APPLICATION PROCESSES AND APPLICATION EQUIPMENT

ITW Gema

Edition 05/2007

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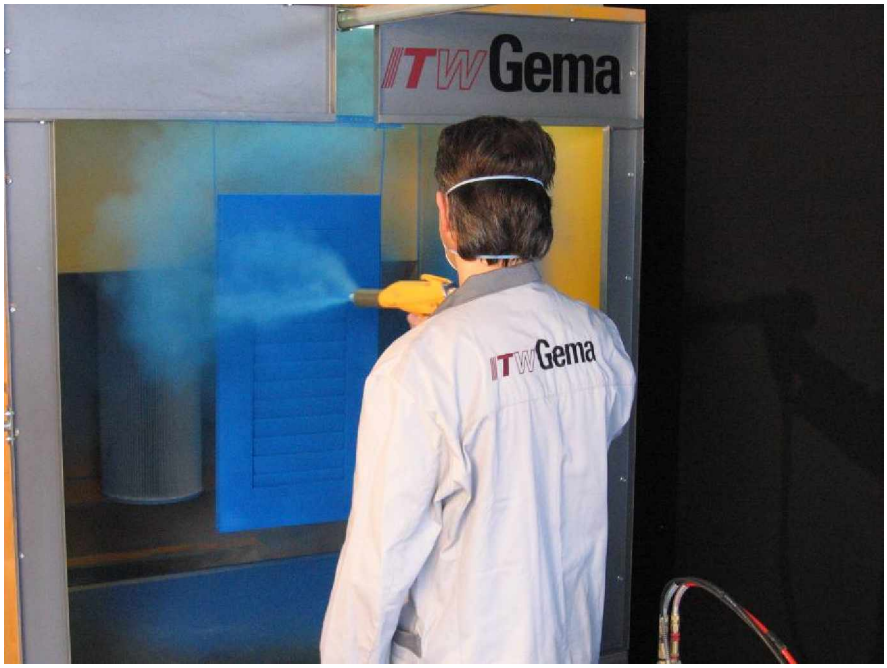
1. Charging systems

Different systems are used for powder charging. The choice of a specific process depends on the application and the user's requirements. In general, the charging techniques are divided into three categories:
electrostatic charging, low-ionizing charging and tribo-charging. Virtually all suppliers achieve the air ion reduction by adding a special part (at ITW Gema this feature is called SuperCorona ®) to the gun. Further systems, which have not yet gained widespread use, are so-called hybrid guns, which combine electrostatic with tribo-charging methods, as well as the inner charging systems. They complete the above-mentioned core techniques.

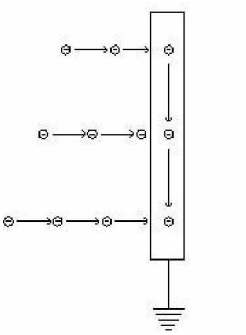
1.1 Electrostatic charging



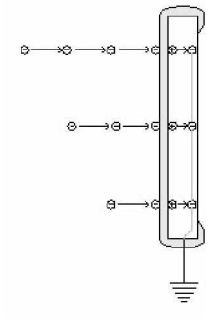
OptiSelect from ITW Gema AG

The principle of the corona charging

Corona discharge is the unhindered escape of free electrons from an electric conductor. This process only occurs in the presence of a strong electric field force. The latter rises with increasing voltage and decreasing wire thickness, this is why a high voltage and a thin wire are needed. In a powder spray gun, this thin wire is called an electrode/electrode tip. The free electrons search for the shortest way to the next grounded part. On their way, they collide with powder particles and cling to them. This is how the powder particles, just as the free ionized air particles, are ionized and attracted to all grounded objects. In the practical application, the workpiece is the first grounded part that the powder encounters and therefore remains bonded to it.



As soon as the ionized powder particle encounters the grounded workpiece, it generates a “counter-charge“ in the workpiece. The two charges attract each other. As the powder is not electrically conductive, the charge cannot drain off and the force of attraction persists. The current draining off the grounded workpiece consists of the colliding free electrons, air ions and the induction current of the counter-charge.



