Nylon powder for easily appliable, economical and environmentally-friendly corrosion protection

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The fluidized-bed process is an important metal-coating technique which, in principle, is simple. To obtain high-quality coatings, however, special requirements must be met concerning both the process itself and the powder employed.

1 Requirements for suitable plastics

For trouble-free processing and finished articles, of high quality the powders must fulfil certain important conditions. Firstly, the relevant polymers must be capable of being converted into the required particle size and shape, must melt in an acceptable temperature range, and must give a pore-free, smooth coating the sintering process without decomposing, forming blisters, or being thermally damaged. The coating process should not give rise to dense fumes caused, for example, by residual monomers, volatile plasticizers, etc. The particle shape and particle size distribution influence the fluidizing behaviour of the coating.

Dust formation in the fluidized-bed coating baths, which is occasionally observed, also depends on this. The bulk density of the powder is also an important parameter. The products available today ensure good leveling and still permit good coverage of sharp edges. Edge coverage presents a problem in all coating and lacquering techniques.

2 Nylon powder

The present powder has excellent properties which permit very easy and simple processing, especially by the fluidized-bed coating process. It is based on a standard product with a well-defined melting range, relatively low melt viscosity and good thermal stability. The powder produced from it has a very advantageous particle shape (Figure 1) in conjunction with an optimum particle size and a broad particle size distribution.

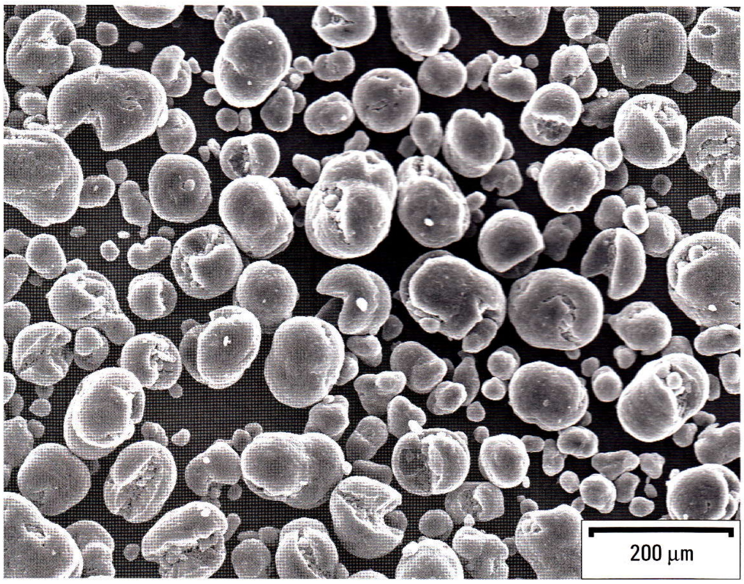


Figure 1: Nylon 12 coating powder

These parameters result in excellent fluidizing behaviour and promote uniform flow of the fluidized bed so that it behaves like a liquid. Removal of fine particles presents the release of dust from the coating tanks.

With such powder quality, a pore-free, smooth coating with good adhesion and edge coverage can be achieved easily and economically.

In addition to the nylon 12 powder, based on laurolactam and sold under the brand name VESTOSINT, Rilsan – nylon 11 powder based on aminoundecanoic acid – is also available.

2.1 Properties of nylon powders

The coating powders obtained from the base polymers by a technologically highly complicated method have extraordinary physical properties and high chemical resistance. An overview of the features relevant for use is given below, the following being particularly noteworthy:

- **low density**
- **high mechanical strength and surface hardness**
- **high impact strength, extensibility and abrasion resistance (even at low temperatures)**
- **good frictional behaviour**
- **low water absorption and water vapor permeability**
- **good adhesion to metals**
- **high resistance to chemicals, oil and gasolene**
- **high heat resistance in service**
- **high stress cracking resistance**
- **high resistance to boiling water and water containing wetting agents**
- **high resistance to salt water**
- **good weather resistance**
- **excellent insulation and dielectric strength**
- **physiologically safe**

This broad property spectrum gives rise to a wide range of interesting applications, which will be discussed in detail later.

3 Reasons for coating

Owing to the excellent fluidizing and processing behaviour and the properties achieved, high-quality corrosion protection with excellent mechanical properties, high heat resistance, good chemical resistance and ageing resistance can be achieved with this nylon powder. These aspects are only a part of the reason why metals in particular are coated with thermoplastics. The slogan "rust consumes money" is extremely relevant. The figures show that damage at a level of DM 33 to 50 thousand million per annum is caused by corrosion and wear in the German economy alone. Another source states that the International Labour Organisation (ILO) in Geneva has found that the annual loss in the developing countries in this area is 100 to 200 thousand million dollars, while the total credit program of the World Bank for these countries is only about 16 thousand million dollars (1986).

The consistent use of feasible technologies can help prevent, reduce or delay the destructive effect of corrosion, thereby resulting in about a 20% reduction in damage. One of these technologies involves the coating of metallic workpieces with polymer powders. This is passive corrosion protection. The coating acts as a barrier between the metal surface and the attacking medium. The protective effect is proportional to the coating thickness: the thicker the coating, the better the corrosion protection to be expected.

