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POWDER COATING SYSTEMS – CONCEPTS AND LAYOUT

1. The determination of the relevant parameters

When planning a powder coating system, the foremost desire or constraint is a process which is ecologically acceptable or an extensively automatized coating process. The objects to be coated as well as the choice of system-technology result in many relevant parameters, which define the choice between the various System-concepts, system-, booth, and recovery-types. In addition the level of automation is defined to a great part.

Definition by Objects:

At first the main parameters are to be defined, which have influence on the concept of the system. These are.

- The quantity of pieces to be coated
- The geometry of the work-pieces
- The required coating-thickness
- The required quality of coating
- Number of colours
- The percentual distribution of main- and special colours
- The frequency of colour change

Definition by System Technology:

Further parameters, that have an influence on the choice of the coating booth are:

- The chain conveyor
- The construction of the hangers
- The pretreatment

The chain conveyor serves the transportation of the work-pieces and thus the automatization of the coating process. Depending on requirements, single-leg-, circular-leg-, or „Power & Free“-conveyors are installed. For an unproblematic conveyance a hanger construction suitable for the respective production is needed. An universal use of hooks and parts-hangers should be possible. The required capacity given by a hanger scheme, allows the definition of the speed of the chain-conveyor. The construction of the parts-hanger depends on the layout needed for the application. To prevent stops in production, two sets of hangers are recommended. Thus one set can be cleaned, while the other is used in production. Before the work-pieces can be coated, they have to be cleansed of all impurities, such as fats, oils a.s.o. This happens in the pretreatment system, which is to be coordinated with the work-pieces, which are to be coated. The quality of the pretreatment is decisive to the results of the coating. The parts are to be dry and should be able to enter the coating-booth with a max. of 40°C heat-content.



The building circumstances:

The last parameters, which have to be defined are:

- Space conditions
- Ground conditions
- Other interferences (air currents etc.)

The ground must be electrostatically conductive and in the surroundings of the planned location of the booth, no influences to the quality of the coating, such as air turbulences or solvent vapours, should exist. High room temperatures should also be avoided. All main parameters have now been defined. At this point the suitable system-type can be chosen. In general we distinguish single-colour-, multi-colour-, and quick-colour-change systems, that, depending on the requirements, can be operated in various levels of automation, with or without manual coating.

2. Tests define the basis for the design

Coating tests are indispensable for the design of automatic coating systems. The tests give information on the due diligence of the planned plant, as well as the number and the layout of coating guns to be used. Measurements of the coating thickness and the weighing of the used powder, allow the calculation of the economic efficiency of the coating. A qualitative opinion can only take place using the original parts and having the customer present during the tests. The coating powder used during the test should correspond to the requirements of the end product in colour and quality.

Preparations:

- Choice of test parts
- Choice of quality and colour of the powder
- Pretreatment of the parts

The goal of the tests:

- Determination of the level of automation
- Determination of the technical layout of the application
- Determination of the distribution of the coating thickness
- Determination of the powder consumption

The test report:

- It documents all coating parameters

A comprehensive test report is the basis for a subsequent quotation. The documented data of all coating parameters as well as the operating sequences and settings of the stroke devices are needed for the commissioning and the production start up by the service specialist and the customer.

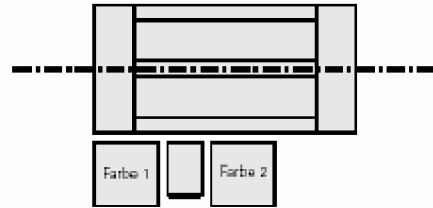
Example of a coating report.

3. Possible plant concepts

Below we show you the mostly used plant concepts. They can be realized with normal cabins as well as so called quick-colour-change plants:

One Booth / Two recovery systems:

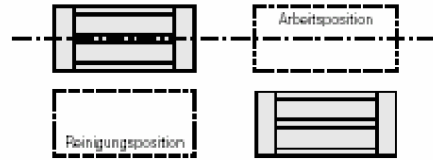
Conventional colour change with additional recovery. After the cleansing of booth and guns, the recovery systems are exchanged.



(Colour 1; Colour 2)

Movable booths:

Using movable booths, which are operated alternately, the cleaning of the booth is possible outside of the chain conveyor.



(Operating position; Cleaning Position)

Booths with separated conveyor lines:

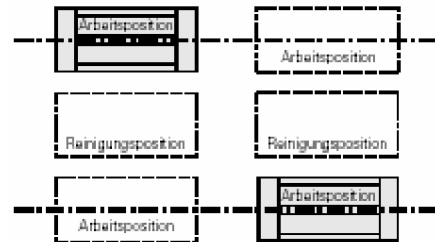
Two completely separated conveyor lines are guided through two coating booths. While coating takes place in one of the booths, the other booth can be cleaned.



