

## POWDER COATING SMALL PARTS

### EMERGING TECHNOLOGY

# Thin powder color topcoat: Powder coating process for small parts in bulk production

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*This article describes a new powder coating process applicable to many types of fasteners and small parts called "Thin Powder Color Topcoat" (TPCT). These coatings are applied to metal parts, with or without a base coating, in an innovative bulk production process that incorporates a proven thermal diffusion coating method. The article explains how the new process is suitable for mass finishing of small- and medium-size parts with powder coatings, providing substantial cost savings when compared with rack or spray coating. Test results indicate positive outcomes on a wide range of materials, showing exceptional durability and versatility in controlling the uniformity, thickness, and colors available for small parts production.*

The evolution of thin powder coating commercial applications began in the early 1970s. With the passing of the Federal EPA Clean Air Act in 1970, the incentive to create eco-friendly alternatives to solvent-based coatings for consumer products spurred the growth of powder coatings in the US. Leading the way was the major appliance industry, which developed large in-plant powder coatings systems. Following closely was the automotive industry, which outsourced the process, creating new opportunities for custom finishers.

The functional, heavy film thickness powder coatings that were popular in the 1960s soon gave way to a new coatings industry in the form of large dedicated in-house powder coating lines and versatile job shops applying thin-film powder coatings. Combining improvements in powder coating systems equipment and powder coating formulae with the application expertise of powder coaters, the emerging industry continued to refine thin powder coating applications. The industry moved on from thick film thermoplastic fluid beds to thinner powder coating applications that used electrostatic spray

(E/S) guns. After that, coatings innovators continued to improve powder application systems, as well as powder coating handling properties, offering a variety of powder coating types and colors that propelled the powder coatings industry into the 1980s.

Growth of the powder coatings industry throughout the 1990s focused on low-cure and fast-cure formulae, metallic-like colors, and formulations featuring better corrosion protection and outdoor weathering properties. The application equipment companies kept pace with ever-increasing efficient powder delivery systems and introduced fast color change booths. Today, the powder coating industry accomplished what it originally set out to do some 40 years ago: powder coatings that provide environmentally safe finishes with high-corrosion protection at competitive pricing in an array of colors, glosses, and textures.

### Shortcomings to present day powder coating applications

But not all was perfect in the powder coatings world. Applications were geared toward large products and as technology continued to evolve, it became evident that some of the processes used for powder coatings applications were lacking, especially when it came to smaller parts with intricate manufacturing specifications. Controlling the thickness for many applications was a challenge and the uniformity of the powder coating was difficult to achieve.

The first powder coatings applications were fluid bed systems, which involved preheating the parts above the melt temperature of the powder resin being applied and then post-heating the parts for fusing or curing of the powder film. The only control for thickness was the temperature of the part upon entering the fluid bed coating and dipping time. This method produced an encapsulat-

ing film with a typical film thickness range of 5.0 mils to 15.0 mils.

With the advent of the modern electrostatic spray delivery systems and booth designs, powder coatings film thicknesses can be controlled with much better accuracy. Still, only a few powder coating systems, like a powder coating blank line, can hold powder thickness tolerances in the 1.2 mils to 1.5 mils thickness range. As long as the powder coatings applications were on flat, relatively large surfaces, the achievable thickness was acceptable.

Today most powder coating applications vary from 1.5 mils to 3.0 mils. As the geometrical shape of the part becomes more complicated, the challenge to control powder coating thickness, especially in corners and crevices, increases tremendously. Recessed and inside corners called Faraday's (Faraday Cage Effect) still present problems with powder coating coverage.

### Small part painting methods

Although there are a number of innovative ways to paint small parts, the options widely used today for high volume, mass finishing with paint and coatings are limited due to practicality and cost considerations. Each of these methods is sound, but none completely addresses all the needs of thin coating small parts in bulk production.

**Liquid dip-drain or dip-spin methods.** Liquid dip-drain or dip-spin painting processes are the most common methods of coating fasteners and small stamped parts. Both methods start as a bulk process by dipping perforated baskets into liquid paint vessels. The dip-drain method drains off excess paint over the paint vessel while the dip-spin method uses centrifugal force. In both methods, parts are usually then baked in a paint curing oven. For high-performance applications, a second coat is applied to add thickness and cover touch marks in the first coat. These types of paint finishes are widely accepted throughout major appliance and automotive markets. However, there are some problems achieving uniform thickness and with the paint filling holes and small recesses.

