"PCT - PURE COATING TECHNOLOGY"
a new coatings technology from Furtenbach"

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Introduction

Furtenbach have developed a completely new coating method. The starting point for the development was the many disadvantages exhibited by methods that are currently in use. The new method can replace all forms of coatings which have hitherto been used, such as finished coatings, pasty coatings, powder/paste combinations or powder coatings which are suspended on site.
In the new method, it is solely the pure powdery mixture of refractory materials which should be applied - Pure Coating Technology. This method allows all coatings previously used in suspension to be applied dry with the same composition of refractory materials. An international patent application has been submitted for both the composition, manufacture and the method.

Prior art

Structure and composition

mineral fillers (refractory)
suspending agent
binder
wetting agent
bactericides
defoamer
rheological auxiliary
solvent, water or alcohol

The solvent portion amounts to 30 to 50%. Isopropyl alcohol, ethanol and unfortunately in some countries still methanol or mixtures thereof are used as alcohols.

The choice of carrier liquid is guided primarily by the binder system used, the user's production process and the possibility of drying whilst processing the coatings. Furthermore, official requirements may make the use of alcohol coatings unprofitable or even prevent it through the stipulation of special constraints. For reasons of occupational safety and environmental protection, the demand for water-based coatings is constantly on the increase.

From a technical standpoint, the functionality of a coating is dependent on the chemical composition of its constituents and is defined exclusively by the mineral fillers. These mineral fillers are defined in advance by the intended use and the user.

Consistency and delivery form

Basically, all conventional coatings which are currently used must be prepared and made ready for use, regardless of their delivery form. The outlay for the preparation and, as a result, the possible sources of error differ from one another, however.

We differentiate:

a) **Finished coatings** offer a high degree of uniformity and require little preparation work.

Finished coatings are to be prepared due to the sedimentation which takes place due to time in storage and transporting. As the main preparation work has already been carried out by the manufacturer using special mixing units, the preparation in the casting workshop is limited to simple homogenisation which mainly takes place directly in the delivery container. High shear forces are to be avoided in the process, so as to prevent possible changes of the flow behaviour of the coating. The supernatant liquid should never be skimmed off before preparing the coating, as the binders and the additives which influence the application-specific properties of the coating to a considerable extent are often dissolved in this supernatant.

Advantages: ready to use, preparation very simple, constant processing setup guaranteed by the manufacturer

Disadvantages: high costs for the transport of the carrier liquid

b) **pasty coatings** are diluted and require more preparation work than the finished coatings. The dilution takes place at the user's premises.

The same basically applies for the **paste coatings** as for the finished coatings, as the main preparation work takes place at the manufacturer here also. In this case, the final preparation is more difficult on account of the coating consistency, as the required amount of carrier liquid is absorbed by the paste with great difficulty. This is remedied here by mechanically comminuting the paste by means of suitable mixing units. This delivery form is chosen so that mainly water-based coatings can be transported cost effectively. The preparation of these coatings should only take place in stages.

Advantages: transport cost saving, small number of sources of error

Disadvantages: harder to homogenise than finished coatings, larger outlay for the preparation, checking the processing viscosity is recommended after each preparation

c) **Two-component systems (powder/paste)**, dilution takes place at the user's premises and a mixing unit is required for finishing.

two-component systems are mainly delivered in order to achieve a transport cost saving for water-based coatings. The powder component is a mixture of fillers and powdery additives. The paste component is a mixture of suspending agent, fillers, binders and liquid additives. With the pasty component, the suspending agent's or thickener's swelling process in the coating is already complete, so only a homogeneous mixing of paste, fillers and carrier liquid is yet to take place. A stationary mixing plant with corresponding stirring unit (dissolver) is required for the preparation.

Advantages: transport cost saving

Disadvantages: mixing plant required, preparation is labour intensive, corresponding dust extraction required

d) **powder coatings**, the entire preparation takes place at the user's premises.