(Colour 1; Colour 2)

Movable booths with 2 conveyor lines:

Two conveyors in combination with movable booth allows for a big flexibility. Big space need is the disadvantage of this system.

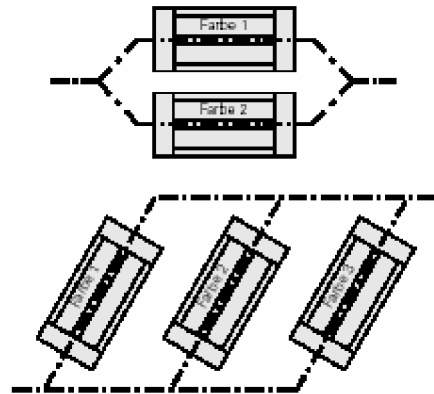


(Arbeitsposition = Operating Position)
(Reinigungsposition = Cleaning Position)

Booth with Power&Free conveyor:

With the Power&Free conveyor the parts run through the pretreatment and the oven together, however get steared separately to the corresponding booth. In this way one booth can be cleaned, while the other booth is in use. The Power&Free conveyor systems are most economically used, when additional conveyor tasks can be solved by a Power&Free system.

(Farbe = Colour)



4. The choice of the booth type

In general booth types are distinguished as booths for single-colour-, multi-colour-, and quick-colour-change-systems. As a rule, the plant elements today are conceived in a modular system. Thus the system elements, in respect to requirements and usage, can be interchanged. Nowadays booths are either built of steel or plastic in sandwich-construction. The plastic booths are a lot more expensive than steel booths, however are more easily cleaned, as the powder sticks less to the walls. The booth types, which are described below, are available in plastic as well as steel construction.

	<u>Stahlblech unbeschichtet</u> Reinigungszeit: 100 % Pulveransammlung: 100 %
	<u>Stahlblech beschichtet</u> Reinigungszeit: 95 % Pulveransammlung: 95 %
	<u>Kunststoffblech</u> Reinigungszeit: 30 % Pulveransammlung: 10 %
	<u>Kunststoff (Sandwich)</u> Reinigungszeit: 40 % Pulveransammlung: 10 %

uncoated iron plate

cleaning time: 100%
powder deposit: 100%

coated iron plate

cleaning time: 95%
powder deposit: 95%

plastic sheeting

cleaning time: 20%
powder deposit: 5%

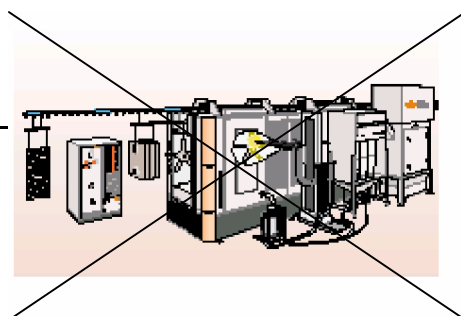
plastic (sandwich)

cleaning time: 20%
powder deposit: 5%

Comparison of booth constructions

4.1 Single colour system

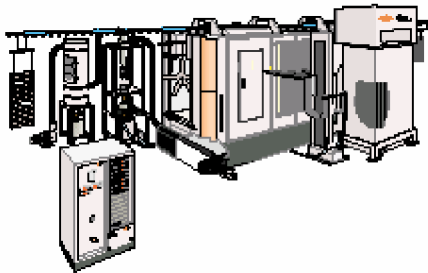
Booth with filter recovery and squeegee are suitable for single colour systems. Although using substantial air amounts they have a mid-sized surface area and are fitted with squeegees. Its simple construction allows an unproblematic operation and maintenance, as well as not asking high skills from the operator. The powder paths are short and therefore allow for reduced powder consumption.



SINGLE-COLOUR-SYSTEM WITHOUT MULTI-CYCLONE.

Booths with Filter Belt Recovery:

They are suitable for single colour systems with many guns. They are equipped with a regular, slow, air control and are very suitable for sensitive applications. By means of extracted air the powder is immediately sucked onto the filter belt and carried out. The recovery system has always the same size, the exhaust system is adapted to the booth size. Using such filter belt recovery systems, the separation level of approx 99% is very high.

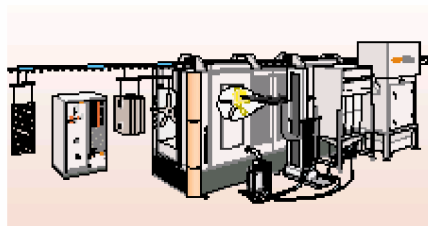


MFR Filter Belt Recovery Booth

4.2 Colour Change Systems

Booths with Multi Cyclone Recovery

These are suitable for a maximum of three to four colour changes per day. They have a mid-sized space need, even with great air quantity and are equipped with a multi cyclone recovery. They are extremely unproblematic in operation and maintenance. The powder paths are short and therefore allow for reduced powder consumption.



