Painting Plastic Automotive Components Electrostatically

Increase productivity, enhance product quality and meet environmental regulations . . .

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More and more automotive components are made of plastics. As with any other substrate, plastic components require cleaning prior to painting. The typical soils that must be removed are shop and material-handling dirt, machining oils, plastic sanding dust, fingerprints and mold release. With today's high production speeds, conveyorized spray washers are best. A minimum of three stages is adequate, but five stages are preferred.

The last stage of cleaning is usually a water rinse with a conditioning chemical to prevent water spotting. The part should then pass through a drying oven to ensure that it is com pletely dry. This is critical, particularly if you are paint ing with water-borne coat ings.

Some plastics, such as RIM (reaction injection molded polyurethane), contain an internal mold release that requires special processing. These materials are removed in the washer, but care must be taken during drying. The surface temperature of the part must be lower than the surface temperature of the post-cure oven. This prevents internal mold releases from migrating to the surface before painting.

Paint Kitchens. The design of the paint kitchen is an important consideration. Ideally, each of the frequently used colors should have a dedicated pumping system. Dedicated fluid tubing should run from the paint kitchen to the spray booth area and back to the paint kitchen. With this design, color changes do not require operators to flush pump and paint lines.

A forklift must have access to the paint kitchen to transport paint drums. If a large volume of one color is used, it may be more efficient to use tote tanks instead of 55-gal drums.

The pumping system needs run-away valves that turn off the pump when the paint drum empties. Without this safeguard, the pump may siphon air and be damaged. With run-away valves, the pump is shut off if a pressure differential is sensed. The pump will also shut off if there is a break in the paint hose.

Check valves should also be installed on the pumps. This will minimize pump "winks," which are momentary drops in pressure caused by the reversing strokes of the pump piston.

All circulating system should include a filtering system to prevent spray devices from clogging. Heaters help maintain the paint at a constant temperature year round.

A major design consideration for paint kitchens is to run pressure-drop calculations prior to sizing the fluid lines from the kitchen to the spray booths. The size of the fluid lines should be based on the paint volume and the minimum pressure required at the last spray device in the paint system. Elevations, elbows and tees in the piping can cause a considerable amount of pressure drop. If the lines are too small, there may not be enough paint volume or pressure for the last spray device. Also, supply and return lines for all paint kitchens should be stainless steel.

The Automated Finishing Line. Today's automotive component paint finishes are typically applied in the following order: 1) Primer; 2) Base or color coat; 3) Color match (metallic finishes); and 4) Clear coat. A typical automated paint system is illustrated in Figure 1.

Primer Application. Unlike metal, plastic is generally non-conductive. Plastics can be formulated with conductive pigments so the parts can be sprayed electrostatically. Usually, non-conductive plastic parts are sprayed first with conductive prep-coat solutions or primers.

The primers (adhesion promoters) are usually applied to dry-film builds of 0.4 mil. These primers can be applied automatically using air electrostatic spray guns or rotary atomizers.

FOCUS: Automotive Painting/Powder Coating

1. TYPICAL AUTOMATED paint finishing system

The use of reciprocators with mechanical toeing angles the spray guns toward the part in upward and downward strokes. This allows for improved painting on the tops and bottoms of parts.

Although the part has no conductivity as it enters the primer booth, the wet primer from the first spray gun makes the part conductive. Coating from subsequent guns on the line will then be electrostatically attracted to the part.

The choice of air electrostatic guns or rotary atomizers depends upon product configuration. With air electrostatic guns, the high-velocity-drive air (approximately 10 meters/sec) behind the paint and the smaller fan pattern provide better penetration into recesses than is achievable with rotary atomizers, particularly with non-conductive parts. However, if deep recesses are not prevalent, rotary atomizers may be best for primer application.

Base-Coat Application. The base coat is applied with rotary atomizers mounted on oscillators. Paint atomization takes place through centrifugal force. The paint is pumped onto a rotary cup that is spinning at approximately 30,000 rpm. The high-speed cup propels the paint into the air, breaking it into fine particles. A small amount of shaping air is directed toward the atomized paint at approximately 0.7 meter/sec to direct the circular spray pattern toward the product.