To guarantee an optimal and constant charging of the powder, the electrode of the Gema gun is rinsed with a soft airflow. Without this rinsing system, the powder would sinter very quickly onto the electrode, reducing significantly its electron flow. In addition, the airflow increases the corona discharge at the electrode.
1 to 3% of the free electrons collide with powder particles, the remaining ones ionize the surrounding atmosphere or remain free. These free electrons and the ionized air, together referred to as space charge, exert an influence on the coating quality. As already described above, the charged powder particles search for the shortest way to the next grounded object. The space charge enhances this force and the powder particles have great difficulty in penetrating into the recessed spaces and tend to deposit on the edges and corners of the workpiece.
We know that identically ionized powder particles repel each other. This repelling force also acts upon the deposited powder particles on the workpiece,

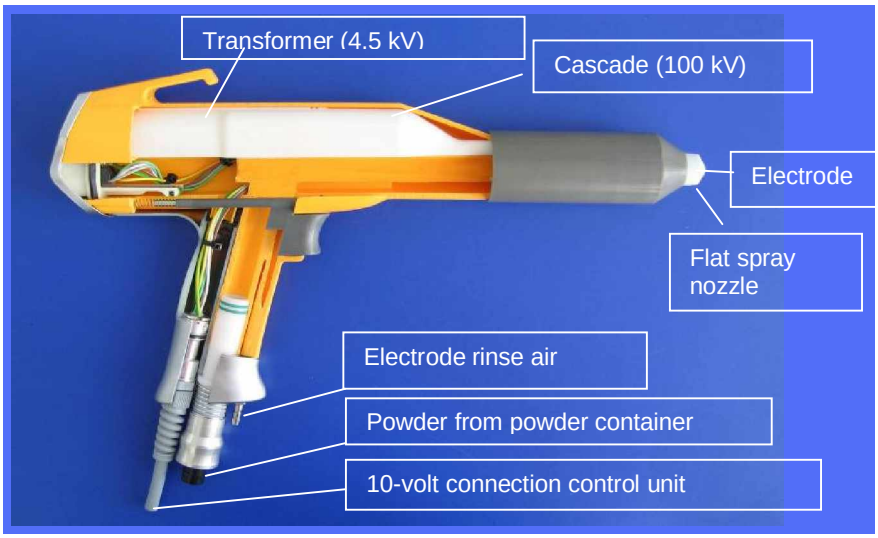
limiting the layer thickness and increasing the uniformity of the powder distribution. When the powder layer on the object gets too thick, it causes an uneven surface called orange peel. A further phenomenon is back ionization, when powder is pushed back resulting in small craters on the surface. By reducing the high-tension at the electrode, the charge and the space charge are also reduced, which in turn prevents orange peel and back ionization. However, as this measure also reduces the charge of the powder particles, the application efficiency of the gun decreases.

The selected air velocity has a major impact on the coating quality. The air essentially serves to convey the powder from the powder container to the gun, through the tip to the object. By adjusting the air quantity, the coating result can be significantly influenced. High air velocities improve the penetration into recesses as well as the wrap, but they also increase the tendency for the powder to be blown off. Small air quantities increase the separation efficiency, but can also negatively affect the penetration capacity. Only the combination of appropriate charging and adequate air velocity delivers optimal coating results.

The application field of the corona charging

Due to its charging principle with a constant supply of electrostatic charge, this type of gun can be used with all application scenarios and virtually all powder types currently available on the market. It is therefore also referred to as a general-purpose gun.

