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Environment-Friendly Electrostatic Spraying Technology of Solvent-Based Coatings

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Abstract

Environment-friendly electrostatic spraying technology and its advantages were introduced. The development prospect of electrostatic spraying technology, mechanism and design principle of the recipe of solvent-based coatings were discussed.

Keywords: Electrostatic spraying; Resource saving; Conductivity; Electrostatic thinner; Sent-based coatings

Introduction

A lot of solvent-based coatings have been used in automobile, equipments, motorcycle and machine trade, etc. As the workpieces which need to be sprayed with solvent-based coatings are different in shape and size, therefore, the spraying difficulty levels are different. Only about 30 percent coatings can be effectively used in conventional spraying process, and most of the coatings are wasted and lead to serious environmental pollution. In order to improve the spraying efficiency and reduce the environmental pollution, great effort has been made by many related manufactures. Bayat et al. [1,2] proved that many advantages of electrostatic spraying technology, such as high transfer efficiency, reduced emissions of VOC and coating, suited for irregular parts and saving spraying materials and labors. With the improvement in transfer efficiency, the clean-up cost went down, the material consumption and the disposal cost decreased, and manpower was saved. This technology can also be used in agriculture area for chemical spraying and waterborne coatings. Although most researchers have focused on the electrostatic spraying of pesticide [1,2] and the exploitation of electrostatic equipments [3,4], little work has been reported on the modulation method of solvent-based coatings in electrostatic spraying. This study offers an effective and simple method to paints praying factories on solvents-based electrostatic spraying technology.

Fixed cup and high-speed rotated cup type electrostatic sprayers had been used in China which could fulfill the demands of resource saving and environmental protection partly in the late twentieth century. As the limitation of the electrostatic spraying technology then, the disadvantages of those electrostatic spraying equipments were insufficiently atomizing and nonuniformly spraying. This case can reduce spraying efficiency and make the workpieces need re-spraying and the post-treatment wasted much time and manpower. For this reason, the electrostatic spraying equipments were insufficiently used then. Since 1990s, some spraying factories in China have imported advanced electrostatic spraying equipments from America, Germany and other developed countries. The advanced spraying equipments have some new advantages such as light weight, sufficiently atomizing, uniformly spraying, clean and easy to use which are of much beneficial to economy and environment. Compared to a conventional electrostatic spraying gun (like American JSS10 hand-held equipment), it was found that the utilization efficiency of solvent-based coatings increased from 35% to 68%. One of these electrostatic equipments could save 120 kg coatings and 60 kg solvents within 18h, and save the cost almost 380$ per day. The data from this tractor factory showed that about 730,000$ materials and 36,000$ electrical energy and labor cost were saved by using electrostatic spraying equipments in 2008.

Principle of electrostatic spraying

The nozzle of an electrostatic spraying gun is an ionized electrode, which can make atomized particles of coatings pick up additional electrons and change to negative electric charge. An electrostatic field created by a grounded power not only draws the paint particles to the workpiece and minimizes the drift and overspray, but also makes the droplets of the coatings absorbed on the parts tightly. Then the electrical charges are driven and returned to the power supply to complete a circuit. During the spraying process, paint droplets flow to the workpiece and are attracted so tightly that the paint drift, overspray and the consumption of the solvent and material in each work piece are minimized [5,6].

Technological parameters of electrostatic spraying

An electrostatic spraying system can output 30~150 kV adjustable voltage, 50~100 mA adjustable direct current in operation, and give about 200 ml paint conveying capacity per minute. The spraying viscosity of paint is 9~18 s (Ford 4# viscosity cup), the volume resistivity of the coatings is 0.2~2.0 Mega-Ohm-meter (MΩ·m), and the jet breadth of the spray is 25 to 35 centimeters [6].

Formula Design of Electrostatic Spraying Coatings

Choice of original paint

The type of paint is chosen according to the properties of match, protection, decoration and adhesion of the workpieces needed. The balance between the original viscosity and conductivity of original coatings is determined by the spraying viscosity and type of the thinner.

Choice of the electrostatic thinner

As the volume resistance resistivity of an original paint is about 0.75~4.0 MΩ·m, it is unfit for spraying before adjustment, so electrostatic thinner must be added to raise conductivity. The electrostatic thinner is a high polar solvent and its conductivity is

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less than 0.10 MΩ·m. Butyl acetate, diacetone alcohol, low carbon alcohol and low carbon ketone are commonly used as electrostatic thinner [7]; their dosages are determined by the spraying conductivity. Metal and carbon black powder have higher conductivity. If the paint has conductive powder, less electrostatic thinner is needed for its adjustment. And as the original viscosity of the paint is higher than its spraying viscosity, the paint must be diluted by thinner before spraying. Usually the adding amount of thinner is about 40% of the original paint, and the amount of the conductive thinner must be controlled strictly. Insufficient conductive thinner could not reach the spraying conductivity and lead to sputter and insufficient atomization. Instead, excess electrostatic thinner may cause leakage, so “non polar” solvents are needed to balance the viscosity and conductivity.