The particle size of rotary-atomized paint droplets is much smaller than gun-atomized paint droplets (Table I). The paint droplets are also consistent in size, resulting in a smooth, uniform coating.

The oscillators move the atomizers in short, vertical strokes to blend the fan patterns. Two coats are usually applied to slowly build the film thickness and achieve the required appearance.

Film builds for base coats vary depending on the color. For example, a royal-blue finish may need a dry-film build of only 0.9 to 1.1 mils because of the color's hiding power. However, a white finish may require a dry-film build of 1.2 to 1.4 mils.

Each color booth station is outfitted with rotary atomizer speed controllers, pneumatic controls, trigger solenoids and a color-change manifold that houses all the automatic color-change parameters. The color-

TABLE I—Paint Droplet Size for Air Spray and Rotary Atomizer Application Methods

Method	Particle Velocity	Average Particle Size	Particle Size Range
Air spray	10 meters/second	3.0 mils diameter	0.5-5.0 mils dia.
Rotary Atomizer	0.7 meters/second	0.8 mils diameter	0.6-1.0 mils dia.

change manifold is mounted inside the spray booth as close to the rotary atomizers as possible to minimize color change time and material waste. All the application devices such as the guns and rotary atomizers are controlled through programmable controllers.

If the base coat is not metallic, the part is conveyed directly to the clear-coat application station.

Metallic Coatings. If the base coat is a metallic paint, a non-electrostatic application station is needed. Without this station, the part will not match the body color of the vehicle.

As illustrated in Figure 2, when metallic particles are applied electrostatically, they align themselves vertically to the part's surface. This gives the color a darker appearance and reduces the reflectivity of the metallic particles.

To overcome this effect, a non-electrostatic station applies a small amount of paint on the parts. The non-electrostatic application aligns the metallic particles parallel to the surface of the part (Fig 3).

The non-electrostatic station consists of conventional air-spray guns mounted on a reciprocator. The station is also equipped with automatic color changers. All functions, including automatic color change and gun triggering, are operated with computer controls.

Clear-Coat Application. As with the base coat, the clear coat is applied wet on wet. A flash time is needed between stations, but baking the finish between coats is not necessary. The clear coat is applied similarly to the base coat. Rotary atomizers are used to apply a smooth finish with minimal overspray. Two spray stations are generally used to build the proper dry-film thickness.

2. WHEN APPLIED ELECTROSTATICALLY, metallic particles align themselves vertically to the part's surface.

3. IN NON-ELECTROSTATIC APPLICATION, metallic particles align themselves parallel to the part's surface.

Typical dry-film builds required for clear coats are approximately 1.5 to 2.0 mils. The final coat provides a high gloss and protects the color coat. These stations are also computer controlled.

Automated Control System. The control system manages nearly all the fluid-dispensing variables in the painting process. It can be designed to identify different part sizes and adjust the spray pattern for optimum coverage. It can automatically perform color changes between parts and even adjust paint flow rates to accommodate the difference in hiding power between colors.

TABLE II—Film Build Relationship to Costs

	Specification	Actual Coverage	Difference
Adhesion Promoter	0.4 mil	0.6 mil	0.2 mil
Color Coat	1.4 mil	1.6 mil	0.2 mil
Clear Coat	1.6 mil	1.8 mil	0.2 mil
Paint Cost	$2,579,950	$3,444,310	$864,360

There are several part-identification methods that can be used in an automated control system. The selection should be based on the type of conveyor system, part shapes and the painting system variables you want controlled.

For example, detection devices such as light curtains and laser beams can detect the size and shape of parts as they enter the spray booth. The spray devices will trigger on automatically, and only for the duration needed to coat the part. Other parameters, such as flow rates to the spray devices, rotary atomizer speeds, shaping air pressure and atomizing are programmed into the system for optimum paint coverage.

Other part-identification methods can provide even more information to the automated control system. Photo cells and bar-coding systems can identify specific part profiles and color requirements. Spray parameters for the spray devices and gun movers automatically adjust, depending on the specific part configuration.

With a recipe-management type of control system, the operator enters the product identification numbers of products to be run that day. When the computer receives the identification numbers it downloads the recipes for those parts. The recipes have the settings required to properly paint the parts.

Information from the detection device is relayed to the programmable controller, which precisely activates and de-activates the application equipment based on preset parameters.