For the **powdery delivery form**, the entirety of the preparation takes place at the user's premises. To accelerate the swelling process, stirring units which bring about high shear forces are to be recommended for this form. Without the use of shear forces, the ingredients' swelling process slows down enormously, but this does not influence the quality of the finished prepared coating. Should the swelling process not yet be completed, problems may occur during processing, however, (dipping or spread behaviour, unevenness of the layers applied, etc.)

Advantages: greatest transport cost saving, long shelf life

Disadvantages: preparation at the consumer's premises, large number of sources of error, high quality mixing units required, preparation very labour intensive, dust extraction required

Problems for the coatings

- Energy-intensive manufacture
- Uneven layer thickness
- Large material loss
- Emissions problems
- Hazard class for transport and storage
- High transport costs

but also in the area of application:

- sedimentation behaviour
- wetting
- shelf life (bactericide)
- foaming
- rheological auxiliary

The question now is what causes the most problems for coatings? In the rarest of cases, the inherent functionality - the refractory materials!

We have made it our object to avoid the disadvantages connected with conventional application methods for liquid coatings and to make use of the advantages of using dry powder coatings at the same time.

We have achieved this object in that, in our new method, we make the granules conductive with a combined polymer and electrolyte solution before the application of the refractory coating material and the refractory coating is applied in the form of a dry coating by means of an electrostatic or tribostatic powder spraying method, in the following also designated as EPS method.

Method overview

The components of the large-scale and automatically operating plant for applying powder coatings in accordance with the EPS method are to be drawn from the Figure 1. The portion of the powder coatings which does not adhere to the objects to be coated during the application is extracted and fed back into the process cycle.

- Pressurised container for the storage of the powder coatings.
- Pressurised container for the overspray (recycling material).
- Compressed air line (> 6 bar).
- conveying system (conveyor belt).
- Chamber for making the granules, moulds, casting moulds and mineral objects conductive with a spraying device.
- Apparatus for electrostatically charging the powder coatings and spray guns.
- Coating chamber.
- Fan for the extraction and conveying of the overspray (residual coating).
- Firing furnace.
- Cooling installation.
- Necessary pipelines.