However, nylon coatings can do more than simply provide protection against corrosion. They preserve sensitive areas of workpieces from damage, ensure good electrical insulation and hygienic lining of containers and articles in the food industry, and provide decorative surfaces. Instead of expensive materials for parts of apparatuses or machine components, they make it possible to use economical materials protected by a satisfactory coating. Furthermore, the service life can be doubled an in specific cases even increased tenfold by an appropriate protective coating. Further aspects include the good antiadhesion effect of the surface and its resistance to salt water, insulation against the effects of temperature, good frictional behaviour and abrasion resistance, as well as the combination of individual properties for these various applications.

4 Design tailored to plastic and coating

The quality of a polymer coating depends not only on the coating powder but also on the design and the manufacture of the parts to be coated. For example, everything should be done to avoid characteristics which may lead to a decrease in the coating thickness, such as burrs, sharp edges, and corners and transitions which have not been rounded off (Figure 2).

All polymers shrink on cooling, resulting in the coating becoming thinner at the critical points than in flat areas. This may considerably restrict the performance characteristics. In unfavourable cases, the coating may even crack. Extreme differences in wall thickness should also be avoided.

The coating process and the handling of the part during pretreatment, coating, and cooling should be considered at the planning stage in order to decide on the most advantageous gripping or suspension point.

For all articles produced by welding metal sheets, pipes, profiles and wires, care should be taken that there are no gaps. Since these gaps are frequently very narrow and powder cannot enter, the air expands during melting and gives rise to blisters and pores in the coating. In order to prevent this, such points must be continuously welded, and all weld and solder joints must be machined. This problem can also be solved if distances of more than 10 mm between the individual parts are ensured by design measures. Cast parts must also be degassed in order to obtain a blister-free surface.

Depending on the thickness of the material and on the required coating thickness, the workpieces must be preheated to 230 - 450 °C. The only suitable articles for coating are therefore those made of materials which do not change their shape at these temperatures, do not lose their properties, and do not release any gaseous substances. Articles of lead or tin and soft-soldered workpieces cannot be coated.

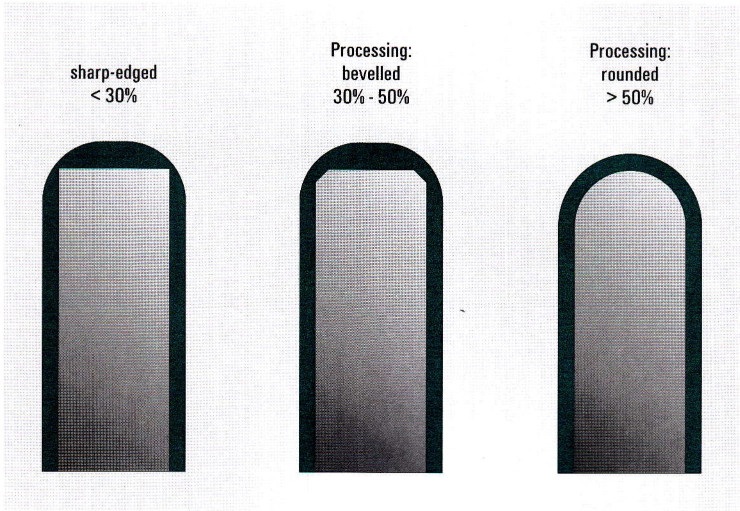


Figure 2: Coating thicknesses at the edges in various versions of wire ends

An important prerequisite for optimum coating is that the design and construction of the workpieces be tailored to plastics technology and coating technology. A valuable aid is DIN 28 051 (formerly VDI guideline 2532) and DIN 28 053 (Figures 3a to 3c).

5 Pretreatment in practice

Another important point for achieving a good coating result is the proper pretreatment which meets the requirements in practice. The problems are already sufficiently well known from lacquered articles.

Since the characteristics of the surface considerably influence adhesion of the polymer coatings, all articles to be coated must be free of dust, dirt, oil, grease, scale, oxide layers, and paint residues. Careful pretreatment is essential for good adhesion and hence for satisfactory corrosion prevention. This is because every coating system is only as good as its adhesion. In the event of delamination of the polymer coating from the substrate, protection against corrosion is no longer assured (Figure 4 on page 6).

