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LIQUID PAINT APPLICATION WITH ELECTROSTATICS

August 2021

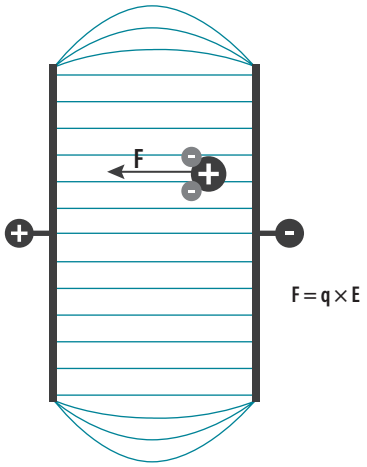
Applying liquid paint with electrostatics
Why investing in this economical and environmentally friendly process is worthwhile

The electrostatic coating of surfaces has been state of the art for years. Highest surface quality and a particularly high application efficiency, which takes into account increasingly stringent environmental regulations, are the drivers of this technology. However, due to the higher initial costs compared to conventional liquid coating and existing safety concerns, some users shy away from the use of electrostatics.

This article, in addition to explaining the basics of electrostatics, shows both the limits of this technology and the great opportunities it presents, and clearly demonstrates that the initially higher investment can be amortized very quickly. A full analysis of the prevailing circumstances is the key to a successful coating process.

What is electrostatics?

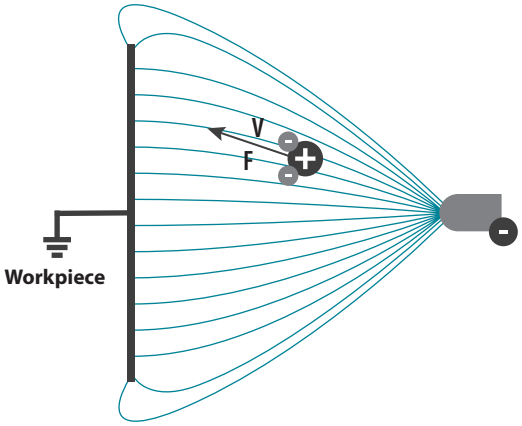
Everyone knows the phenomenon: the sudden discharge of an arc of light during a thunderstorm, the brief „electric shock" when getting out of the car, or simply the annoying dust deposits on our electrical appliances. Charged particles are responsible for this. Equally charged particles repel each other and differently charged particles attract each other (e.g. the negatively charged dust particle on the grounded screen). The electric field determines the movement of charged particles. In it, the particles experience a force along the field lines depending on charge and field strength.



Coulomb force on charged particles in the electric field

The role of electrostatics in coating

When preparing surfaces for coating, we try at all costs to avoid or eliminate any charge, in order to prevent negatively charged dust particles from adhering to the workpiece but when we coat electrostatically, the exact opposite is true. The aim is for an electric field that is as strong as possible to help guide the charged paint droplets along orderly paths to the workpiece without ending up as waste in the separator and damaging the VOC balance.



Task of the electrostatic gun:
Atomization + generation of the electric field
+ charging of the paint droplets

The aim is therefore to generate the strongest possible electric field and to negatively charge the atomized paint droplets. The paint spray gun must be able to do both perfectly, in addition to the usual atomization performance. The voltage required for this is generated by a high-voltage cascade and can be set up to a maximum of 100,000 volts, depending on the application process.

Requirements and suitability for successful electrostatic coating

Suitable paint:
Water-based paints are generally electrically conductive. Solvent-based coatings must have at least the minimum conductivity required to charge the material particles, which are then conducted toward the workpiece by the field lines of the high voltage. The material manufacturer should be contacted if there are any questions.

Conductive workpieces:
Application with electrostatics is most suitable for electrically conductive workpieces, especially those made of metal. The resistance of the workpiece should not exceed 1MΩ. Wood is also suitable if a certain residual moisture of at least 15% is present in the workpiece. In addition, non-conductive workpieces made of plastic or glass are also frequently coated with this technology. However, this requires special pretreatments. Under certain circumstances, it is sufficient to apply a conductive primer beforehand - as is the case, for example, with the coating of glass bottles *(see picture)* - or to start coating directly at the grounding point so that the conductive coating, which is still liquid, creates a conductive connection to the grounding point. In all cases, optimum grounding of the workpiece must be ensured.