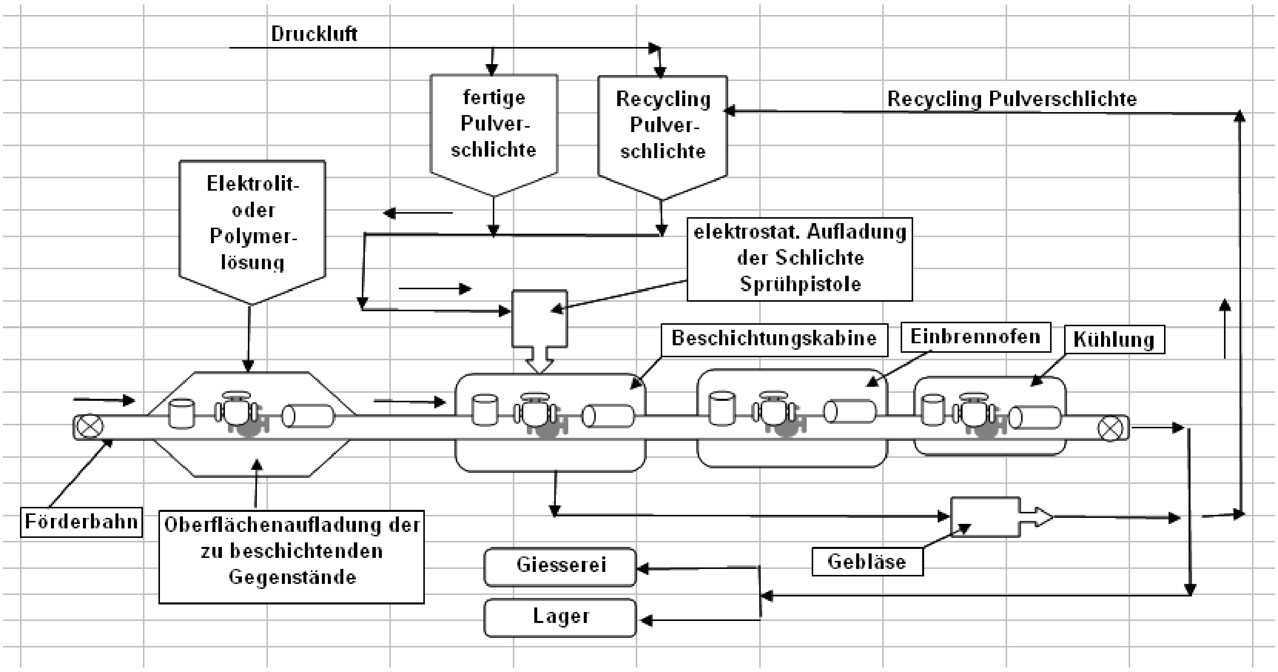

Figure 1: Diagram of the plant for “applying” the powder coatings in accordance with the EPS method

Deutsch	**Englisch**
Förderbahn	Conveyor belt
Elektrolit- oder Polymerlösung	Electrolyte or polymer solution
fertige Pulverschlichte	Finished powder coatings
Recycling Pulverschlichte	Recycling powder coatings
elektrostat. Aufladung der Schlichte Sprühpistole	Electrostat. charging of the coating spray gun
Beschichtungskabine	Coating chamber
Einbrennofen	Firing furnace
Kühlung	Cooling
Gebläse	Fan
Giesserei	Casting
Lager	Storage
Oberflächenaufladung der zu beschichtenden Gegenstände	Surface charging of the objects to be coated

A suitable conveying system guarantees the continuous transport of the granules to be coated through the plant. The entire range of products offered comprises everything from manual conveyors to a fully-automated power and free system.

Pretreatment of the granules and surfaces

The pretreatment of the granules to be coated can take place in two different methods:

<u>Application method 1</u>

The powder coatings to be applied consist of the mineral fillers and 1.0-10% of a thermoplastic or aminoplastic polymer in solid powder or granulate form and are applied onto the objects to be coated, such as granules, moulds and lost foam models, by means of the electrostatic powder spraying method - see below.

In the sense of this method, the term “thermoplastic polymer” comprises all polymers, irrespective of chemical composition, which change their aggregate state from “solid” to “pasty” or “liquid” due to the action of temperature. The term aminoplastic polymers mainly comprises urea, melamine, thiourea resins and the like.

The surface of the objects to be coated, such as granules, moulds and lost foam models in the casting industry and the other mineral objects, are made conductive befreo the application of the coatings by means of the spraying on of an electrolyte solution. Before the application of the powder coatings, the objects sprayed with electrolyte solution can be dried if required or coated without drying and processed. Metallic objects do not require any pretreatment, as their surface is conductive.

Application method 2

The powder coatings only consist of the mineral fillers.

The surface of the objects to be coated are treated by means of the spraying on of an electrically conductive polymer solution before the application of the coating.

Electrically conductive polymer solutions in the sense of the invention are solutions, dispersions and suspensions of polymers in water or organic solvents. What is meant by “polymers” in the sense of the invention is all organic and inorganic polymer materials, irrespective of the chemical composition, which can be dissolved, dispersed or suspended in water or organic solvent.

The objects sprayed with the polymer solution are passed to the application of the powder coatings without drying.

Modification and application

What is important is the individual adjustment and adaptation of the electrolyte or the electrolytic polymer solution to the conditions and areas of application of the individual granules to be coated. Applications for sand granules and lost foam granules, as well as for the type of binder are to be differentiated here. The method was tested with all popular binder types - from cold box, through hot box and furan to inorganic ones.

Coating with the “PURE COATING TECHNOLOGY”

A reminder of the composition of the coatings:

Structure and composition of coatings

mineral fillers (refractory)
suspending agent
binder
wetting agent
bactericides
defoamer
rheological auxiliary
solvent, water or alcohol

and what is needed for the coating:

mineral fillers (refractory) and nothing else!