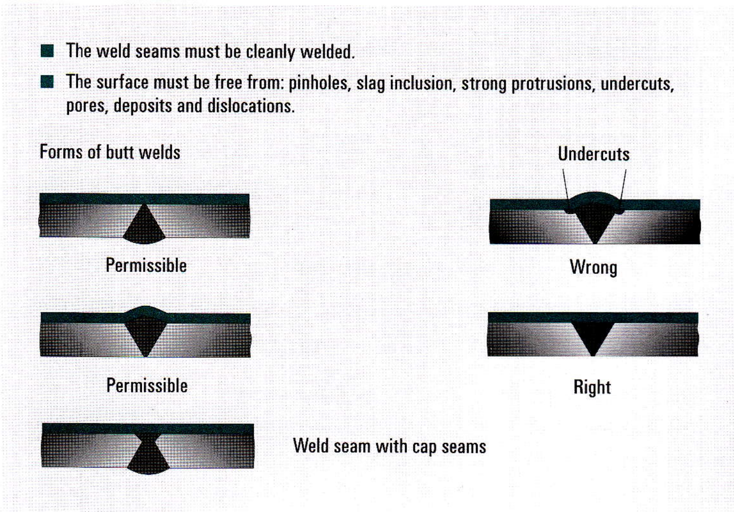


Figure 3a: Design information – weld seams

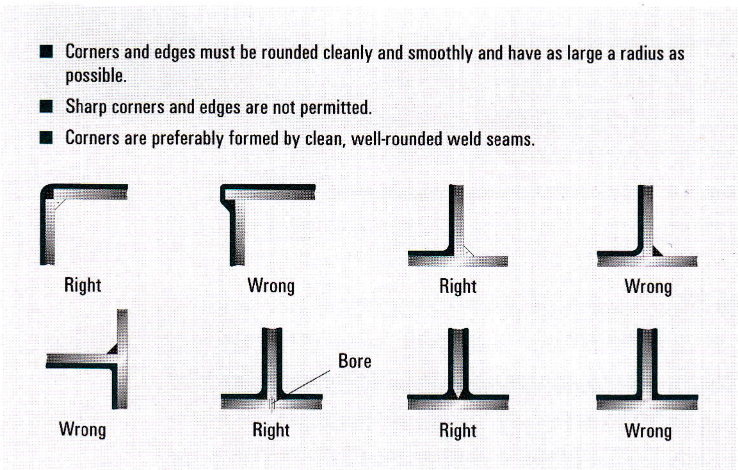


Figure 3b: Design information – edges, corners and bars

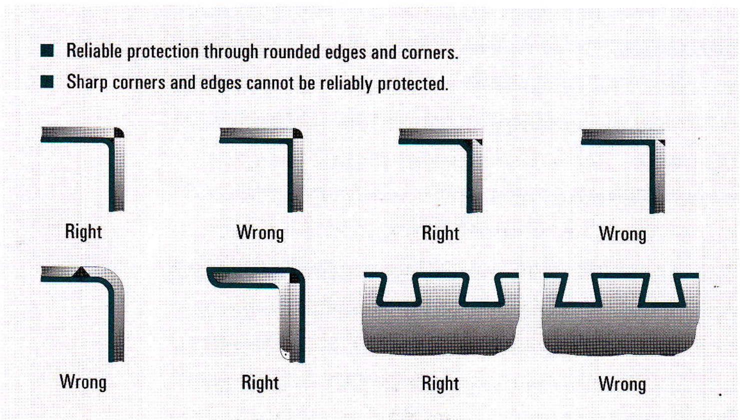


Figure 3c: Design information – edges, corners and bars

For normal requirements, degreasing in alkaline baths or with tri- or perchloroethylene vapor in closed systems is often sufficient. In the case of more stubborn impurities or more stringent requirements, mechanical and/or chemical operations, such as shotblasting and pickling, are also required. The blasting material used may be steel shot, cast iron granules, wire shot, light metal granules or standard corundum or special fused alumina, and in special cases glass beads. The quality of the blasted steel surface should correspond at least to Sa 2 ½ or preferably Sa 3.

The classification according to degree of purity is contained in DIN standard 55 928, part 4 "Prevention of corrosion of steel structures by means of coatings, preparation and testing of the surfaces" and is based on the internationally recognized Swedish standard SIS 055900-1967 "Degrees of rusting of steel surfaces for rust prevention coatings". This standard is published by the Swedish Standardisation Commission, Box 3295, Stockholm 3, Sweden, in cooperation with the American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, Pa. 19103, USA (recognized by ASTM Designation D 2200-67) and Steel Structures Painting Council (SSPC), 440 Fifth Avenue, Pittsburgh 13, Pa., USA (recognized by SSPC visual Standard SSPC-Vis 1). The classification referred to above is also in compliance with ISO standards 8501-1 and 8501-2.

In order to achieve satisfactory adhesion, it is essential to free the metal surface from adhering dust and abraded material after blasting.

While degreasing or degreasing combined with shotblasting are sufficient in many cases for ferrous metals, nonferrous metals, such as aluminium, magnesium and zinc and their alloys, as well as galvanized steel, always require chemical pretreatment of the parts. In multistage processes, phosphating and yellow or green chromating are carried out. The thickness of this intermediate coating is 0.1 to 2.5 μm. In contrast to articles which have been degreased, blasted or pickled, parts pretreated in this way can be stored.

For applications where coatings are subjected to particularly high stress, for example where there are frequent temperature changes, where there is contact with hot or detergent-containing water, and where inner coatings of pipes or containers, or parts are exposed to weather use of an adhesion promoter is essential. Adhesion promoters are dissolved synthetic resins which are applied in the same way as conventional lacquers. They crosslink on baking, form a moisture barrier and, owing to their polarity, adhere both to the metal substrate and to the plastics coating.

Adhesion promoters are applied with a spray gun, by brushing on or by dipping or flooding, the viscosity being adapted to the particular process. Drop formation or accumulation of adhesion promoter in indentations leads to defects in the coating and must be avoided. The articles provided with adhesion promoter must be thoroughly ventilated.

After evaporation of the solvent, the adhesion promoter is baked during the heating process required for coating . An intrinsic color which shows the specialist whether the correct preheating conditions were chosen is then observed. The surface must be smooth and without cracks; in other words it must not exhibit thermal damage. An excellent bond between metal and polymer layer and, hence, very good corrosion prevention are achieved with a coating thickness of 5-10 μm.