MRS Multi-colour-system

4.3 Quick-Colour-Change booths

The use of a quick colour change system with a specially constructed booth for quick colour changes is profitable starting from five colour changes per day. They can be alternately equipped without or with upto 2 manual coating openings which can be used a pre- or after treatment stations. A vertical gun layout eases an object related setting and saves space. Plastic panels of the booth, restrict powder deposits, which is supported by a central exhaust system. The cleaning of the booth is normally done manually, using a rod with air nozzle. Systems with automatic cleaning devices are available as option.



Examples of MagicCylinder plants



Examples of MagicPlus plants

Criteria for choice of cabin structures in respect to colour changes:

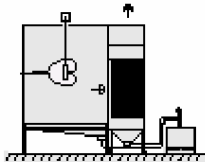
Criteria	coated steel	stainless steel	Plastic sandwich	Plastic sheeting
Durability	8	10	8	*
Scratch resistance	8	10	7	-*
Easy cleaning	5	5	10	-*
Small powder deposit	4	4	10	10
Small powder adhesion	5	4	10	10
Safety	10	10	8	8
Low investments	10	9	6	8
Upto 6 guns	10	10	10	10
Upto 10 guns	8	8	10	10
Upto 15 guns	5	5	10	5•
More than 15 guns	2	2	10	2
Upto 1 colour change per day	10	10	8	
Upto 2 colour changes per day	8	8	8	8
3 to 4 colour changes per day	5	5	10	10
5+ colour changes per day	2	2	8	10
Height of object upto 1500 mm	10	10	10	10
Height of object upto 2000 mm	8	8	10	10
Height of object upto 2500 mm	5	5	10	10
Height of object upto 3000 mm	2	2	8	10
Height of object greater 3000 mm	0	0	6	10
Possibility of extension	10	10	5	2

10 = very suitable, 1 = not suitable, * sheet is changed with every colour change, •sheet width limited to 2.5m

5. The Recovery Systems

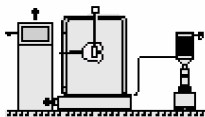
Only filter recovery with squeegee:

Exclusive filter recovery systems are only suitable for single colour operations. They are normally equipped with a squeegee. Their level of separation is approx. 99,9%.



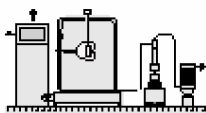
Filter belt plants with filter:

Filter belt booths with post-filter for the cleansing of the extracted air or dust, are only suitable for single colour operations. Their level of separation is approx. 99,9%.



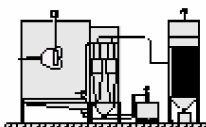
Filter belt plants with mini-cyclone:

Filter belt booths which are equipped with a mini-cyclone are suitable for operations with upto one colour change per day. Their level of separation is approx. 98%.



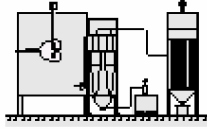
Multi-Cyclones in combination with squeegees:

Multi-cyclone plants are equipped with squeegees, should the booth be long or equipped with many guns. As the cleaning of the booth is more difficult with squeegees, they are suitable for one or two colour changes per day. Their level of separation is approx. 93%