Application of the powder coatings in accordance with the EPS method

The application of the powder coatings takes place in a stationary, closed, emission- and dust-free process by means of the electrostatic powder spraying method (EPS method).
The electrostatic powder spraying (EPS method) for the coating application is as follows:

First, the “powder coatings” are fluidised, that is to say loosened with blasts of air, in a powder container. With the aid of injectors, the fluidised powder is conveyed out of the container to the spray gun and electrostatically charged there by means of integrated high-voltage generation and expelled in the direction of the granule, mould, lost foam models, mineral or metallic object to be coated. Electrostatic forces deflect the powder particles onto the objects to be coated, which were previously made electrically conductive. The objects to be sprayed must be earthed well before the start of the spraying. The portion of the powder coatings which does not adhere to the objects to be coated during the application (overspray) is extracted and fed back into the process cycle. A variant which operates in a whirlpool is especially suitable for small parts. The electrostatic charging of the powder particles can take place with the following types of spray guns:

1. **Corona spray guns**: This type of spray gun is most popular. The powder particles are negatively charged. A high voltage of approx. 100 kV is applied at the corona electrodes. As a result, air ions are created which electrostatically charge the powder particles. Faults in the coating layer can possibly occur due to the "back corona effect". This is caused by air ions which charge the deposited powder layer.

1. **Tribo spray guns**: The powder particles are positively charged. The powder particles charge electrostatically due to triboelectric processes during the turbulent passage through the gun. The success of the coating is very dependent on the coating material used for this technology.

An electric field is generated between the earthed granule which had previously been made conductive and the spray gun, which field the powder particles then follow. Depending on the requirement, a coating layer of from 30-500 µm is produced.

The characteristic of the spray cloud has a decisive influence on the coating result. Suitable nozzle systems are available for adjustment. According to the present results, nozzle systems made from ceramic or high-grade steel are suitable.

Figure 2 shows the cross section of a powder-coated object.

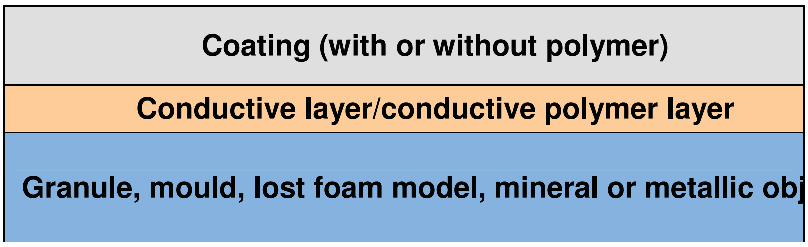

Figure 2: Cross section of a powder-coated object

Drying - firing

The drying, heating and/or firing of the coated objects takes place in a furnace with continuous or discontinuous feed.

During the thermal treatment of the objects coated in accordance with the coating method 1, the powdery or granulate thermoplastic or aminoplastic polymer initially melts. The melted polymer adheres to the surface of the object to be coated and then a crosslinking reaction starts so that a closed polymer film results, which adheres very well and acts as a binder and binds the powdery fillers of the coating.

The objects coated in accordance with the coating method 2 behave as follows in the sense of the polymer solution sprayed onto the object surface. The solvent contained vaporises and the polymer contained begins to crosslink so that a closed polymer film is created on the surface of the object to be coated, which adheres very well and acts as a binder and binds the powdery fillers of the coating.

The drying, heating and/or firing of the coated objects takes place at temperatures between 100 and 400℃, depending on the chemical composition of the polymer contained and depending on the thermal resistance of the coated object.
For lost foam models, the thermal treatment takes place at correspondingly lower temperatures. In this case, a polymer, the melting point of which is lower than that of polystyrene, must be used. A fast and effective heating of the applied coating powder is striven for. This can be achieved by means of radiation drying.

In accordance with the present experiment results with "PURE COATING TECHNOLOGY"*,* the following heating methods present themselves for the drying, heating and/or firing of the coated objects with the powder coatings:

Hot air drying: An effective yet slow heating and drying can also be achieved with a conventional hot air drying.