The OptiSelect manual gun



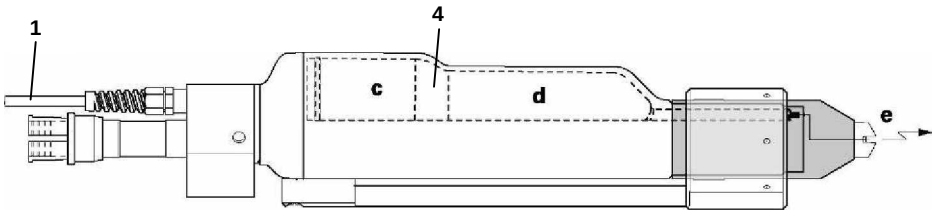
Powder cloud profiles

Deflector plate

Flat spray nozzle

1.2 Low-ionizing charging (SuperCorona®)

Low-ionizing charging with the retrofittable SuperCorona® add-on (**b**) is used in all coating scenarios requiring both thicker powder layers and a high coating quality with regard to the visual appearance. With conventional electrostatic charging systems, high surface quality cannot always be achieved where recesses are to be covered and the front edges have to be even. Either the recesses cannot be covered or the built-up layer thickness on the edges is too thick. From a layer thickness of 60-70 µ onwards, this may result in an orange peel-like surface. The reason is an excess of free ions. The thickness of the powder layer prevents them from bleeding off their charge via the object. The SuperCorona® add-on prevents the free ions (space charge) from reaching the workpiece. By means of the SuperCorona® ring, they are led back to the gun for grounding. The add-on part basically consists of a conductive ring with six electrodes and a contact wire leading to the grounded gun fixture. Typical fields of application for the SuperCorona® are the coating of drawers, rims and profiles. A further field of application is the coating with textured powder, where the SuperCorona® achieves a significantly more balanced pattern (reduction of the "picture framing effect"). In addition, it reduces the powder recoil in manual coating applications.

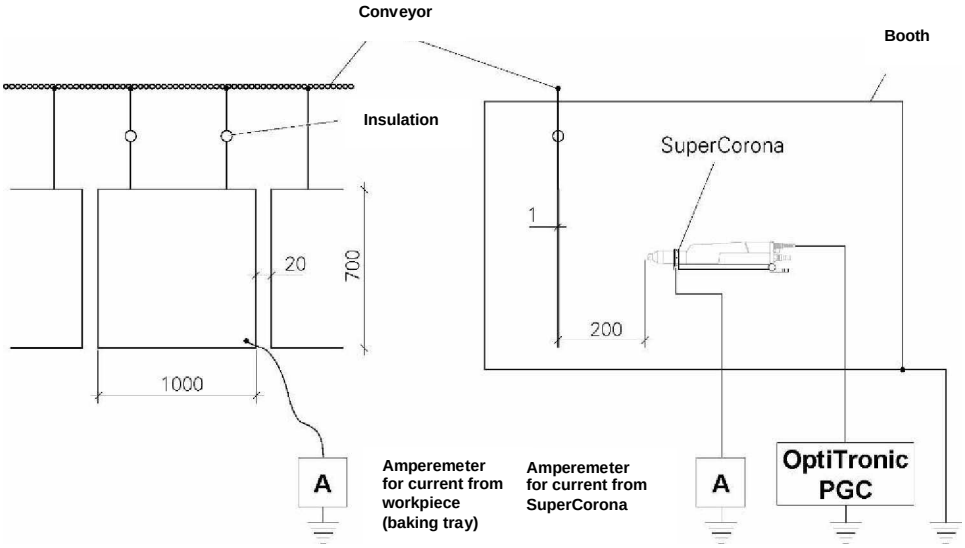


OptiGun with SuperCorona®

Via the gun cable (**1**), the control unit supplies the high-voltage generator (**4**) in the gun with DC voltage. The electronics (**c**) integrated into the gun converts DC voltage to AC voltage. This is changed via a multiplier circuit (**d**) to the rectified high-voltage required for the application. The generated high-voltage is led to the electrode (**e**) in the gun tip.

