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Powder coating

Powder coating is a type of coating that is applied as a free-flowing, dry powder. Unlike conventional liquid paint which is delivered via an evaporating solvent, powder coating is typically applied electrostatically and then cured under heat. The powder may be a thermoplastic or a thermoset polymer. It is usually used to create a hard finish that is tougher than conventional paint. Powder coating is mainly used for coating of metals, such as household appliances, aluminium extrusions, drum hardware and automobile and bicycle parts. Newer technologies allow other materials, such as MDF (medium-density fibreboard), to be powder coated using different methods. The powder coating process was invented around 1945 by Daniel Gustin US Patent 2538562.

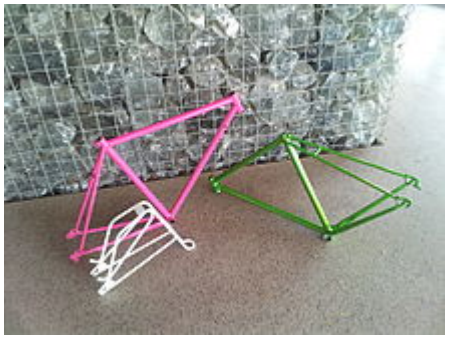
Contents

Properties of powder coating

Because powder coating does not have a liquid carrier, it can produce thicker coatings than conventional liquid coatings without running or sagging, and powder coating produces minimal appearance differences between horizontally coated surfaces and vertically coated surfaces. Because no carrier fluid evaporates away, the coating process emits few volatile organic compounds (VOC). Finally, several powder colors can be applied before curing them all together, allowing color blending

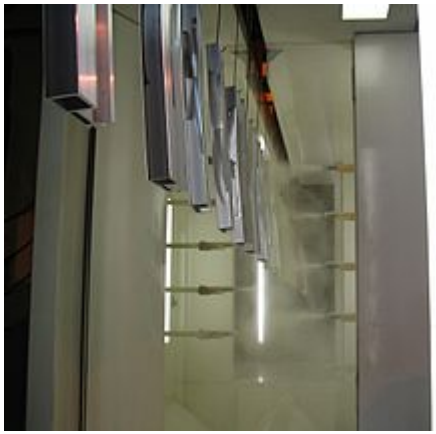
and bleed special effects in a single layer.

While it is relatively easy to apply thick coatings that cure to smooth, texture-free coating, it is not as easy to apply smooth thin films. As the film thickness is reduced, the film becomes more and more orange peeled in texture due to the particle size and glass transition temperature (Tg) of the powder.


Powder coated bicycle frames and parts

Most powder coatings have a particle size in the range of 2 to 50 μ (Microns), a softening temperature Tg around 80 °C, a melting temperature around 150 °C, and are cured at around 200 °C. for minimum 10 minutes to 15 minutes (exact temperatures and times may depend on the thickness of the item being coated). [1] For such powder coatings, film build-ups of greater than 50 μ (Microns) may be required to obtain an acceptably smooth film. The surface texture which is considered desirable or acceptable depends on the end product. Many manufacturers prefer to have a certain degree of orange peel since it helps to hide metal defects that have occurred during manufacture, and the resulting coating is less prone to showing fingerprints.

There are very specialized operations where powder coatings of less than 30 micrometres or with a Tg below 40 °C are used in order to produce smooth thin films. One variation of the dry powder coating process, the *Powder Slurry* process, combines the advantages of powder coatings and liquid coatings by dispersing very fine powders of 1–5 micrometre sized particles into water, which then allows very smooth, low film thickness coatings to be produced.


Aluminium extrusions being powder coated

For garage-scale jobs, small "rattle can" spray paint is less expensive and complex than powder coating. At the professional scale, the capital expense and time required for a powder coat gun, booth and oven are similar to a spray gun system. Powder coatings have a major advantage in that the overspray can be recycled. However, if multiple colors are being sprayed in a single spray booth, this may limit the ability to recycle the overspray.