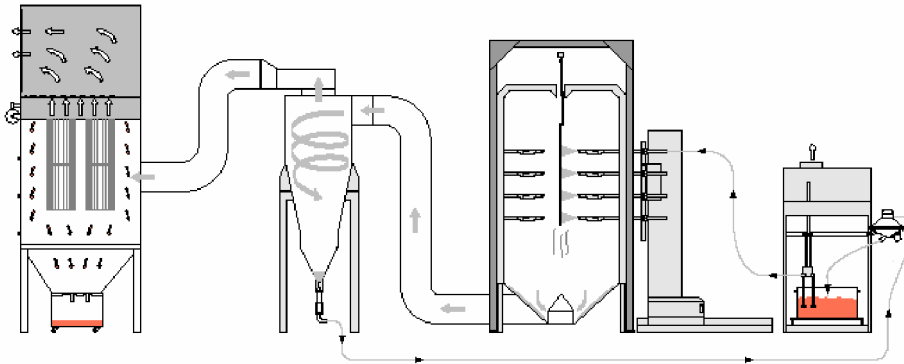
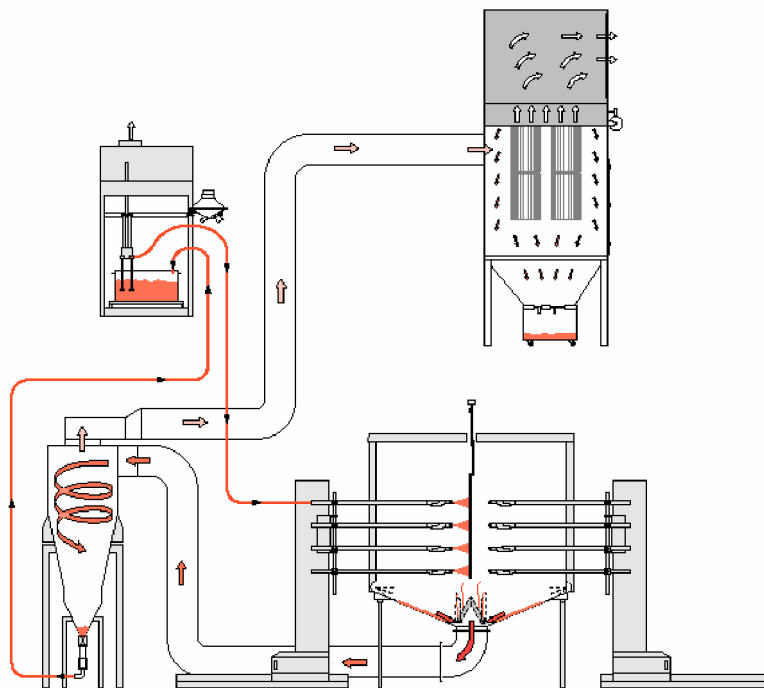
Multi-cyclone without squeegee:

Multi-cyclone plants are suited to three or four clour changes per day. Their level of separation is approx. 93%.



Mono-cyclone:

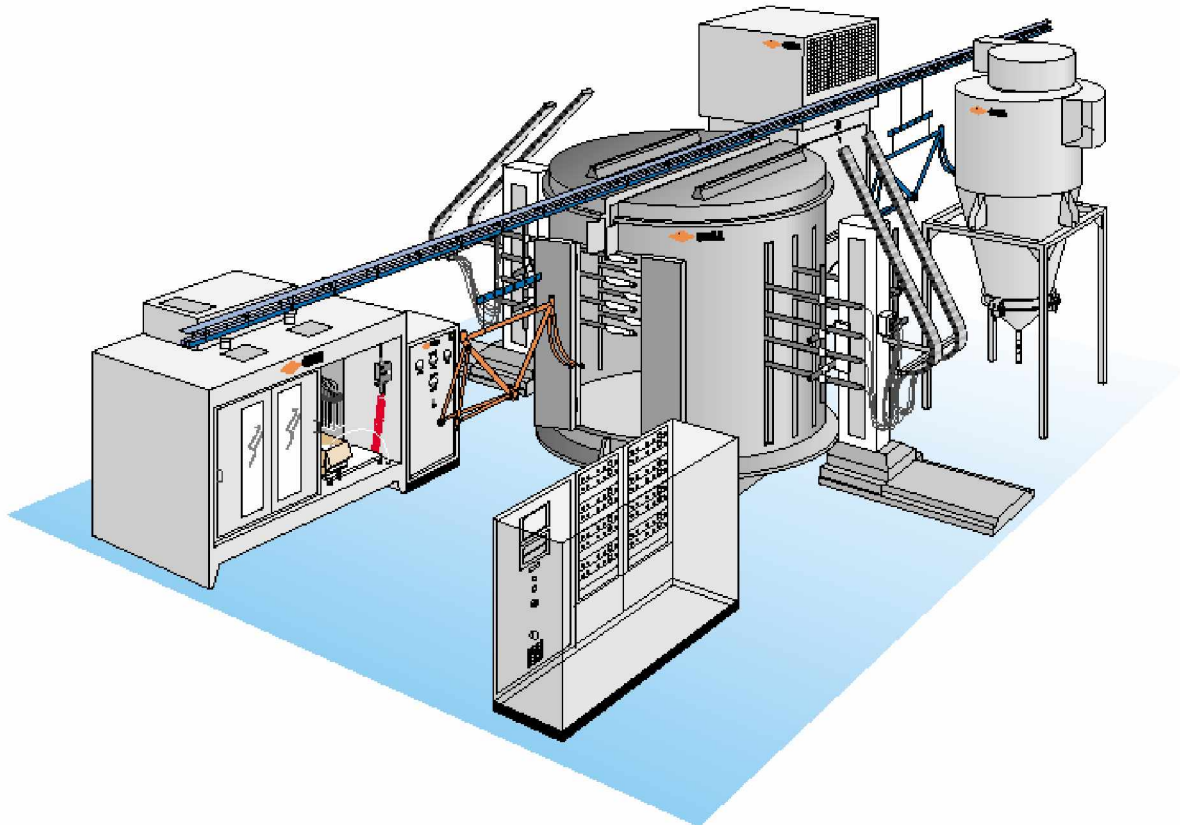
All colour change booths, steel- as well as plastic booths are equipped with mono-cyclones. The level of separation is approx. 95%.