Measuring results from coating tests with and without SuperCorona®

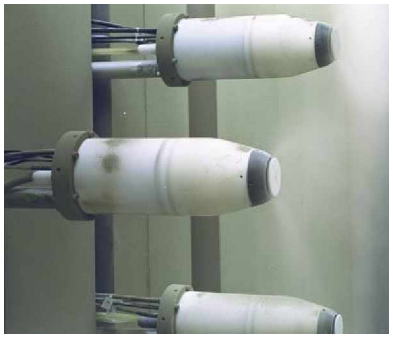
	w/o SuperCorona®	w/ SuperCorona®
Distance gun - workpiece	200 mm	200 mm
Powder output	203 g/min	203 g/min
Current at PG1 gun	70 µA	90 µA
Current at workpiece	55 µA	3,6 ÷ 4,5 µA
Current at SuperCorona®		65 µA

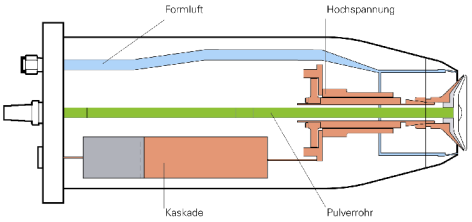


Functional diagram SuperCorona

1.3 Powder bell

The operating principle of the powder bell corresponds to that of the bell commonly known for wet-paint applications. The charging of the powder occurs via the charging edge of the rotating deflector disc. The rotation speed can be adjusted according to the powder type and desired cloud formation. The powder is supplied by the central tube. The high-voltage cascade is taken from the electrostatic powder gun and integrated into the bell body. Additional air allows the adjustment of the powder jet as well as the increase of the forward speed in direction of the object. Powder bells offer an extremely uniform layer application coupled with high application efficiency. Moreover, the number of atomizers can be reduced depending on the application scenario. In addition, the high uniformity of the powder output decreases the average layer thickness, offering a high powder saving potential. Powder bells achieve a very limited penetration depth, thus being suited in the first place for large, flat surfaces. When choosing a booth, it should be taken into account that powder bells build up big, soft powder clouds and therefore react very sensitively to airflows. With powder bells, the maximum powder output is approximately 600 - 700 g/min.





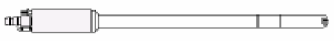
Powder bell

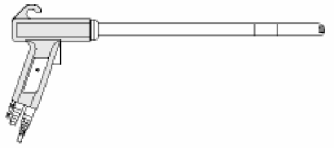
1.4 Tribo charging

The tribo method charges the powder by friction. From experience we know that two plastic foils, which we want to separate from each other, tend to attract each other again. Both surfaces pick up an electric charge of an opposite polarity. Tribo-charging makes use of this phenomenon, with the only difference that the charge is imparted. The powder particles are brought into contact with another plastic material and are immediately separated again. This process can take place in a tube, hose or via a disc. Preferably, it should occur with a high air velocity, as this generates turbulence in the tube, which in turn increases the number of contacts. The used plastic material is mainly Teflon and the charge is positive. Tribo-charging can only be controlled to a certain degree. Just as with electrostatic charging, the powder is transported via an injector to the powder gun. As the conveying speed of the powder alone is not sufficient to generate the required charge in the gun to impart on the powder, the velocity of the powder is increased by means of additional air. An independent regulation of the air quantity and the required charge on the powder can therefore only be controlled to a certain extent.

The advantage:
of tribo-charging is its good penetration depth. Tribo-charging generates virtually no excess ions in the air. The space charge is insignificant. This is why the penetration of powder into recessed items such as mailboxes and rims is better. Compared to the electrostatic charging technique, the charge of fresh powder is higher. The coated surfaces are more even, the “orange peel” is less distinct. The gun construction is simple and the generated induction charge can be easily read with a µA meter. The atomization nozzle for the powder can be shaped any way.

The disadvantages:
of tribo-charging are poor flexibility and powder reclaim. Not every powder can be processed with a tribo-charging gun. Special tribo supplements are needed (aluminum oxides). Fresh powder is charged the best, whereas several times recycled powder cannot be used anymore. The higher gets the percentage of the fines in the powder, the poorer gets the tribo-compatibility.