Very good grounding:
The greatest possible cleanliness, especially at the electrical connections and grounding lines, as well as at the tools, is a basic requirement for proper grounding and thus for the best possible electrostatic effect. Only in this way can as much material as possible reach the workpiece and the application efficiency be maximized. Any kind of deposits and residues can cause grounding interruptions or creepage distances that prevent the positive electrostatic effect.

Workpiece geometries:
More complex bodies with lattice structures or round shapes are particularly suitable for coating with electrostatics, since the coating material also reaches the rear side of the workpiece due to the wrap-around effect, resulting in the greatest material savings. The time required for coating per workpiece can be significantly reduced.

Advantages of electrostatic coating

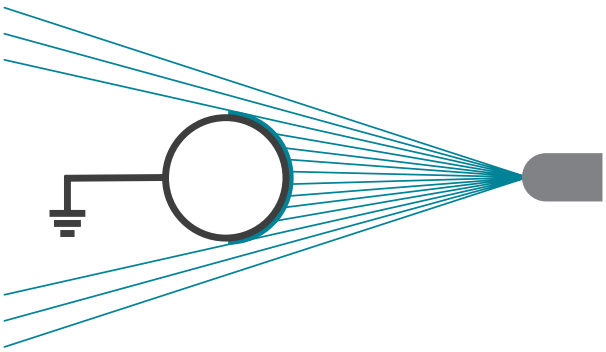
The field lines of the electric field always strike the workpiece perpendicularly - even on the side facing away from the spray jet. This results in a number of advantages for the painting process. Thanks to its high application efficiency, the electrostatic process is also particularly economical and environmentally friendly.

Wrap-around effect:
The workpiece is also coated on the reverse side facing away from the spray jet.

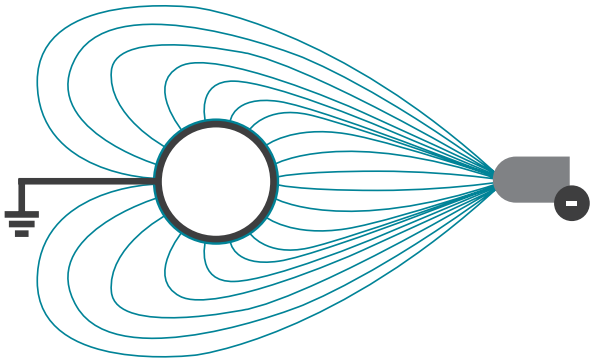
Fine atomization:
In addition to conventional atomization, the repulsive forces ensure smaller droplets. Depending on the situation, electrostatics can be used to lower the material and air pressure even further, thus achieving smoother atomization with an even smaller droplet size.

Uniform coating quality:
The charged paint droplets travel along the field lines to the workpiece and strike it vertically and evenly distributed as they repel each other. This results in a high surface quality.

Optimum edge coating:
By concentrating field lines at the corners and edges of a workpiece, undercoating at these points is avoided.



Without electrostatics
Significant overspray / no wrap-around



With electrostatics
Less overspray / significant wrap-around

Solvent- or water-based systems?

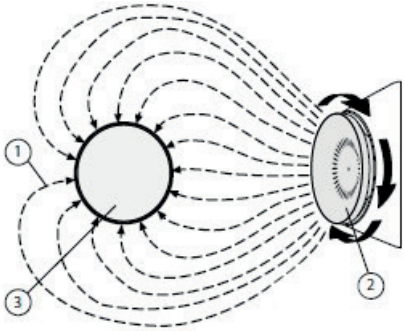
The choice of the paint system fundamentally determines the method of charging the paint and thus also the applicator and the entire coating system.

Solvent-based coatings are charged directly with an electrode positioned in the center of the spray jet and located directly in the gun. This is possible because solvent-based coatings have a comparatively high electrical resistance (i.e., low electrical conductivity) and the voltage is already dissipated within the applicator, so there is no danger to the user. If the conductivity is too high, there is a risk that too much current will flow to ground and the high voltage will drop sharply. In this case, the high voltage acts back into the material hose and can flash over to the outside. Special material hoses that are high-voltage resistant and insulated enable these coatings to be processed with the identical technology.