A style-change flag hangs from the conveyor just before the paint booth entryway. When a photocell detects this flag, the programmable controller requests recipe information from the computer and sets the system parameters accordingly.

Automated System Cost Savings. Fluid-delivery-flow computers that regulate I/P transducers, precisely control paint delivery rate. By controlling the flow rate, paint can be applied to specified film thickness.

Without automatic fluid delivery, the operator regulates the flow by physically turning a regulator. The delivery rate will be inconsistent and based on either the operator's visual inspection or dry-film builds. In most cases, manually adjusted fluid-delivery rates result in more paint on the parts than necessary.

TABLE III—Comparison of Actual Paint Costs Before and After Installing an Automated System

	Manual System	Automated System	Difference
Parts painted per year	8,160,000	8,160,000	0
Parts painted per gallon	75	340	+265
Paint cost per gallon	$50	$50	$0
Paint cost per year	$5,440,000	$1,200,000	-$4,240,000

As seen in Table II, an increased film build of just 0.2 mil for each application can increase paint costs significantly. These costs are derived from an existing paint shop based on its current production and paint costs. In this example, $864,360 is added to the company's paint costs each year due to excess paint coverage.

Automatic color changes are timed to minimize the amount of solvent dumped to waste. They can also take place sequentially for the highest productivity. For example, the first booth in a two-booth coating system will change color as the second booth finishes the batch. This reduces the amount of open conveyor space needed for color changes, increasing productivity.

Table III is a comparison of the actual paint costs for a manufacturer of plastic automotive exterior components before and after installation of an automated paint system.

System Diagnostics. Automated control systems can be programmed to provide a variety of diagnostic functions. The diagnostics can be programmed to simply display the fault on the screen, sound an alarm or take specific action such as shutting down all or part of a system. Examples of system diagnostics are:

- Reciprocator/oscillator operation—Proximity switches in reciprocators and oscillators can alert the PLC when the devices malfunction.
- Conveyor operation—Encoders can be read by the conveyor interlock and send an alarm if there is an unscheduled conveyor stop.
- Booth-air monitoring—A differential pressure switch monitors air flow. If the booth is not operating, the system will not allow paint to be sprayed. Functions like this can also satisfy National Fire Protection Association codes.
- Electrostatic power supply status—The system indicates which power packs are powered up and whether a fault condition exists.
- Rotary atomizer status—The programmable controller sends warnings for bearing air loss, loss of speed signal and over speed of turbines.

Process Reporting. Automated

finishing systems can include report functions. Information can be processed with conventional personal computer software to enhance statistical process control procedures. Process reporting can also identify areas where system productivity and efficiency can be improved. Some examples are:

• Alarm history—The contents of the alarm log file are printed and categorized as required. This report helps identify ongoing system faults so corrective action can be taken.

• Product report—Information regarding the number of parts coated per batch, shift and day can be captured and analyzed. Related information, such as start and stop times between batches, is also retrievable.

• Paint use report—The amount of primer, color and clear coat for each batch is logged in the system. The amount of coating per part can be compared with specifications and adjusted.

• VOC emissions report—Based on the amount of paint used and the paint's VOC content, the programmable controller can calculate the amount of VOCs released. A report can be generated to help meet EPA requirements.

Programmable controllers can also control and monitor oven temperature, conveyor speed, pretreatment systems, heaters, shut off valves and exhaust motors.

Systems can also include flow metering devices on the touch-up spray guns. Manual spray operators can set the spray guns for the proper flow rates to prevent spraying excess paint. The flow rates are monitored on the supervisor's computer to guard against unauthorized change. The system can send an audible alarm or blinking light in the event of flow rate changes outside of optimum settings.

Today's automated paint systems are bringing finish quality, operating productivity and paint savings to a higher level than ever before. These systems are helping automotive component manufactures increase operating productivity, enhance product quality and meet environmental regulations.

Automatic paint system can range from a simple single-gun operation to a fully integrated control station. Regardless of the system type, the ultimate goal is to apply paint with uniform film thickness, minimal overspray, reduced rejects and higher productivity. By selecting the correct system for your operation, you will improve control of your finishing line and achieve a fast payback on equipment costs. **PF**

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