Tribo gun

1.5 Hybrid gun (tribo/electrostatic combination)

The hybrid gun is a combination of a corona and tribo gun. It combines the advantages of both systems. Should the friction charging capacity be insufficient, electrostatic charging can be used to back up the process. In both cases, the charge is positive. Both tribo-compatible and non tribo-compatible powder can be processed. The design is relatively complicated, as both systems (sliding surfaces in Teflon and high-voltage generator) have to be integrated into the same gun. This is why this type of gun also has higher maintenance costs.

1.6 Inner charging

Most corona guns feature an outer charging system. The electrode is located on the outer end of the gun. The nearest grounded part is the workpiece. The electrostatic field is created between the workpiece and the electrode. The charging of the powder takes place close to the electrode. With the inner charging system, the ground is in the gun itself. The charging of the powder occurs in the gun and near to the electrode. Compared to outer charging, most of the free ions move directly to the ground, resulting in a lower space charge as well as a higher penetration capacity. The problem lies in the sintering of powder and the tarnishing of the grounded electrode. Due to the extremely short charging distance, the powder rate is very limited.

1.7 Comparison of the charging systems

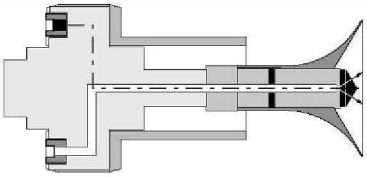
Criteria	Electrostatic	Super Corona	Tribo	Bell
Separation efficiency *(flat part)*	60 – 70 %	60 %	60 –70 %	70 – 75 %
Area performance in m^2/min	0,1 – 1,5	0,1 – 1,5	0,1 – 1,0	0,5 – 3,0
Powder rate	< 400 gr.	< 400 gr.	200 gr.	700 gr.
Penetration capacity	good	good	good to very good	poor
Layer thickness distribution	good	good	good	very good
Impact of the powder quality	low	low	high	low
Orange peel effect	yes	low	low	low
Wear and tear	low	low	high	high
Fault susceptibility	low	low	medium	medium

2. Gun tips

According to the coating requirements, guns can be equipped with different tips. In order to achieve optimal coating results, the choice of the nozzle has to be adapted to the actual coating requirements. The tips serve two purposes: they atomize the powder and build up a homogenous powder cloud. Depending on the charging technique, they also carry the electrode.

Deflector plate

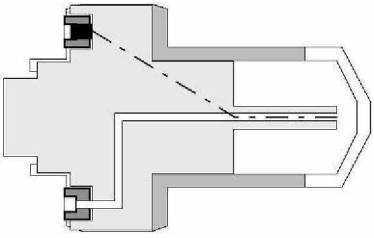
The deflector plate has been used since the beginning of powder coating. The powder jet bangs against the plate of approximately 16 - 32 mm in diameter, where it is scattered. This generates a homogenous powder cloud, which slowly approaches the grounded workpiece. The cloud can only be controlled to a certain degree and its penetration capacity is low. It is used for flat parts and large surface areas. The maximal powder output is around 300 - 400 g/min. with corona guns and approx. 200 - 250 g/min with tribo guns.



Round spray nozzle

Flat spray nozzle

The flat spray nozzle is a gun tip with a slot. The powder in the tube is accelerated and slowed down before and after the slot, resulting in a high turbulence. The powder cloud is characterized by an elliptical cross-section and can be properly directed onto the object. The nozzle is used for more complex parts with recesses. The maximal powder output is approx. 150 - 200 g/min. with corona guns and approx. 100 - 150 g/min with tribo guns.