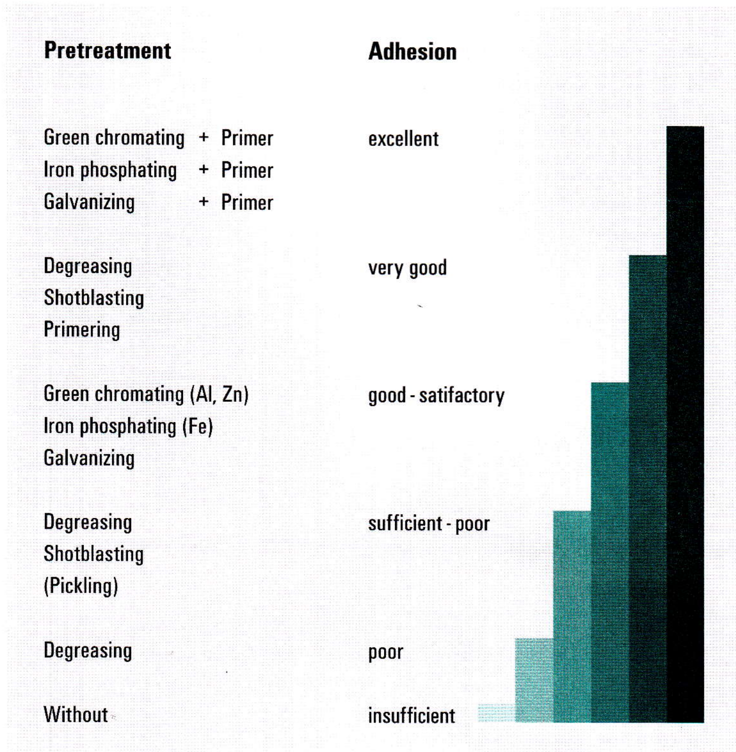


Figure 4: Relationship between pretreatment and adhesion

6 Fluidized-bed coating process

This technology, developed in 1952 and patented 1953 by Erwin Gemmer, is based on the combination of the fluidized-bed and the dipping process. Fluidized beds have played an important role in chemical process engineering since 1926. The fluidized-bed coating method is thus certainly likely to be the oldest powder coating process. The advantage of this technology is the relatively elegant way in which the positive properties and advantages of metals are combined with those of nylon.

This process is an economical method of coating preheated, preferably metallic articles, with plastics. With inexpensive apparatus, it is possible to achieve coating thicknesses of 250 to 500 μm. If necessary, coatings of 1-2 mm can also be realized.

Workpieces of any shape made of steel, metal alloys or aluminium, and parts made of glass, porcelain or ceramic materials can be coated.

5.1 Preconditions for carrying out the process

1. Article design which meets coating technology and plastics technology requirements
2. Pretreatment tailored to the conditions of use
3. Coating powders with the required properties and the necessary processing characteristics
4. Forced-air oven with good temperature control and temperature distribution
5. Fluidized-bed coating tank
6. Auxiliaries and auxiliary equipment

The first three points have already been discussed in detail in the previous sections.

6.1.1 Forced-air oven

The heating of carefully pretreated metal parts is carried out in a hot, forced-air oven heated by fuel oil, gas or electricity which provides a constant temperature over the entire interior space through thermostatic control and air circulation by means of fans. This provides the required workpiece temperature and ensures even temperature distribution. An electrically heated furnace is usually the cheapest to acquire but more expensive to operate. The opposite applies in the case of oil furnaces.

The geometry of the articles to be coated and the required throughput determine the dimensions and the furnace type, which can be a chamber furnace, continuous furnace, rotary hearth furnace, top-hat furnace or paternoster furnace. Theoretically, there are no limits to the size of the parts. Here, apart from the problem of parts being handled by the manufacturer, the coater and the user, economic considerations are also critical.

In mass production, the procedure can be automated by means of a conveyor belt or suspension conveyor system which transports the parts through all stations, including preteatment. The furnaces operate between 230 and 450 °C.

6.1.2 Preheating

Apart from the criteria already described, such as the base material, the wall thickness of the workpiece and the coating powder, factors which influence the properties of the coating are preheating temperature, residence time in the furnace and dipping in the powder tank. The stored heat content of the metal must be sufficient completely melt the adhering polymer powder. Since thick-walled articles have a higher heat content than thin-walled ones, the latter must be heated to a higher temperature. Although lower preheating temperatures are sufficient for thick-walled parts, they require a correspondingly longer heating time. There is therefore a lower limit to the preheating temperature below which complete melting of the powder does not occur which produces a rough surface. If the temperature is too high, overheating may damage the coating material by degradation. The thermal stability and the processing range are determined by the type of polymer. In the case of articles with large differences in material thickness or with a complicated shape, the different heat capacities may make it impossible to obtain defect-free coated parts at any preheating temperature. There are two possible remedies.

So called <u>shock heating</u> attempts to equalize the different heat capacities of wall thicknesses by increasing the temperature and reducing the heating time, in order to obtain coating thick nesses which are as regular as possible. In general, an extremely high furnace temperature – usually the maximum possible – and a very short heating time are used. This ensures that the thin regions are provided with the maximum possible heat capacity which can be stored, while the thicker parts have sufficient heat capacity for adequate melting of the powder, even after a short heating time. The optimum parameters must however be determined by suitable tests. This method gives a very uniform coating thickness even in the case of large differences in wall thickness.