The use of water-based coatings plays an increasingly important role in environmental protection. There are two different processes for this.

In the case of **internal charging**, the water-based paint is charged either in the applicator or in the paint container. Due to the high conductivity of the paint, the entire system - applicator, material hose, pump and paint container with accessories - is under high voltage and must be insulated accordingly for safety reasons.

Illustration of the charging method using a high-speed rotation atomizer:



1 - Paint particles
2 - Rotating bell
3 - Grounded object

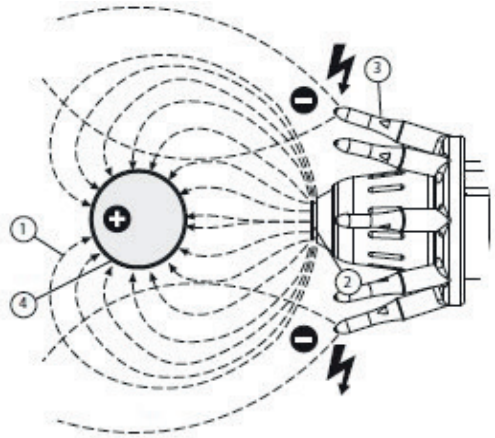
High-speed rotation atomizer with internal charging

To isolate all components that come into contact with the material (such as material hoses, pumps and paint containers), the paint kitchen must be protected by a closed room or a grid. Alternatively, it is also possible to install it in a high-voltage-resistant cabinet, such as the AquaCoat 5010/5020. This cabinet consists of the completely insulated supply unit including pump, high voltage supply, safety technology, material hose and gun. Access to the paint container is only possible when the system is completely discharged. The built-in safety system ensures that the painter never comes into contact with the high voltage.

AquaCoat electrostatic system

In external charging, due to its high conductivity, the water-based paint is charged using electrodes positioned outside the spray jet (Corona process). The high voltage emitted via the electrode ring ionizes the ambient air in such a way that the sprayed material is charged. This process is used in particular in high-speed rotation atomizers for applying water-based coatings in the automotive industry.

Here, the applicator is well insulated so that it is not live. The material savings are somewhat lower compared to coating with internal charging. However, the major advantage with external charging is that the user does not have to charge and insulate the entire coating system, including the paint kitchen, which significantly reduces the investment costs of the system.

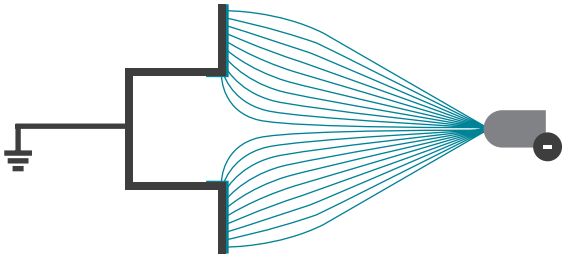


1 - Paint particles
2 - Rotating bell
3 - Electrode ring with electrode fingers
4 - Grounded object

High-speed rotation atomizer with external charging

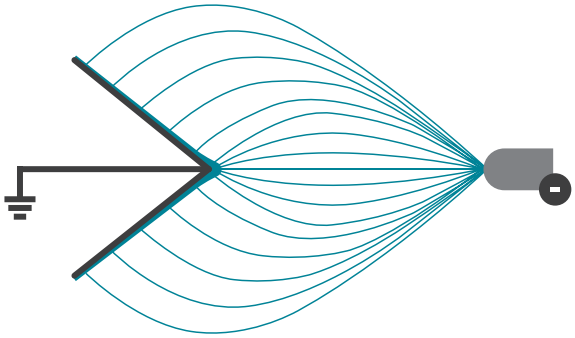
Limits of electrostatics

Internal coatings, cup-shaped structures or cavities: Here, the Faraday effect prevents the penetration of field lines by completely shading the electric field. In such places, it needs to be possible to switch off the electrostatics (for a short time) in order to be able to coat these areas. Alternatively, comparatively high material and air pressure must be used.