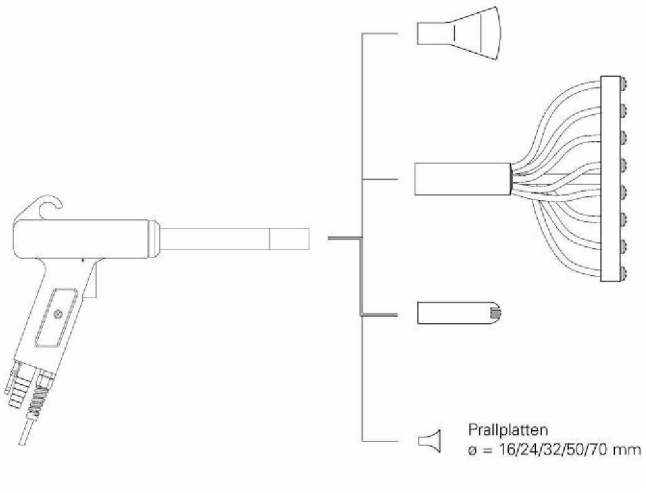


Flat spray nozzle

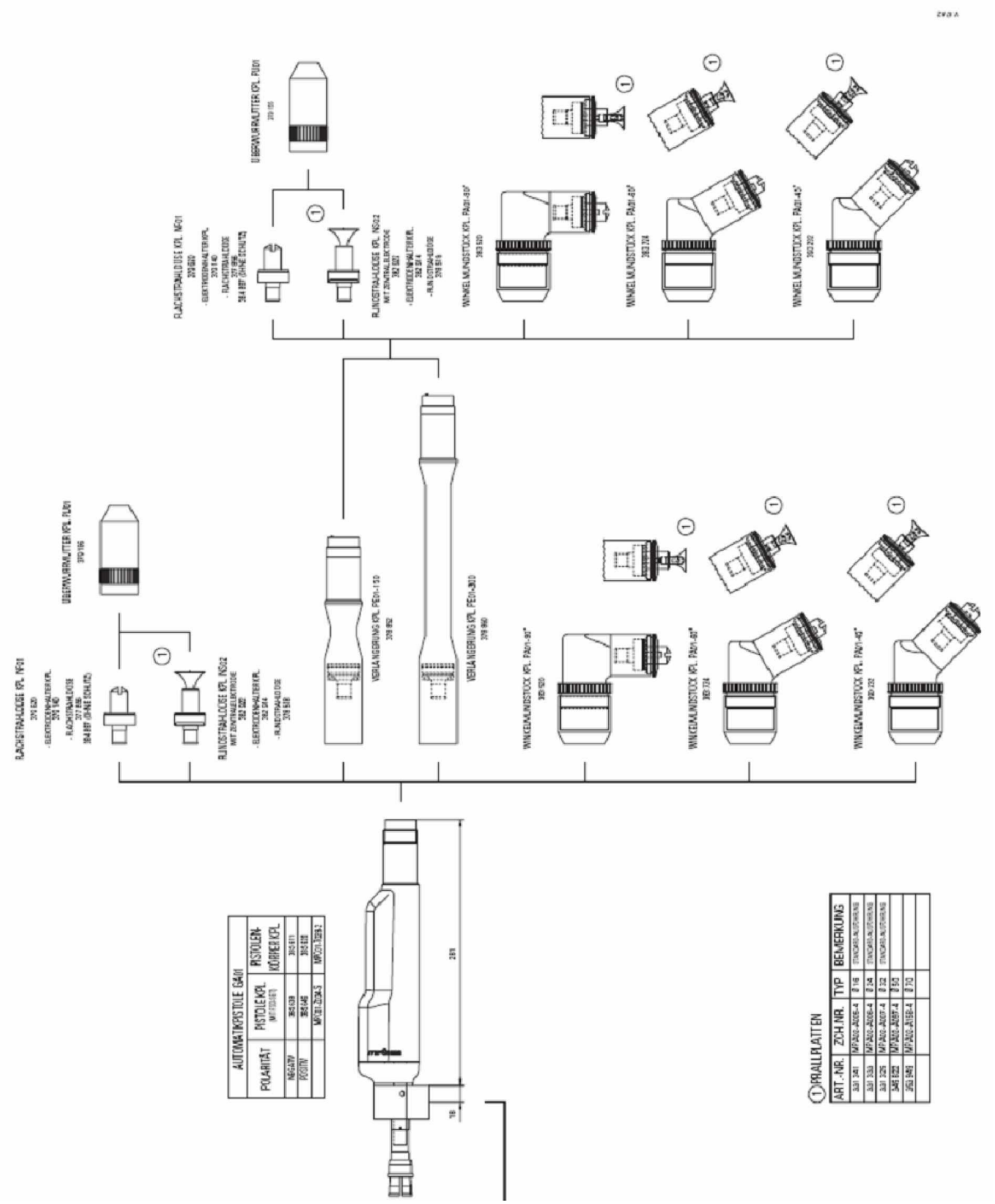
Swirl nozzle

With the swirl nozzle, the powder jet is scattered by means of a tangentially entering airflow. The air additionally introduced into the coating room, however, affects the coating quality. This is why this type of nozzle is not very popular.

OptiSelect with nozzle assortment



Gun tip assortment for tribo guns



Gun tips and extensions for electrostatic charging

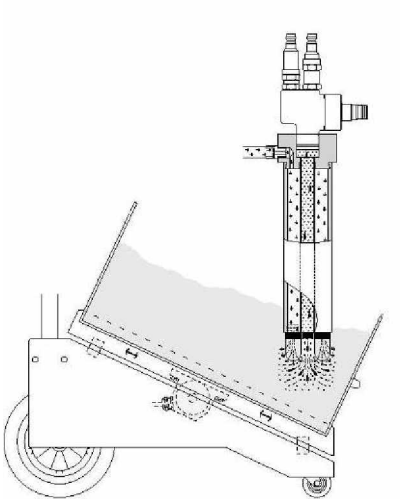
3. Application equipment

Application equipment is subdivided into manual and automatic equipment. Standardized modules are configured according to the customer's requirements. Application equipment typically includes control units, guns and powder containers. There is a distinction between control units for