In the case of sensitive workpieces, materials or coating powders, the double heating method is used, involving considerably reduced preheating temperatures and hence substantially gentler heat treatment. The powder does not melt completely after dipping. A second heat treatment immediately after coating and once again at lower temperatures, ensures the best possible surface. This subsequent external heating acts on the surface for only a short time. However, this procedure is a compromise since the double application of heat means that shrinkage and associated stresses are increased.

All furnace temperatures must be substantially above the melting range of the particular polymer.

6.1.3 Fluidized-bed coating tank

The required fluid-bed coating apparatuses should be tailored to the dimensions of the parts to be coated, to enable these to be completely immersed in the polymer powder. In practice, there are coating tanks with a depth of up to 7 m and a length of up to 10 m. The simple structure of a coating tank comprises, a lower chamber with a minimum height of 250 mm, an air-permeable intermediate base, and the upper chamber with a cover. The lower chamber has one or more compressed air connections, its

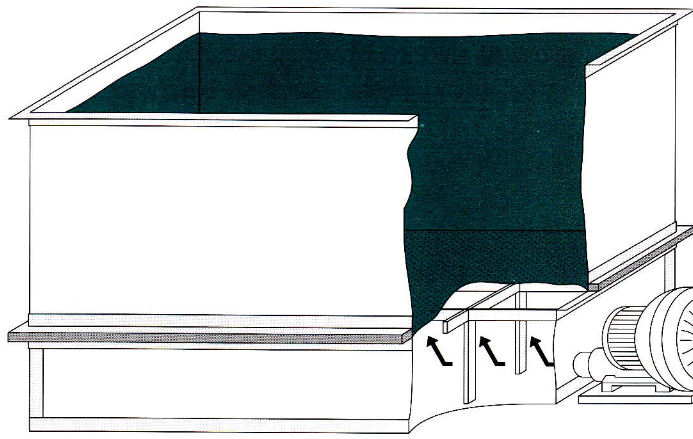


Figure 5: Fluidized-bed coating tank

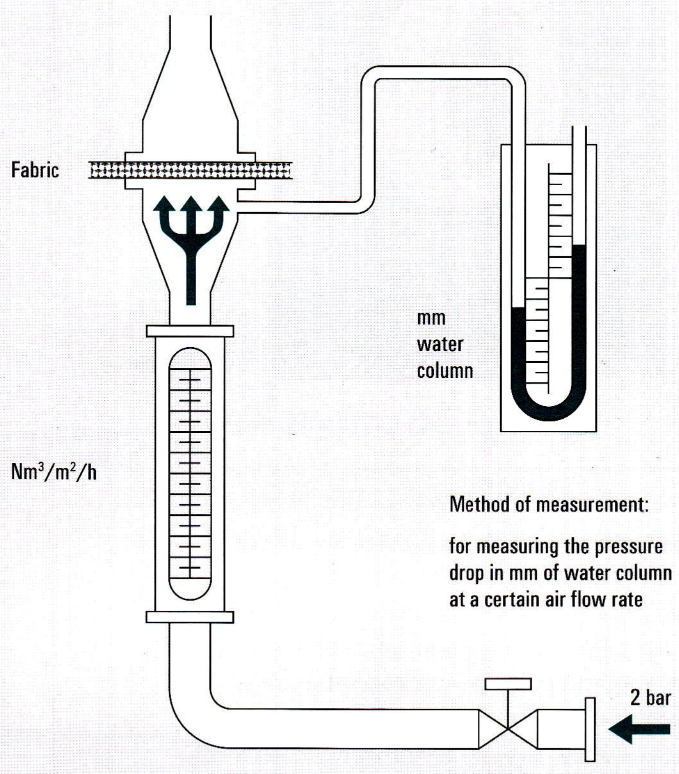
depending on size. In order to distribute inflowing air uniformly and to ensure regular, uniform fluidization of the powder, the intermediate base must have uniform air permeation resistance over the entire area. The material used are woven fabrics of cotton, metal or synthetic materials, sintered sheets of metal, plastic or ceramic, and felt sheets. For example 4 mm thick sheets of polyester fabric have been successfully used. The porosity of the intermediate base must be low enough that even the smallest powder particles cannot enter the lower chamber or block the base. Pore size should therefore be less than 25 µm (Figure 5).

To avoid contamination of the powder, the compressed air must be completely clean and oil-free. A simple control valve should be present for metering the air.

An airflow rate of 50 - 100 m^3/h per square meter of base area and air pressure of 700 to 1,000 mm water column are required for operating a fluidized-bed coating bath (Figure 6).