**Barrel electrocoat method.** The barrel electrocoat (e-coat) is another method of painting small parts. Parts are loaded into perforated process barrels and then indexed through a series of cleaner and metal preparation stages before entering the e-coat tank and subsequent post-rinse stages. The part process barrels are mechanically rotated in each step and are allowed to drain over each tank before moving on to the next step. The e-coated parts then are cured in a baking oven. Barrel e-coat provides a high-performance bulk paint finish. However, the initial capital investment for equipment, relatively large footprint for floor space, and limitations in color may detract from the barrel e-coating process.

**Continuous belt e-coat method.** The continuous belt e-coat process is another choice for painting small- to medium-size parts. In this case, the barrels in the barrel

e-coat process are replaced with a specially designed steel mesh belt that carries parts through the pretreatment and e-coat stages, and ultimately, the bake oven. The e-coat belt coater has some limits on part shape, and touch marks have to be considered.

**Racking parts method.** Another option for finishing small products is racking the parts for liquid painting or powder coating. Many small parts and most fasteners cannot be racked, however. For those that can be racked, the cost of labor to rack small parts has to be considered. Small racked parts are moved through pretreatment, coating, and a baking oven by overhead conveyor or an indexing system.

### How thin powder color topcoat (TPCT) technology works

Thin Powder Color Topcoat, or TPCT, is an emerging technical process used to apply powder coatings with a thin, uniform thickness on small parts. The process is continuous for mass finishing fasteners and small parts and stampings. Until now, only thick layers of powder coating could be applied to small parts. As explained earlier, before TPCT, the small parts were preheated, and the hot parts introduced into a powder coating fluid bed. In that process, the powder melts and fuses to the part, and then it is post-cured in a bake oven.

The TPCT powder coating method applies a uniform layer of powder coating at ambient part temperature to provide a continuous protective paint film when baked to the powder coating cure schedule. The first coat of TPCT coating has an average thickness of 0.5 mil. A second coat can be applied, when desirable, at a similar film thickness. (Figure 1 shows TPCT-coated parts.)

**Process development.** Initially the research goal was to develop a topcoat for zinc thermal diffusion coatings, a

FIGURE 1

Screws coated with Thin Powder Color Topcoat (TPCT) in grey hybrid epoxy



high-corrosion resistance coating specified for automotive metal stampings and many types of steel fasteners and hardware. The topcoat is required to meet the end use color requirements in the automotive industry. It can also provide additional protection for environmental testing such as neutral salt fog test requirements and special surface attributes like lubricity for door latch components.

The research with TPCT went beyond testing as a topcoat over the zinc diffusion coatings. The TPCT process can also be used directly over steel forgings and stampings, iron castings, aluminum, and powder metal component parts as a standalone coating. TPCT has also been tested on non-metallic substrates like high-temperature plastics. Even some wood products are candidates.

**TPCT coating process steps.** The TPCT coating process is a continuous operation and starts with a surface preparation, which is the same for all substrates including zinc diffusion coating basecoat. TPCT may be applied directly onto steel or other uncoated substrates. The same surface preparation process is used for readying parts for a second coat of TPCT as well. Raw steel parts and other substrates must be clean and free of soils and lubricants before the parts can be prepared for TPCT.

Prep CP3 is the preparation solution used in the TPCT coating process. CP3 is environmentally sound, with no HAPS (hazardous air pollutants) and no VOCs (volatile organic chemicals). In warm climates, the surface preparation works at ambient temperatures. It only needs to be heated to 75°F to 80°F in cold weather months when the indoor temperature is below this temperature threshold. The equipment used to apply the preparation solution is not critical, and typical coating industry part washers used to remove soils and lubricants can be used to apply CP3.

The surface preparation step does not require any water for post-rinsing. This means water overflow tanks with discharge floor drains are not used. The surface preparation is a closed-loop system and only requires CP3 make-up additions. This is a wet process and parts need to be dried before powder coating, just like conventional E/S powder coating applications.

Any drying method is acceptable, but the drying equipment should be sized for the part volume from the surface

preparation step. Steel mesh belt conveyor driers work well. Another drying process, dehumidification drying, is ideal for the TPCT process. Dehumidification drying uses low humidity air to remove moisture rather than heating parts for water evaporation. This method eliminates heating and subsequent cooling before TPCT coating.

The parts need to be cooled below the powder coating softening point before entering the TPCT coater. Slightly warm parts or room-temperature parts can be TPCT-coated. Hot parts will cause the powder coatings to flock or fuse and should be avoided to maintain the TPCT thin coating thickness.

