coating film after coating. Generally, compressed air or a portable dust collector can be used to blow off the remaining sand and dust.

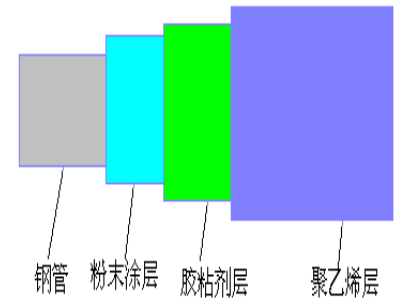
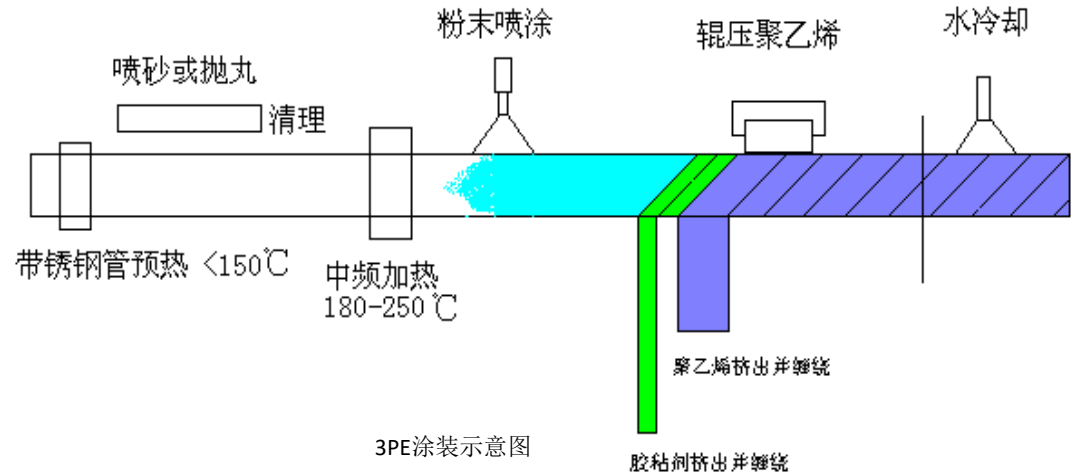
Coating process of fusion bonded epoxy powder coating

Double layer

4. Intermediate frequency heating to make the temperature reach 200~250°C, and the temperature range is determined according to the specific situation.
5. Electrostatic spraying, coating on the powder coating line. The first coat first coats the bottom epoxy powder; the second coats the top coat epoxy powder. When the first bottom epoxy powder coating is not fully cured, spray the second top coat epoxy powder coating to make the bottom powder coating It melts and solidifies well with the middle bonding layer of the surface layer powder coating, which enhances the bonding force between the layers. The thickness of the coating film is determined according to the application. Generally, the coating film thickness of the basic powder coating is $\geq 250\mu\text{m}$ for ordinary grade, and $\geq 300\mu\text{m}$ for reinforced grade; the thickness of the surface layer coating film is $\geq 370\mu\text{m}$ for ordinary grade and $\geq 500\mu\text{m}$ for reinforced grade.
6. Cool with cooling water.

Coating process of fusion bonded epoxy powder coating

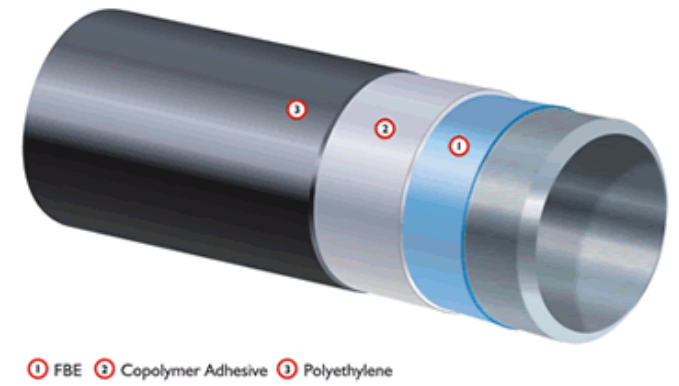
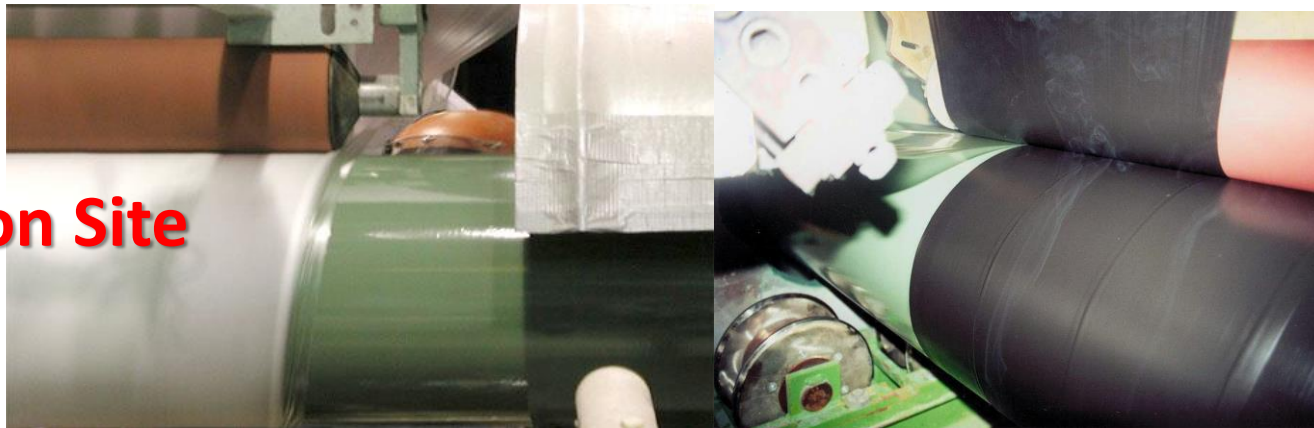
Three layers