Advantages over other coating processes

1. Powder coatings contain no solvents and release little or no amount of volatile organic compounds (VOC) into the atmosphere. Thus, there is no need for finishers to buy costly pollution control equipment. Companies can comply more easily and economically with the regulations of the U.S. Environmental Protection Agency.[2]
2. Powder coatings can produce much thicker coatings than conventional liquid coatings without running or sagging.
3. Powder coated items generally have fewer appearance differences than liquid coated items between horizontally coated surfaces and vertically coated surfaces.
4. A wide range of speciality effects are easily accomplished using powder coatings that would be impossible to achieve with other coating processes.[3]
5. Curing time is significantly faster with powder coating than with liquid coating.[4]

Types of powder coating

There are two main categories of powder coating: thermosets and thermoplastics. The thermosetting variety incorporates a cross-linker into the formulation. When the powder is baked, it reacts with other chemical groups in the powder to polymerize, improving the performance properties. The thermoplastic variety does not undergo any additional actions during the baking process as it flows to form the final coating.

The most common polymers used are: polyester, polyurethane, polyester-epoxy (known as hybrid), straight epoxy (fusion bonded epoxy) and acrylics.

Production

1. The polymer granules are mixed with hardener, pigments and other powder ingredients in an industrial mixer, such as a turbomixer
2. The mixture is heated in an extruder
3. The extruded mixture is rolled flat, cooled and broken into small chips
4. The chips are milled and sieved to make a fine powder

The powder coating process

The powder coating process involves three basic steps:

1. Part preparation or the pre-treatment
2. The powder application
3. Curing

Part preparation processes and equipment

Removal of oil, dirt, lubrication greases, metal oxides, welding scale etc. is essential prior to the powder coating process. It can be done by a variety of chemical and mechanical methods. The selection of the method depends on the size and the material of the part to be powder coated, the type of impurities to be removed and the performance requirement of the finished product.

Chemical pre-treatments involve the use of phosphates or chromates in submersion or spray application. These often occur in multiple stages and consist of degreasing, etching, de-smutting, various rinses and the final phosphating or chromating of the substrate & new nanotechnology chemical bonding. The pre-treatment process both cleans and improves bonding of the powder to the metal. Recent additional processes have been developed that avoid the use of chromates, as these can be toxic to the environment. Titanium zirconium and silanes offer similar performance against corrosion and adhesion of the powder.

In many high end applications, the part is electrocoated following the pretreatment process, and subsequent to the powder coating application. This has been particularly useful in automotive and other applications requiring high end performance characteristics.

Another method of preparing the surface prior to coating is known as abrasive blasting or sandblasting and shot blasting. Blast media and blasting abrasives are used to provide surface texturing and preparation, etching, finishing, and degreasing for products made of wood, plastic, or glass. The most important properties to consider are chemical composition and density; particle shape and size; and impact resistance.

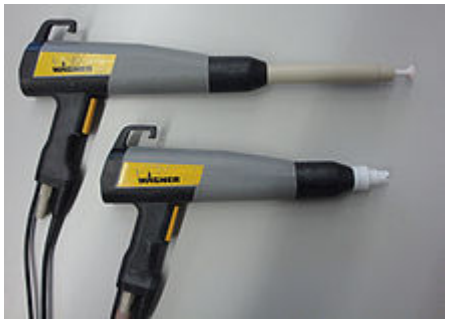
Silicon carbide grit blast medium is brittle, sharp, and suitable for grinding metals and low-tensile strength, non-metallic materials. Plastic media blast equipment uses plastic abrasives that are sensitive to substrates such as aluminum, but still suitable for de-coating and surface finishing. Sand blast medium uses high-purity crystals that have low-metal content. Glass bead blast medium contains glass beads of various sizes.

Cast steel shot or steel grit is used to clean and prepare the surface before coating. Shot blasting recycles the media and is environmentally friendly. This method of preparation is highly efficient on steel parts such as I-beams, angles, pipes, tubes and large fabricated pieces.

Different powder coating applications can require alternative methods of preparation such as abrasive blasting prior to coating. The online consumer market typically offers media blasting services coupled with their coating services at additional costs.

Powder application processes

The most common way of applying the powder coating to metal objects is to spray the powder using an electrostatic gun, or *corona* gun. The gun imparts a positive electric charge to the powder, which is then sprayed towards the grounded object by mechanical or compressed air spraying and then accelerated toward the workpiece by the powerful electrostatic charge. There is a wide variety of spray nozzles available for use in electrostatic coating. The type of nozzle used will depend on the shape of the workpiece to be painted and the consistency of the paint. The object is then heated, and the powder melts into a uniform film, and is then cooled to form a hard coating. It is also common to heat the metal first and then spray the powder onto the hot substrate. Preheating can help to achieve a more uniform finish but can also create other problems, such as runs caused by excess powder. See the article "Fusion Bonded Epoxy Coatings"



Example of powder coating spray guns

Another type of gun is called a *tribo* gun, which charges the powder by (triboelectric) friction. In this case, the powder picks up a positive charge while rubbing along the wall of a Teflon tube inside the barrel of the gun. These charged powder particles then adhere to the grounded substrate. Using a tribo gun requires a different formulation of powder than the more common corona guns. Tribo guns are not subject to some of the problems associated with corona guns, however, such as back ionization and the Faraday cage effect.