**MagicPlus Scheme****MagicCylinder Scheme**

6. The Sizing of the Plant

The described booth types and recovery plants are all available in various sizes. The correct sizing is of great importance, as an over-sizing causes unnecessary costs, on the other hand an undersizing can quickly effect the coating quality and safety negatively. The essential parameters in sizing the booth and the recovery systems are:

- the calculated quantity of exhausted air
- the used quantity of powder
- the number of guns
- the required level of recovery
- the quality-requirements
- the space conditions



BALD NEUE ZEICHNUNGEN VERWENDEN!! (Use new drawings)

Coating appliances consist of gun control inserts, combined with manual- / automatic guns.

7. The Gun Control Modules

These are used for the setting of the coating values for each gun. These are in particular powder quantity, air quantity, air flushing for the electrodes, high-voltage and current intensity. Appliances with different operational comfort are available. Conventional controls with manual setting for transportation- and dosage-pressure, high-voltage of the guns, as well as proportional controls with stored programs for all relevant coating parameters.



8. The guns

We differentiate Corona- or tibo-guns. The Corona-gun is a high-voltage gun, which can be used for all kinds of powders. With the SuperCorona one has a form of low-ionic-charging, which allows the application of thicker powder coats without unpleasant orange peel. The same principle can be applied to the enamel-coating, the guns however are manufactured with other materials, due to the abrasive properties of the enamel-powder. The tribo-gun is a friction gun without high-voltage supply and requires a specially treated powder. The powder bell works similar to the liquid painting bell, is however only used, when only flat parts are coated with one colour in a booth. According to the requirements of the objects which are to be coated, different appliances as well as various nozzles are available.



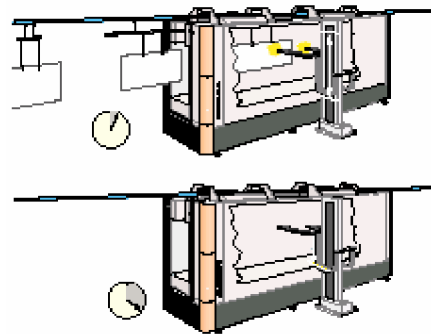
9. The Object Control

While simple manual appliances need no more than one gun control, an automatic plant has higher requirements, going as far as complete plant controls. Presently, following levels of automation are possible:

Automation Level 1:

Interval control for gun groups:

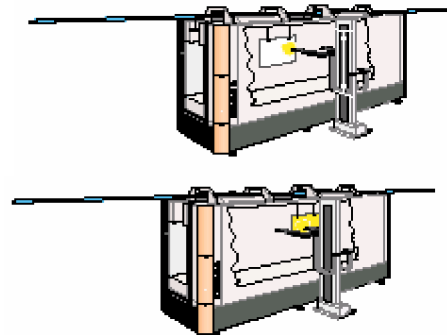
This function allows the object to be coated to be registered at the booth entrance by a multi-cell array and guns are switched on with respective retardation. Registered intervals lead to the guns being switched off with respective retardation.



Automation Level 2:

Interval control for single pistols:

This function allows the guns to be switched on separately. Should intervals appear the guns are switched off in retardation. At this automation level the control can be integrated in a superior cabin control (PLC).



Automation Level 3:

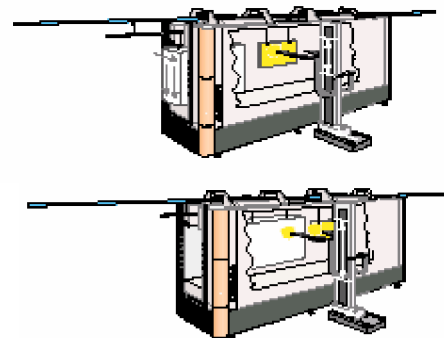
Interval control and horizontal stroke

The interval control functions as above. With the horizontal stroke the reciprocators are set to the width of the widest part at the beginning of the coating operation and run-out of the cabin at the end of the coating operation.

Automation Level 4:

Height recognition and horizontal stroke with vertical gun layout:

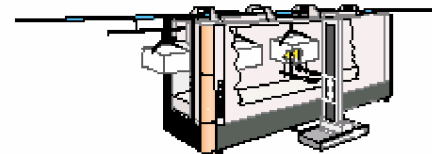
The horizontal stroke still follows the widest part. On the other hand the coating heights are recognized and only the guns needed to coat the respective parts are switched on.