one, two or more guns. With regard to the powder container, the customer has the choice between fluidized and vibrating systems or being equipped with a stirrer. Also the manufacturer's original powder box can be used as a powder container, a solution particularly suited for frequent and quick color changeovers.

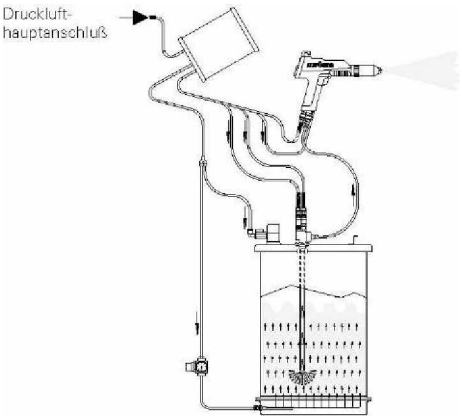
3.1 Manual equipment

A manual coating system basically includes a control unit, a manual spray gun, a powder container, a precision injector, a powder hose, cables and pneumatic ducts. High-performance manual coating equipment is ideally suited for small to medium production runs. As these imply also frequent color changes, the equipment should therefore always be easy to clean.

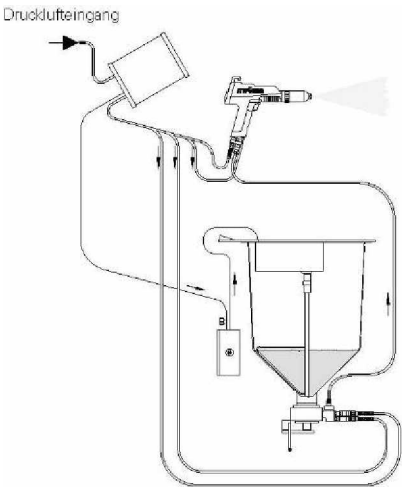
The OptiFlex powder coating series from ITW Gema AG