Another way to coat and protect from back ionization and the Faraday cage is with a special wave board created by Spectracoat.

Powder can also be applied using specifically adapted electrostatic discs.

Another method of applying powder coating, named as the fluidized bed method, is by heating the substrate and then dipping it into an aerated, powder-filled bed. The powder sticks and melts to the hot object. Further heating is usually required to finish curing the coating. This method is generally used when the desired thickness of coating is to exceed 300 micrometres. This is how most dishwasher racks are coated.

Electrostatic fluidized bed coating

Electrostatic fluidized bed application uses the same fluidizing technique as the conventional fluidized bed dip process but with much less powder depth in the bed. An electrostatic charging medium is placed inside the bed so that the powder material becomes charged as the fluidizing air lifts it up. Charged particles of powder move upward and form a cloud of charged powder above the fluid bed. When a grounded part is passed through the charged cloud the particles will be attracted to its surface. The parts are not preheated as they are for the conventional fluidized bed dip process.

Electrostatic magnetic brush (EMB) coating

A coating method for flat materials that applies powder with a roller, enabling relatively high speeds and accurate layer thickness between 5 and 100 micrometres. The base for this process is conventional copier technology. It is currently in use in some coating applications and looks promising for commercial powder coating on flat substrates (steel, aluminium, MDF, paper, board) as well as in sheet to sheet and/or roll to roll processes. This process can potentially be integrated in an existing coating line.

Curing

When a thermoset powder is exposed to elevated temperature, it begins to melt, flows out, and then chemically reacts to form a higher molecular weight polymer in a network-like structure. This cure process, called crosslinking, requires a certain temperature for a certain length of time in order to reach full cure and establish the full film properties for which the material was designed. Normally the powders cure at 200 °C (390 °F) for 10 minutes. The curing schedule could vary according to the manufacturer's specifications. The application of energy to the product to be cured can be accomplished by convection cure ovens, infrared cure ovens, or by laser curing process. The latter demonstrates significant reduction of curing time.

Removing powder coating

Methylene chloride and acetone are generally effective at removing powder coating. Most other organic solvents (thinners, etc.) are completely ineffective. Recently the suspected human carcinogen methylene chloride is being replaced by benzyl alcohol with great success. Powder coating can also be removed with abrasive blasting. 98% sulfuric acid commercial grade also removes powder coating film. Certain low grade powder coats can be removed with steel wool, though this might be a more labor-intensive process than desired.

Powder coating can also be removed by a burning off process, in which parts are put into a large high-temperature oven with temperatures typically reaching an air temperature of 300 - 450 °C. The process takes about four hours and requires the parts to be cleaned completely and re-powder coated. Parts made with a thinner-gauge material need to be burned off at a lower temperature to prevent the material from warping.

Market

According to a market report prepared in August 2016 by Grand View Research, Inc., the global powder coatings market is expected to reach USD 16.55 billion by 2024. Increasing use of powder coatings for aluminum extrusion used in windows, doorframes, building facades, kitchen, bathroom and electrical fixtures will fuel industry expansion. Rising construction spending in various countries including China, the U.S., Mexico, Qatar, UAE, India, Vietnam, and Singapore will fuel growth over the forecast period. Increasing government support for eco-friendly and economical products will stimulate demand over the forecast period. General industries were the prominent application segment and accounted for 20.7% of the global volume in 2015. Increasing demand for tractors in the U.S., Brazil, Japan, India, and China is expected to augment the use of powder coatings on account of its corrosion protection, excellent outdoor durability, and high-temperature performance. Moreover, growing usage in agricultural equipment, exercise equipment, file drawers, computer cabinets, laptop computers, cell phones, and electronic components will propel industry expansion.[5]

See also

- Laser printer
- Fusion bonded epoxy coating
- Powder coating on glass

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