Microwave (MW): Waveband, 1 m to 1 mm; Frequency 300 MHz to 300 GHz).

Infra red: It is mostly carried out with infrared heaters which give off a heat of from 200℃ to 400℃. The infrared rays are absorbed or reflected by the coated granules in accordance with the composition and surface of the same. The non-reflected portion of the radiation leads to a temperature increase of the powder coating and the objects to be coated. The powder coating is heated up very quickly. The heating times are therefore short. The fast heating of the powder coating and the melting of the thermoplastic or aminoplastic polymer requires an exact compliance with the heating time. Infrared heating is only to be used with continuous throughput methods in which the transport speed can be adapted precisely to the dry product so that the coating is not overheated at individual points of the object to be coated.
Infrared (IR): Waveband 1 mm to 800 nm; Frequency range $3 \cdot 10^{11}$ to $3.75 \cdot 10^{14}$ Hz.

Light pulse heating method: It is principally a type of UV radiation heating method. In the light pulse heating method, UV rays are bundled by means of reflectors and deflected as parallel bundles onto the granule surface. Thereby, it is possible to change the spacing between surface of the coated object and reflectors within a range of approximately 1000 mm. This type of heating is particularly suitable if polyester, polyurethane and urea or melamine resins are used as binder. The heating duration lies between 35 and 15 seconds.

Electron beam heating: This method is used for curing powder layers which are more than 400 µm thick. They cure completely in fractions of seconds. The method therefore allows correspondingly high belt speeds. In this method, electrons are emitted from a tungsten wire and bundled in an electric field. The bundled electrons (electron beam) cover the entire width of the conveyor belt. The hardening of the polymer contained takes place without generation of heat in an irradiation zone which is approximately 100 mm long. This method is only cost effective for high throughput quantities. Additionally, particular safety precautions are necessary, as the radiation is very dangerous for humans.

After the thermal treatment of the coated objects in the furnace, these are supplied for further use or stored either directly or after cooling has taken place.

Advantages of "PURE COATING TECHNOLOGY":

The most important advantages are:

- no alcohol
- no water
- no sedimentation
- no lost material
- no bactericides
- smallest amount of gas generation
- only harmless components
- every coating is doable
- also for inorganic substances

Furthermore, the following advantages can be shown:

- Shortening of the manufacturing time. The manufacture of the powder coatings according to the invention takes place by means of a homogeneous mixing of the raw materials used. A solubilisation over a number of hours, as is necessary for the conventional coatings, is not required. So, a cost saving results with regards to personnel and energy costs.
- Saving of raw materials, as no suspending agent, thickener, wetting agent, defoamer, etc. is required for the new powder coatings.
- Solvent-free or reduced-solvent process and so no or extremely reduced quantity of organic emissions.
- Safer transport and handling. Avoidance of the transport of dangerous goods.
- Saving of transport costs. For conventional, solvent-containing coatings, approximately 50% solvent (alcohol or water) is transported.
- Process reliability and elimination of coating storage in accordance with the German regulation on flammable liquids [VbF] – (alcohol coatings).
- An even distribution of the coating onto the granules, moulds and lost foam models in the casting industry or onto the mineral and metallic objects.
- Material saving thanks to the avoidance of wastes and dust emissions during the application of the powder coatings, as operations take place in a closed system.
- Overall, more competitiveness, principally in the automobile and supplying industry.

The environmental relevance of the method comes about through the following advantages:

- Solvent-free process, so extreme reduction of the emissions.
- Resource efficiency on the basis of the saving of resources, resource usage and avoidance of waste.
- There is a reduction of manufacturing time, particularly the solubilising of the suspending agent and thickener, and thus an energy saving, when compared to the “conventional” liquid coatings.
- Safe handling and high process reliability. Product storage does not take place in accordance with the VbF regulation (alcohol coatings).
- No source of danger in accordance with the regulation on hazardous incidents.
- Reduction of the weight by approximately 50% and so energy saving during transport.
- Safer transport and handling, avoidance of the transport of dangerous goods (no dangerous goods).

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