In addition to the air permeation resistance of the intermediate base, free-flowing, spherical particles having a particle size spectrum of 30 -

Conditions	Value
Pore size	< 25 µm
Air requirement	~ 50 - 100 m³/h/m² of the base area
Required air pressure in lower chamber	corresponds to the pressure loss in the intermediate base and powder ~ 0.5 - 0.8 h + 200 (mm water column) h = powder height in mm



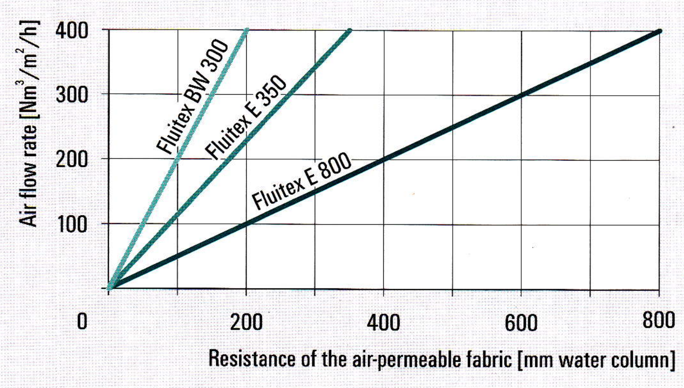


Figure 6: Requirements for the fluidized-bed coating apparatus

250 µm are required for homogeneous and constant fluidization behaviour, as already mentioned. The type of plastic, the particle shape and the particle size distribution have considerable influence on the fluidization effect and the required air flow rate. The tank is filled to a maximum of 70%. Under these conditions, the powder volume increases by about 25% when the compressed air is passed in, and a constant air flow ensures a liquid-like state without pronounced blister formation and without dead zones in the corners. Consequently, the hot metal part can be dipped into the fluidized powder bath without detectable resistance even in the case of complicated shapes, and, by means of movements to and fro, uniform coating of all parts of the article is achieved even in poorly accessible areas. In the case of critical coatings, edge extraction is often used to remove the entrained powder and to prevent very fine particles from flying around and causing coating defects and impurities.

In the case of unsuitable powders or poor fluidization conditions, electrostatic charging of the powder and/or pulsation during fluidization may occur.

In automatic continuous plants, coating tanks are raised by means of lifting systems and execute oscillating movements.

6.1.3.1 Coating process

The pretreated metal parts heated to above the melting range of the powder are immediately dipped into the coating bath to avoid heat loss and are moved to and fro in the tank. Since air flow causes powder particles to move mainly vertically up and down, articles should be immersed so that the surface to be coated is parallel to this direction. In the case of articles with a complicated shape, there is danger that some region will be in a horizontal position.

The article must therefore be moved during dipping. The type and intensity of the movement (rotating, swivelling or shaking) depends on the shape, the size, and the weight of the object. The movement also helps to prevent powder deposits (Figure 7).

After a dipping time which is usually between 2 and 6 seconds and during which an appropriate amount of powder is sintered on, the adhering particles melt to form a smooth, homogenous and pore-free coating with uniform thickness. The surface quality is influenced by, among other things, the particle shape and the particle size distribution.

Coating thickness can be influenced by the preheating temperature and the dipping time and is limited by the heat storage capacity of the workpiece. While the coating thickness is usually 250-500 µm, several millimeters can be reached in the case of thick-walled parts. This is best achieved by repeated dipping. Coating thickness of less than 250 µm can be achieved only in the case of materials with very good flow and film-forming properties.

When the article is removed from the fluidized-bed coating tank, the excess powder flows off from all vertical surfaces. The remaining excess powder is removed by shaking, vibration or blowing. In automatic plants, this can be effected by shapers mounted on the transport chain.

In order to avoid internal stresses, the coatings should be slowly air-cooled. Matt surfaces of great hardness result. If glossy coatings are required, the coated part is dipped into a water bath after the powder has completely melted. Since quenching in water substantially suppresses crystallisation in the surface zone, the layers are predominantly amorphous, i. e. more flexible and with slightly less surface hardness than semicrystalline coatings.

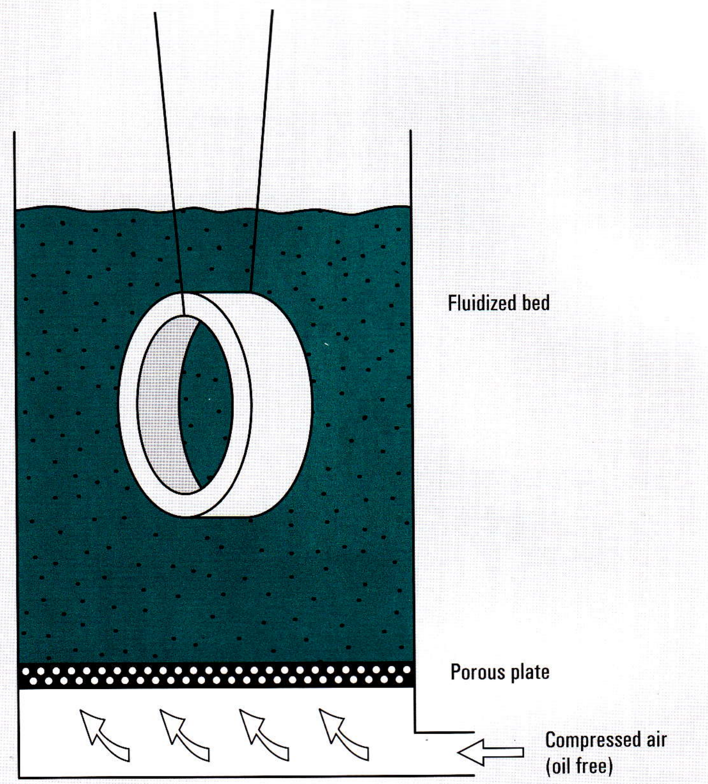


Figure 7: Principle of the fluidized-bed coating process

The gripping point or suspension point is touched up in the final check by means of a 2-component lacquer of the same color with a short curing time.