The dosage and type of the thinners are chosen according to the electrostatic equipments and the weather. The paint droplets move faster in electrostatic spraying system than that in conventional spraying, so the thinner volatilizes faster and more thinner is consumed in the electrostatic spraying. Furthermore, hot weather also makes the thinner volatilize fast. In order to slow down the evaporation of the thinner and balance the conductivity in electrostatic spraying process, some slow-evaporating solvents such as high boiling aromatic, n-butyl lactate solvents are needed. Pay attention to the balance of evaporation velocity and solubility of the electrostatic thinners, because they are different with the type.

Calculation of electrostatic parameters

There is an exponent relationship between the conductivity of an electrostatic paint and the conductive thinner. The eligible conductivity of a spraying paint is between 15 and 0.40 MΩ·m. The relationship between the adding dosage x (wt%) and the whole conductivity y of the coatings (MΩ·m) is shown in the formula (1) [8].

$$y=A_1e^{-BX}+A_2X^B \quad (1)$$

Where A_1 is the conductivity of original coatings;

A_2 is the conductivity (MΩ·m) of the thinner;

B is the characteristic constant of the thinner, and the B value is about 10 to 200. From the formula (1) we can know that that: $\lim_{X\to 0}$, $y=A_1$. y is the conductivity of unadjusted coatings, and no electrostatic thinner is added in this case. When $\lim_{X\to 1}$, $y=A_1e^{-B}+A_2\approx A_2$, y is the conductivity of the electrostatic thinner now. As the y value in formula (1) is not easy to get, and the A_2X^B is much less than A_1e^{-BX}, A_2X^B can be ignored in the calculation, so the formula (1) can be changed to the formula $y=A_1e^{-BX}$. The A_1, A_2, and B value of some materials are listed in Table 1.

Generally speaking, if the A_2 value of different electrostatic thinners is similar, the B value of the thinners will be similar too. We can estimate the B value of an electrostatic thinner using this rule in Table 1. Butyl acetate, diacetone alcohol, cyclohexanone, and high boiling point hydrocarbon have lower volatility, and alcohol, acetone and toluene etc have higher volatility, so we should choose the thinner according to the weather flexibly. We can use formula $y=A_1e^{-BX}$ and Table 1 to calculate the conductivity of the paint. In fact, it is convenient to control the conductivity of the paint using a high volt shake meter.

Coatings	Amino baking	Metal powder	Alkyd resin	Arene and gasolene
A_1 (MΩ·m)	~2.5	~1.0	~4.0	>4.0
Electrostatic thinner	Butyl lactate	diacetone alcohol	_	Alcohol, acetone and cyclohexanone
B	~13	15~25	_	15~20
A_2 (MΩ·m)	0.01~0.02	0.002~0.015	_	0.002~0.015

Table 1: A and B value of coatings and electrostatic solvents.

Components	content/weight (g)
Acrylic resin (60%)	45
Melamine–formaldehyde resin (60%)	12~20
Red pigment	8
Butyl lactate	6
Diacetone alcohol	9
Xylene	15
High boiling point hydrocarbon solvent	4

Table 2: The recipe of red acrylic amino baking electrostatic paint.

Components	Content / weight (g)
Hydroxy acrylic resin (60%)	40
Polyisocyanate resin curing agent (60%)	12~20
Metal powder	14
Alcohol	5
Acetone	6
Xylene	15
High boiling point hydrocarbon solvent	8

Table 3: The recipe of sparkling acrylic polyurethane electrostatic paint.

The conductive mechanism of electrostatic thinner

As polar molecules, the electrostatic thinners possess dipole moment, which can produce induced polarization and reinforce directed dipole in external electric field. The polar molecules of the electrostatic thinner in the paint are orientation polarization in the external electric field and the conductivity is reinforced [9]. The more the electrostatic thinner in coatings, the higher conductivity of the paint is obtained. Two reference recipes of the electrostatic paint are listed in Table 2 and Table 3.

Conclusion

Electrostatic spraying is a practical technique; it can increase the utilization ratio of coatings from 35% to 68%. This technology not only saves the consumption of the paint and thinner, but also reduces air pollution. It highly benefits economy and society, and should be developed widely.

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References

1. Bayat A, Zeren Y, Refat M (1994) Agriculture Mechanization in Asia and Latin America 25: 35-41.
2. Asano K (1986) Electrostatic spraying of liquid pesticide. J Electrostat 18: 63-81.
3. Cramariuc R, Nisiparu L, Cramariuc B (2009) The energetic balance of the two different electrostatic processes: Electrostatic liquid spraying and electrostatic induction for electrical field measuring. Journal of Electrostatics 67: 209–214.
4. Moon JD, Lee DH, Kang TG, Yon KS (2003) A capacitive type of electrostatic spraying nozzle. Journal of Electrostatics 57: 363–379.
5. Leupold HA (2000) Magic cylinder adjustable in field strength. US Patent 629756 July 31.
6. Hakberg B, Lundqvist S, Carlsson B, Högberg TA (1983)A theoretical model for electrostatic spraying and coating. Journal of Electrostatics 14: 255-268
7. Xu XH, Wang YH, Jiang YT (1997) Chinese Paint Technology (first volume), Beijing, Publication of Chemical Industry 688-722.

8. Zhang JP (1994) The formula design of electrostatic spraying coatings. Chinese Paint and Coatings Industry 5: 26-29.
9. Franck G, Ballu P (2010) Electrostatic spraying apparatus including mobile electrodes, and method for electrostatic spraying using such a spraying apparatus: WO/2010/097539 Feb 23.