Functional diagram OptiFlex B manual equipment



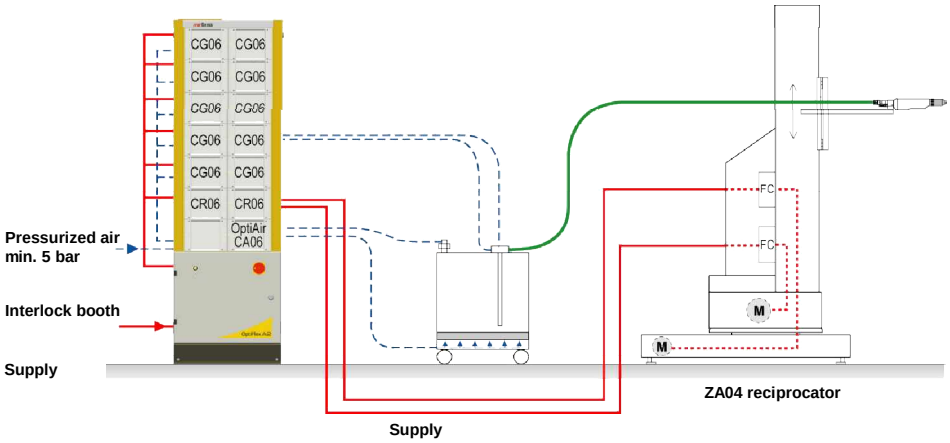
Functional diagram OptiFlex F manual equipment with fluidized container



Functional diagram OptiFlex S manual equipment with stirrer unit

3.2 Automatic equipment

An automatic system basically consists of the same elements as the manual coating system, i.e. control units, spray guns, powder containers, injectors and powder hoses. In addition, interlock and automation controllers are used. High-performance equipment for automatic coating has to meet the requirements of large production runs. Individual modular systems are ideally suited for such needs, as they offer customized solutions with standard elements for any plant configuration.



Functional diagram OptiFlex A2 with powder container control and ZA04

Control modules

In the simplest case, each gun and each reciprocator requires its own control unit. With every further degree of automation, additional control modules are required to control the single steps and to align with one another. This leads up to fully automated PC and PLC solutions.

The control modules can be divided into the following categories:

- gun modules
- automatic modules
- reciprocator control modules

Today, the following degrees of automation are possible:

- gap control for gun groups
- gap control for single guns
- gap control and width feed
- height recognition and width feed
- fully automated operation

OptiTronic gun control

With the new OptiFlex equipment series, ITW Gema treads new paths in the field of controller technology. The objective is to ease the coater's work as much as possible, to achieve the optimal coating quality in the simplest possible way. The equipment series includes all control units that a fully automated coating system requires. From the simple gun controller to the control module for reciprocator movements and fresh powder supply, the OptiFlex equipment configuration can be individually configured according to the customer's needs and coating requirements.

OptiStar control module

OptiStar consists of a simple basic unit, which can be extended with additional modules. New key features of the OptiStar gun control module are the following:

- Storage capacity of 250 coating programs for reproducible coating results every time.
- Digital display of the coating parameters for accurate and reproducible adjustment.
- Programmable high-tension and spray current, which are automatically readjusted and allow for consistent powder charging (increased penetration depth and more even coating results).
- The powder hose length correction function allows the standardization of the single powder outputs to obtain same-shaped spray patterns of the guns, uniform layer build-up as well as a reduction in the average layer thickness, which in turn results in powder savings.
- FlowControl module for continuous fluctuation compensation with regard to pressurized air and dynamic pressure.
- DigitalBus module for data exchange with a higher-level control.

Injectors

The injectors' task is to transport a precisely defined powder quantity from the powder containers or the powder carton to the guns. Similar injectors are used with enamel powders, but they are made of other abrasive-resistant materials.

OptiFlow injector

Powder containers

Powder containers serve to supply the guns with powder. According to the requirements, they feature different capacities and can be equipped with a wheel base, vibration table, airmover, level control and different numbers of injectors.

Powder containers 100 l and 50 l

Fresh powder systems

Fresh powder systems are used when large powder quantities are processed and quality standards require fresh powder to be continuously added to the recycled powder. Depending on the size of the system (number of guns) and the powder manufacturer's carton, different systems are employed.

PP05 powder pump

Reciprocators

The reciprocators' task is to move the guns. According to specific applications, the user can opt for different models.

ZA04 reciprocator at Magic Plus