Automation Level 5:

Height recognition and horizontal stroke with horizontal gun layout:

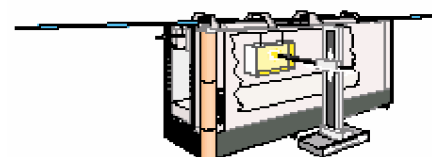
The horizontal stroke still follows the widest part. In addition the height recognition adapts the stroke on the z-axis to the height of each part. According to the stroke the guns are switched on or off, and the powder quantity is controlled by the PCG modules.



Automation Level 6:

The fully automatic operation:

The objects are not coated according to the recognized geometry, but is recognized solely by the multi cell array and the respective coating program to the part is run. The horizontal stroke follows the width of the particular part and is not only based on the widest part. This level also incorporates the synchronized coating, whereby the reciprocators move with the parts and several axes are processed simultaneously.



8.1 The Control modules

In general the plant control is composed of a control cabinet with various modules, which control the particular functions of the guns, reciprocators a.s.o. Depending on the level of automation following modules kann be used. The gun control modules were discussed at a previous stage, therefore the following explains the other control modules.

8.2 The monitoring controls:

The interlock control modules serve the control and release of interlock-functions in plant with fluidized powder containers as well as the status display of the powder container. The PMC modules allow an individual adaptation of all plant-specific requirements and controls the release of pre-fluidification and fluidification of the powder container, as well as upto 32 gun modules. The PMC modules can be obtained in two different automation levels.

The SDC diagnostic system serves the monitoring of the function of 10 gun- and 4 reciprocator controls. The light-emitting diode on the front panel shows if a connected device is working or not.

8.3 The Controls of the FreshPowder supply:

The FPC FreshPowder-control modules monitor and control the transport of the powder from the powder stock into the powder container. These modules are available in two different automation levels.

9. The FreshPowder supply

FreshPowder systems are used, when the demand for powder is high and the quality requirements call for a constant input of FreshPowder to the recovered powder. Depending on the size of the plant (number of guns) and the powder container of the manufacturer, various systems can be used. Starting from the 25 kg container of the manufacturer upto a direct FreshPowder conveying system from the original 250 -500 kg Big Bag of the manufacturer.

10. The reciprocators

Reciprocators have the function of moving the guns. Depending on the use, various versions are available. While a simple short-reciprocator can be sufficient for the easiest case, a reciprocator with running capabilities should be used for complex coatings. The optimal reciprocator and its optimal settings were defined and documented during the coating tests. An exact repeatable coating performance, which warrants an uniform equalness and coating thickness, is only possible with a layout made to customer specifications. Depending on the work input, the plants can operate in upto three dimensions. In big-industry several bi-dimensional reciprocators with several guns is not extraordinary anymore, especially since these are controlled by a single compact control and which guarantee a equal coating quality. The control of the reciprocator is placed in the control cabinet of the powder-coating appliance. A micro-processor control guarantees a constant stroke speed and the exact observance of the dead centers. The settings of the conveying speed and the stroke height can be programmed and retrieved at all times. The velocity of the chain conveyor and the strokes, which guarantee an optimal coating quality have a mathematical coherence.



The reciprocator controls:

The PRC controls serve a free programming of the reciprocator and axis-movement in 64 different operating positions. The control can be selected manually by using the keyboard or can also be selected by using external digital control signals. The PRC modules are available in three different automation levels. The control module CR03 („Gematic“) is a novelty, through which all axes can be freely programmed.



11. Required Safety Appliances

Further to the observance of the maximal powder concentration, safety appliances have to be installed. In cases of automatic coating, the booth in general has to be equipped with a self-acting fire-suppression-system. Furthermore, when using cyclones a flame arrester resp. an after-filter has to be established. Nowadays both is preferably attained with CO₂- extinguishers.

12. Further points to pay attention to

To secure an operation free of interruptions a compressed air preparation plant is imperatively required. The maximal allowance of steam content of 1,3 g/Nm³ and the maximal allowance of oil-steam-content of 0,1 ppm are only attainable by use of a compressed-air-dryer with a downstream fine-mesh filter. For specially high quality requirements, the complete powder circulation is nowadays frequently integrated in a pressurized booth, to prevent dust-entry into the workshop. Siemens-Nixdorf realized this concept with an additional air conditioning, resulting in superb surfaces with very low rejection rates.

13. Example for the use of a quick-colour-changing system

The Company Grammer AG (Ltd.) in Amberg is a worldwide leader in the innovative development and manufacturing of driver- and passenger seats as well as parts for car-interiors. Head-rests, arm-rests and center-consoles make up a part of these products. With a staff of more than 7000, spread over 24 consolidated companies in 13 countries, they develop and manufacture acknowledged solutions in this spectrum, which contribute to safety, preservation of health and well-being. This philosophy has tradition at Grammer's, as the 23-year old Georg Grammer took over the well-known saddlery of his father in 1954 and in the same year founded a workshop to manufacture cushions for tractor-seats.