TPCT coaters are specially designed machines built specifically for applying a uniform powder coating dry film that cures at an average first coat thickness of 0.6 mil (15 microns). A volumetric feeder loads the TPCT coater at a set rate from the previous drying step. The CP3 treated and dried parts pass through the coating chamber and automatically feed through the exit channel for the final curing step. (See Figure 2.)

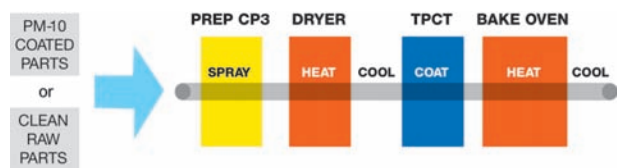
TPCT coaters can be designed for part rates from 1,000 pounds per hour to 6,000 pounds per hour. For larger volumes, multiple coaters feed a single bake oven. Steel mesh belt conveyor ovens are used to cure thermoset curing powder coatings or fuse and polish thermoplastic powder coatings.

Touch marks can occur from part-to-belt contact or part-to-part contact during the curing cycle in the bake oven. When this is not acceptable, a second coat of TPCT is applied starting with the Prep CP3 step. Any of the typical heating sources for powder coatings ovens can be used for the TPCT belt conveyor oven.

**Color and gloss.** TPCT powder coatings can include any of the colors available for electrostatic spray powder coating applications including a choice in gloss. The full range of resin types is available including epoxy, epoxy-polyester hybrid, polyester, acrylic, and thermoplastic resins like nylon. (See Figure 3 for finished color samples.)

**FIGURE 2**

**Schematic of the Thin Powder Color Topcoat (TPCT) process**



**FIGURE 3**

**Finished color samples**



## Test results for TPCT processing

Parts tested per ASTM B117 neutral salt spray specification with zinc thermal diffusion basecoat and powder coating topcoat applied by electrostatic spray have shown greatly improved corrosion protection when compared with powder coating over zinc phosphate conversion coating. The same corrosion protection can be expected when using the TPCT powder coating application.

In one case of customer testing, automotive screws for underhood assemblies were tested per ASTM B117 salt spray test. The screws were first coated with zinc thermal diffusion coating with a thickness of 0.5 mil (12 microns). The screws were then powder-coated by using the TPCT method. Two coats of grey epoxy-polyester hybrid powder coatings were applied. The thickness of the two TPCT powder coating layers were 0.9 mil (23 microns) for a total stack-up thickness of 1.4 mils, or 35 microns, on average.

The automotive screws showed no red rust after 504 hours of salt-spray testing. The same screws after 864 hours of testing showed signs of only slight rust and after 1,384 hours were rated 2 percent to 3 percent red rust surface area. (Table 1 shows salt-spray results.)

When two coats of TPCT powder coating are applied directly over steel, the salt-spray test results are comparable to electrostatic powder coating over steel with a conversion coating. For less demanding requirements, one coat of TPCT can be used when minor touch marks are not an issue.

## Conclusions

When it comes to powder coating bulk processes, especially when coating finely threaded and small fasteners and parts used in the automotive industry, TPCT will prove to be a superior method of achieving the thin and

uniform coverage, while maintaining efficiency and generating substantial savings in the process. It is clear from test results and projected applications that there are numerous advantages to using TPCT coatings. These include

- High-performance powder coatings attainable on small parts
- No HAPs or VOCs emissions
- No hazardous metals
- ELV, WEEE, and RoHS compliant<sup>1</sup>
- No rinse water required
- Fast color changes in 2 minutes
- Air-conditioned powder room not required
- No compressed air required
- No powder recovery system required
- Small equipment footprint
- Easily automated and size-scaled for volume

The TPCT process will fill a definite void in the coatings industry where the necessity to thin coat and mass finish small and medium parts is critical. The automotive industry continues to demand high-volume throughput and economical production costs, as well as meeting high-quality standards while reducing any negative impact on the environment. TPCT is ideally suited to meet those requirements and can be easily adapted to customers' coating color requests as well. **PC**

## Endnote

1. European regulations: ELV (End of Life Vehicle Directive); WEEE (Waste from Electrical and Electronic Equipment); and RoHS (Restriction of Hazardous Substances in Electronic and Electrical Equipment).

## Editor's note

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**TABLE 1**

**Salt-spray test results for automotive screws that were first coated with zinc thermal diffusion coating and then topcoated by using the TPCT method**

Hours	% Red Rust
504	None
864	Slight
1368	Light 2 - 3

Automotive screws tester  
Per ASTM B117 Salt Spray