6.1.3.2 Powder consumption

The powder consumption per square meter can be easily calculated from the coating thickness in micrometers multiplied by the density of the coating material.

For nylon, this is as follows: $\mathbf{P = s \cdot \gamma}$

P = powder consumption [g/m^2]
s = coating thickness [µm]

γ = density [g/cm^3]
(1.01 g/cm^3 for Nylon 12)

For a coating 300 μm thick, the powder consumption is therefore as follows:

$$P = 300 \cdot 1.01 = 303\ g/m^2$$

The material costs per square meter are calculated as follows:

$$M = \frac{s \cdot \gamma \cdot V}{1{,}000}$$

M = price per square meter [DM/m^2]
s = coating thickness [μm]
γ = density [g/cm^3]
V = price of the powder [DM/kg]

7 Factors affecting coating quality

The coating of wire baskets will be used as an example to summarize the details which play a role in the overall result. Figure 8 shows all criteria which have to be coordinated in the case of dishwasher baskets so that their coatings

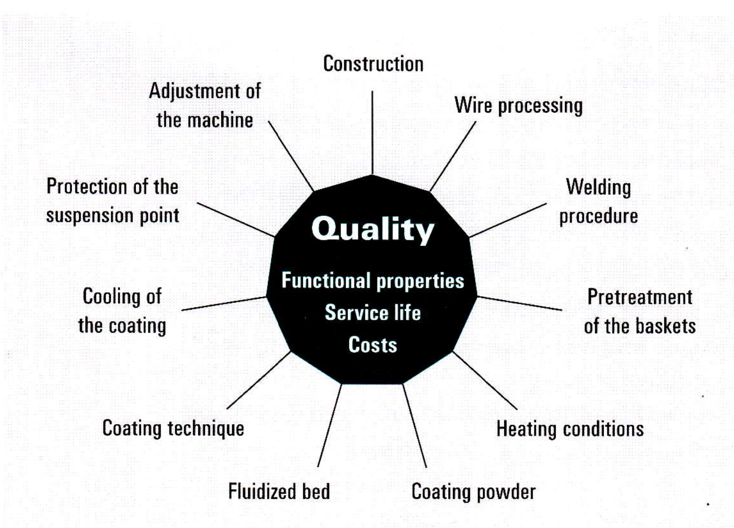


Figure 8: Factors affecting the quality of wire baskets

have the same service life as other parts of the dishwasher.

It is clear that weaknesses in one point can scarcely be compensated for by other areas. Careful attention to all points mentioned is therefore extremely important if efforts to achieve quality are to succeed.

8 Testing the powder and the coating

In order to ensure constant production quality, it is useful to subject the powder to an incoming check and the coated articles to a suitable production check.

8.1 Powder monitoring

Powder suppliers can provide certificates with values determined from product tests.
The following data are relevant:

- viscosity
- flowability [s]
- bulk density [g/cm^3]
- particle size distribution
  [particle size fraction: μm in %]

Apart from viscosity, the other properties can be tested in the plant laboratory. These data give an overview of the constancy of the powder supplied and, as already described, characterize the values relevant for processibility. The production of the powder is certified according to DIN EN ISO 9001.

8.2 Testing the coating

After the coating plant has been started up and when changing over to other articles, the quality of the coating must be checked. Quality control should be carried out at certain intervals during production. Even if the coating parameters have been empirically determined by experiments and have been optimized for each part, checking of the subsequent production is absolutely essential. Unfortunately, possibilities for nondestructive testing of the finished coating are very limited. Apart from checking the surface characteristics, it is only possible to check the coating thickness and freedom from pores. The adhesion achieved can be determined only with simultaneous damage to the coating.

8.2.1 Optical testing

Optical testing of the coating should have priority over every other measure. It permits the detection of coarse defects, such as uncoated parts, blisters, inclusions, impurities, holes, large differences in the coating thickness and mechanical damage during coating. In case of doubt, a magnifying glass with eight to tenfold magnification can be used as an aid.

8.2.2 Checking coating thickness

A number of apparatuses based on different measuring principles are available for nondestructive measurement of the thickness of nonmagnetic coatings on nonferrous metals and steel. These are economical and robust measuring instruments for the workshop and production plant, which are familiar from lacquer technology.

8.2.3 Checking for pores

A pore searcher, a spark coil or a porosimeter can be used to test for freedom from pores, when it is also possible to detect cracks and weak points. Test liquids and dye solutions can also be used for determining defects. Use of apparatus and the method used are dependent on the type of coating material, the thickness of the coating and the intended use of the protected articles, and on whether the substrate is conductive or not.

8.2.4 Adhesion testing

The adhesion test provides information about the quality of the bond between the coating and the metal; the pretreatment also plays a role.

An initial examination reveals that a loss of adhesion may be caused by delamination of the coating from the substrate in articles having an unfavorable geometry. The reason probably lies in the design of the part and inadequate pretreatment; attention has to be paid to both these factors in order to effectively counteract the resulting shrinkage.

Adhesion is usually tested using a cut in the form of the St. Andrew's Cross and a cross-hatch based on DIN 53 151/ISO 2409-1972. A more stringent test consists of carrying out the cupping test (Erichsen) in the cross-hatch according to ISO 1520, with cupping of 5 and 8 mm and subsequent exposure to stress.