In the meantime these cushions have been developed into technically outstanding seating-systems, which for example are installed in trucks, construction-machinery or in modern railways, such as the Transrapid in Shanghai or the ICE's. 1976 an innovative manufacturing process was introduced, the so called technique for rear-foaming. The unique technology, then laid the foundation for a new era in the manufacturing of upholstery and has since been continuously improved and refined.

This positive approach to the use of modern technologies has remained in the manufacturing at Grammer. This was evident, when the decision was taken to replace the existing liquid painting plant. This system incorporated a small manual coating appliance. It was equipped with a 1 meter high pedestal, which demanded a considerable fitness of the worker, especially if one considers the climatic conditions in a liquid painting plant!

Starting 1998 the replacement of the liquid painting plant with powder coating was discussed. At that time first test were run. Due to reasons of cost, the project was not realized, as the liquid painting plant then still functioned without problems.

When the control of the liquid painting plant failed, the floor of the plant had rusted through, and costs for the revision of €90'000.- were quoted, the chance was taken to reconsider the possibility of a new, modern, powder coating plant. It was decided that liquid painting would not be used any more. On the one hand a scratch resistant immersion painting could hardly be attained. On the other hand Grammer's wanted to accent the desire of environmental protection.

Seating systems show a variety of colours, especially as every single transportation company has its corporate colour. Grammer has concepted its production to an extreme Just in Time. 2000 drivers seats for tractors, construction machiners and stackers are delivered daily, in numerous varieties, as well as 400 passenger seats for the railway. Given these facts, it became obvious that only a highly flexible quick-colour-change system for powder coating came into question. The decision fell on the „MagicCylinder“ System from ITW Gema AG.

After inspection of a plant at Wanzl, Laupheim, and intensive tests in the application laboratory of ITW Gema AG in St. Gallen, Switzerland, the installation of the new plant began in November 2001. It should be noted, that Grammer did not have any production stops, as the existing manual cabin of the powder coating plant, was moved and taken into operation again. During the visit at Wanzl, the idea was taken up, to also install the cabins even-earthed. The advantage was taken to partly use the existing pits of the liquid painting plant.

Why „booths“? The existing manual coating booth was moved to the back and the conveyor was layed lower. So the possibility was kept to coat smaller series in the manual booth at short notice.

The main plant however, the „MagicCylinder“, was equipped with a pre- and aftercoating station, to, if need be, manually coat difficult parts. The cabin can accomodate parts of upto a heighth of 1'500mm and a width of 1'000mm, parts of upto 2'800mm in length using the pre-treatment. The above at a maximal conveyor speed of 4 m/min.

All parts, by the way, are painted in advance by immersion. According to Mr. Standecker, Team leader of the coating plant, the combination of immersion painting and powder coating has proved itself to be the best in respect to quality.

For a continious FreshPowder input into the circuit, the powder center is equipped with a suction system. This sucks the FreshPowder directly from the container and feeds it directly into the ducting leading to the cyclone. This increases the coating quality additionally.

What are the first experiences with the new plant? Mr. Fochtner, Product Manager: „ The integration in the existing plant, worked very well. In particular, the technical assistance of Mr. Herget, the local sales agent of ITW Gema AG, has to be emphasized. His technical competence helped us enormously and he was a big help in all aspects.“

„ The MagicCylinder was our favorite from the beginning, especially as the cleaning takes place from outside and the booth does not have to be entered. From a safety point of view, as well as in respect to health aspects, this is a very big advantage of this system.“

Mr. Standecker adds: „ In respect to reduction in work force and material recovery, the system has fulfilled all our requirements.

Also the ecological aspect is not to be disrespected. We had to pay approx. 20'000 € duties yearly for hazardous waste, while operating with immersion painting, and tody we can operate completely with material recovery, with a minimal amount of powder in the circuit.“

The plant becomes economical through the use of the new control units OptiTronic, which in addition are included in a network with a superior control using ProfiBus. Again Mr. Fochtner: „The programming possibilities are intensively used and are a great help when looking at our huge parts spectrum. In addition the TouchPanel is very much handier than a control with a keyboard and mouse.“

This is used very frequently seeing the immense colour spectrum . And with 8-10 colour changes daily (2 shifts) a lot more can be processed as before.