Shading: *Field lines do not penetrate cavities. The Faraday effect hinders the electrostatic coating process.*

Overcoating:
Opportunity and risk at the same time. The field lines are concentrated at edges and corners, thereby ensuring reliable coverage, but can also quickly lead to overcoating (picture frame effect). At these points, it is recommended that the high voltage is reduced accordingly.



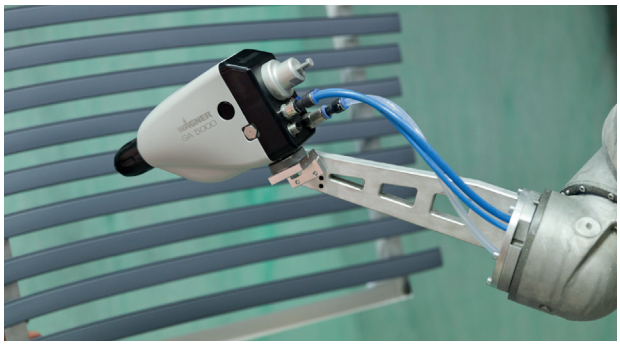
Densification: *Field line concentration at edges and peaks leads to overcoating*

Application technologies in electrostatics

Electrostatic technology is used for airspray and AirCoat applications (both also available as AquaCoat versions for water-based coatings), as well as for high-speed rotation atomization. The process is not suitable for applications with a material pressure of more than 250 bar, because the relatively large droplets and the very high spray pressure generate high levels of kinetic energy, which sideline the electrostatic effect.

The key factor in creating a good electrostatic effect is the selected coating process and its settings. The lower the material and air pressure is set on the applicator, the better the electrostatic effect. The reason is simple: the kinetic energy of the paint droplets is superimposed on the attractive force in the electric field. So the smaller the droplet size and kinetic energy introduced, the less overspray is produced and the more wrap-around and uniformity of the coating is generated.

Airspray
The conventional air atomizing process is the classic form of paint atomization. The paint is atomized at a low material pressure (usually between 1-3 bar) solely by the atomizing air supplied (also at 1-3 bar). This produces very fine and small droplets. The airspray process is used in combination with electrostatics in many industrial applications as it produces a very high level of surface quality.



Automatic airspray gun with electrostatics

AirCoat
A characteristic feature of the AirCoat process is the higher material pressure of up to 250 bar, which atomizes the material as it leaves the nozzle. In addition, the spray jet is particularly smooth and homogeneous due to the supply of additional atomizing air. This is ensured by the central air supply (air cap) located directly at the nozzle bore, which surrounds the spray medium like a jacket. High coating speed and low paint mist formation combined with very good coating quality are further key benefits. The kinetic energy of the droplets is still small enough for electrostatics to be used.

Manual AirCoat gun with electrostatics

High-speed rotation atomization
In this process, the material is atomized by centrifugal forces on a bell disk running at very high speed (approx. 20,000 - 60,000 rpm). The steering airs of an air guide ring direct the material in the desired direction and adjust the size of the spray cloud according to need (200 - 700 mm). With this process, a very fine atomization can be achieved, which, in addition to an effective electrostatic charge, also enables a very thin coating thickness application of 5 - 15 µmm.

High-speed rotation atomizer mounted on a robot arm

The right product and process selection

Rule of thumb: The lower the material and air pressure is set, the better the electrostatic effect will be. In practice, the material pressure is often set much higher than necessary. Then, of course, the air pressure must also be correspondingly high. As a result, the high kinetic energy and the resulting overspray prevent the paint droplets from being effectively attracted to the workpiece. Therefore, it is always better to increase the pressures slowly until the optimum atomization is achieved.

Airspray, AirCoat or high-speed rotation?
The smallest droplets are produced by pure air atomization or high-speed rotation. The painting process is somewhat slower here than with the air-assisted airless process (AirCoat), but the highest surface quality can be achieved. With the AirCoat process, the droplets as well as the overspray and the working speed are greater, although a very good surface quality is still achieved due to the electrostatic effect.