The adhesion test can be performed under more severe conditions if samples with a cross-cut or cross-hatch are boiled for 2 hours, cooled, and an attempt is then made to detach the coating from the substrate. This test can also be carried out using the salt spray test.

Experience can be supplemented by the various long-term tests, such as the salt spray test, the Kesternich test, a test under conditions of high temperature and humidity, the detergent test and a Xenon test, as well as outdoor weathering and thermal ageing, The picture is rounded out by special tests, such as a test for resistance to oxygen and hot water, the Säkaphen test, and the thermal shock test.

9 Coating defects

Some typical phenomena which have specific causes and can be avoided by appropriate measures have been observed during practical work. These defects may be due to the unfavorable shape of the part being coated, inadequate processing, or impurities in the powder in the fluidized-bed coating tank or in the ambient air. This may give rise to problems, including those due to holes, pores, blisters, craters, dark specks, yellowing, differences in coating thickness, uneven and/or rough surfaces (orange peel structure), accumulations of material, insufficient adhesion and delamination.

10 Applications

Owing to their property spectrum, nylon powders are used in a wide range of applications in various industries. A selection of applications from certain industries is shown below.

Building industry:
Fittings, door frames, door handles, railings, gutter holders.

Electrical industry:
Insulation of coils, switch parts, rotors, stators, magnet cores; busbars for chargers, battery supports, telephone wires, hot water storage tanks.

Environmental technology:
Waste water pipes and channels, drinking water pipes, gate vales, covers, step irons, sludge presses, rollers.

Food industry:
Containers for bakeries, dairies, confectionery factories, meat product factories, stands for the maturing of cheeses, rollers for fruit presses.

Furniture:
Office furniture, furniture for schools, canteens, etc., garden and park furniture.

Health sector:
Hospital furniture, medical equipment, orthopaedic components.

Household appliances:
Baskets for dishwashers, inserts for refrigerators and chest freezers, freezer evaporators, part of washing machines and household appliances.

Mechanical engineering:
Machine housing and stands, fittings, hand wheels, isolating valves, valves, cellular wheel sluices, hydraulic cylinders, shafts and sleeves, induction coils, self-locking screws, measuring tapes, printing rollers.

Plant and apparatus construction:
Stands and housings, electroplating, containers, connecting elements and pipes for drinking water, adaptors, bearing blocks, insulating flanges for pipelines, well pipes.

Sport and leisure equipment:
Boat accessoires, climbing frames, bicycle frames, play and exercise equipment.

Textile and clothing industry:
Baskets, various small parts, such as hooks, eyes, rings, hangers, sales stands, rollers for transportation.

Vehicle construction:
Frames, handles, retaining rods, seat frames for vehicles of all kinds, seat springs, level indicators for gasotene, spline shafts and sleeves.

Various other applications:
Shopping and transport baskets and stands, shopping trolleys, sales and presentation stands, containers, frames and surrounds.

11 Summary

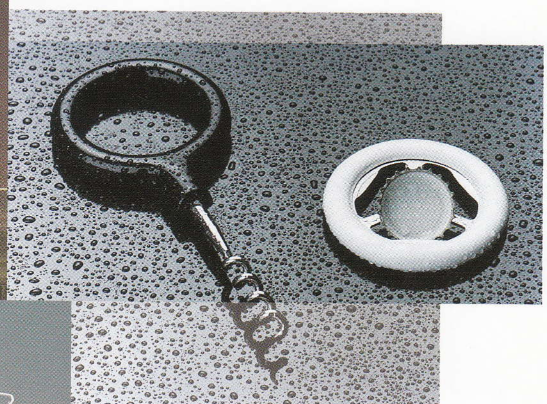
It is well known that corrosion prevention is expensive. However, no corrosion prevention, or prevention which is poorly performed, is very much more expensive.

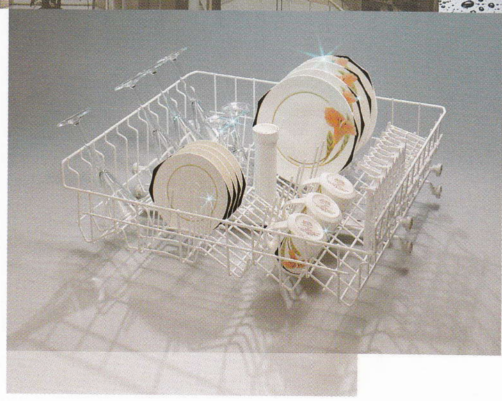
When all the facts are considered, it is clear that all involved (user, coater and powder manufacturer) are in the same boat with regard to achieving an optimal result. There is also the matter of people's attitude to coating with polymer powders, something which is becoming more and more important owing to steadily growing awareness of environmental issues.

The fluidized-bed coating process does not use any solvents, and the nylon powders used are completely environmentally friendly since they do not emit any cleavage products. The quality achievable is a very good reason for using these coatings, which meet the highest requirements with regard to surface characteristics, properties, and corrosion prevention. Furthermore, the process requires neither complicated plants nor particularly qualified personnel and is therefore very economical.

Since coating powders also have a favourable price/performance ratio, their importance and hence their market share will continue to grow in the future. From the ecological standpoint, the environmentally friendly coating method meets present market requirements and provides an answer to some of the issues of our time, such as protection of the environment and conservation of energy and raw materials.







Uses of VESTOSINT® coating powders