3PE结构示意图

Thickness of FBE layer normally $\geq 150\mu\text{m}$

Construction Site



① FBE ② Copolymer Adhesive ③ Polyethylene

Coating process of fusion bonded epoxy powder coating

3 layers

1. Preheat the steel pipe. This process can remove the sundries, loose oxide scale and oil stains on the surface of the steel pipe.
2. Carry out sandblasting treatment to make the surface reach the Sa2.5 level required by the standard GB/T8923-2011, the anchor pattern depth of the surface is in the range of 50~75 μ m, and the appearance is silver gray.
3. Cleaning. The residual sand remaining on the surface must be removed before the intermediate frequency heating, otherwise it will affect the appearance and adhesion of the coating film after coating. Generally, compressed air or a portable dust collector can be used to blow off the remaining sand and dust.

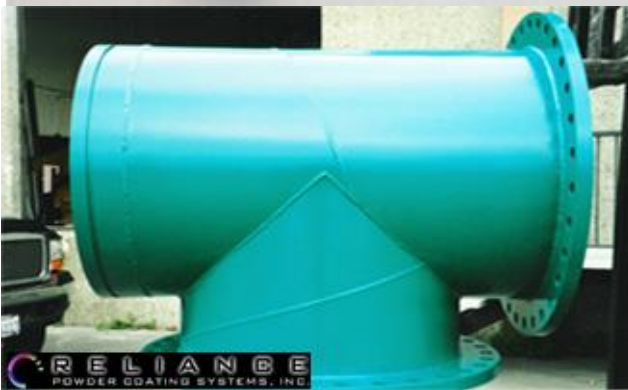
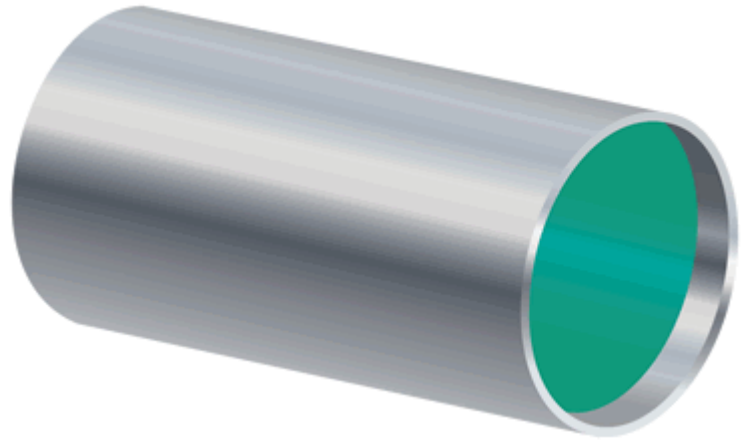
Coating process of fusion bonded epoxy powder coating

3 layers

4. Intermediate frequency heating to make the temperature reach 180~250°C, and the temperature range is determined according to the specific situation.
5. Electrostatic spraying, coating on the powder coating line. The thickness of the coating film is generally $\geq 80\mu\text{m}$
6. In the process of epoxy coating gelling, use an extruder to squeeze the adhesive to make the adhesive and the epoxy powder coating fuse together well, so that there is a good bonding force between the two coatings.
7. On the adhesive coating, when there is a certain temperature, use the extruder to squeeze the high-pressure low-density polyethylene coating to make the adhesive and polyethylene fuse together well, so that the two coatings Have a good binding force.
8. Cool with cooling water.

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Inner-coated pipes and special-shaped pipe fittings



Coating process of fusion bonded epoxy powder coating

Repair of Coating Layer



破损图

清理图

修补图

Coated Joints