As a very good alternative, the high-speed rotation process, which is primarily used in large series, is becoming more and more popular in general industry. It also produces very fine atomization and a high level of coating quality and material efficiency.

All the main advantages of electrostatics apply equally to all electrostatic products - whether manual or automatic, for solvent- or water-based coatings, low-pressure or high-pressure, or as a high-speed rotation atomizer.

The decision whether to coat manually or automatically is based primarily on economic conditions and, of course, on technical feasibility. Manual coating is used wherever automation via lifting devices, linear axes or robots is not worthwhile or cannot be implemented, e.g. for very long crane parts or aircraft fuselages.

The WAGNER product portfolio

WAGNER offers a wide range of manual and automatic products and solutions for electrostatic coating, covering all processes and requirements.

	Airspray Manual	Airspray Automatic	AirCoat Manual	AirCoat Automatic	High-speed rotation Internal	High-speed rotation External
Solvent-based paint	GM 5000EA 	GA 5000EA 	GM 5000EAC 	GA 5000EAC 	TOPFINISH RobotBell / Bell 1S 	
Water-based paint	GM 5020EAW + AquaCoat 5010/5020  	GA 5000EAW + AquaCoat 5010/5020  	GM 5020EAC + AquaCoat 5010/5020  	GA 5000EACW + AquaCoat 5010/5020  		TOPFINISH RobotBell ECH / Bell 1S ECH  

Examples from practice

Amortization in 70 days:
A manufacturer of industrial lifting platforms has a 2K system and two electrostatic guns of older design in use and previously worked with a material pressure of 150 bar. With this high material pressure, and the high atomizer air pressure that requires, the paint droplets obtain such a high velocity that the electric field cannot catch them. The result: During coating, paint mist is formed as with conventional air atomization and the painter has to paint all around in three work steps to ensure that the workpiece is satisfactorily coated.

With the WAGNER GM 5000EAC, it was possible to almost halve the material pressure at the first go. This was achieved by reducing the upstream pressure to 80 bar and the atomizing air pressure to 1.25 bar. The result is convincing: The workpiece is coated in only two instead of three work steps, which means a great time saving for the customer. In addition, the paint savings amount to approx. 30 - 35 % compared to the previous process. Furthermore, the gun is about half the weight. A direct comparison at two identical workstations showed a reduction in paint consumption from approx. 60 kg to just over 40 kg per day. At a material price of approx. 9 €/kg, a 30% saving results in a calculated amortization time of only 70 days for both workstations.

Changeover from conventional airless process to electrostatics with AirCoat:
The customer was working with an electric high-pressure diaphragm pump at 120 bar spray pressure at the gun. Accordingly, the paint mist and overspray were high. Using the same paint and an electrostatic AirCoat gun with a 0.013“ nozzle, the material pressure was reduced to 35 bar and the atomizing air pressure to about 1 bar - only a quarter of the previous pressure. With this setup, the customer was able to achieve the ideal atomization quality for his application. Together with the electrostatics, the customer now uses only 60 L of paint per day at €8/L - exactly 60% less material. This means that the system pays for itself in just over a month.

These are certainly two extreme examples. However, they show that with electrostatics, significant savings potential and rapid amortization are also possible in the area of manual application - despite the higher investment for gun and control unit at first glance.

Conclusion

The investment costs for electrostatic coating are higher than for conventional processes. However, this technical expense is worthwhile for the user, since the benefits of this technology clearly outweigh the costs: Generally, a very high application efficiency is achieved. This saves the user material costs of up to 50% or even more compared with conventional processes.

- VOC emissions are significantly reduced, with virtually no VOCs being generated in water-based coating applications. As a result, the target values can be met and the paint waste to be disposed of and its costs are minimized.
- Generally, a higher surface quality is achieved than with standard processes.
- The workpieces can be coated more quickly, which increases productivity.
- Paint mist is significantly reduced. This makes work much easier for the user, particularly in enclosed areas such as containers.
- Cleaning effort and costs are significantly lower.
- Exhaust air filters can be replaced at longer intervals, which also helps to reduce costs.

Ultimately, this process not only leads to excellent surface quality, but also makes a significant contribution to more environmentally friendly coating processes.

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