FIRMA / COMPANY : Grammer AG

ORT / PLACE : Amberg

LAND / COUNTRY : Germany

OBJEKTE:

Sitzsysteme (*Baumaschinen / Bahn / LKW*)

PARTS :

Seats (*construction machinery / railway / trucks*)

GRÖSSE :

H : 1500 mm

B : 1000 mm

L : 2800 mm

SIZE :

H : 1500 mm

W : 1000 mm

L : 2800 mm

ANLAGE :

1 x OptiMatic

2 x Easy-Select Handpistole

16 x PG 2-AX Automatikpistole

2 x ACR 2/06/30 Hubgerät

1 x Magic Cylinder

1 x SPS mit Touch Panel

SCOPE OF DELIVERY :

1 x OptiMatic

2 x Easy-Select Manual Gun

16 x PG 2-AX Automatic Gun

2 x ACR 2/06/30 Reciprocator

1 x Magic Cylinder

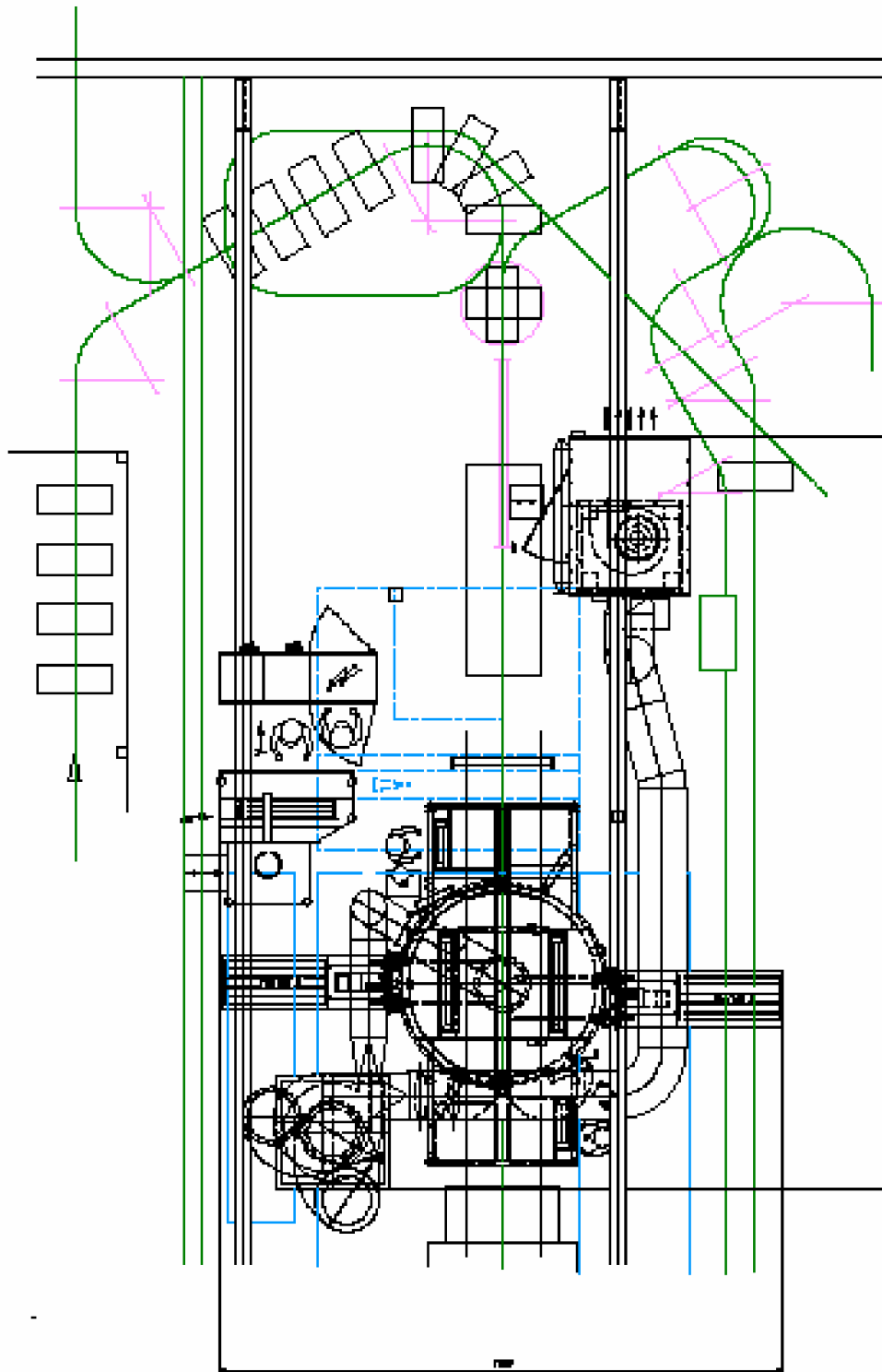
1 x PLC with Touch Panel

FÖRDERERGESCHWINDIGKEIT

3.5 – 4.0 m/min

CONVEYOR SPEED :

3.5 – 4.0 m/min



Layout of the MagicCylinder plant at Grammer AG (Ltd.)

