Custom coating: Powder coating process control

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This article is the second in a series on how to manage a custom coating shop. The series is intended to help you operate your business more effectively. The first article, published in the February issue, focused on marketing and discussed the importance of developing a marketing plan. This article outlines some of the most effective methods and techniques to track and control the powder coating application process, and reduce the reject rate through continuous improvement. The article analyzes control variables on a typical conveyorized powder coating system. Other articles, which will be published in subsequent issues, will focus on quality control, job costing, job quoting, and powder cost control.

Process control in a powder coating shop begins with a general understanding of the overall process and the variables that can affect the overall system and its performance. A number of control techniques can be used by line operators to keep the powder coating system in check.

A powder coating system includes separate processes working in sequence to achieve a common goal—a quality, cost-effective finish. A successful powder coating company is made up of various processing components functioning together in harmony much like organs within the human body. Like the human body, the health of the overall finishing operation depends on the quality of the components that operate within it. Following is a breakdown of the components in a powder coating system and their control features.

Compressed air

Clean, dry air is essential for overall quality in the powder coating system. The air compressor breathes life into the equipment, allowing the powder to flow through the powder feed and recovery equipment. Compressors simply take air and compress it, moisture and all. As a result, the moisture must be removed before the air can be used in the powder coating system.

Poor air quality causes clogged equipment, wet powder, and a contaminated finish. A properly designed and well-maintained air filtration system ensures good air quality and helps maintain healthy powder delivery and recovery. As a final safeguard, you should place a filter at the air-supply hookup to the powder gun. Generally, this is a 5.0-micron filter in a glass canister that can be easily checked visually for moisture, oil, or other contaminants.

Conveyor and racks

A well-maintained conveyor and racking system is also an important part of maintaining control in the powder coating system. Materials handling by racking represents the circulatory system of the powder coating process. Periodic cleaning and proper lubricating can't be overemphasized.

The efficiency of the overall system is greatly affected by proper electrostatic ground and smooth delivery of parts from one process to another. Automatic lubricators are available for conveyor systems and are worth the investment for new system construction.

Surface preparation

The leading cause of rejects in the finishing indus
today is inadequate surface preparation before coati
Unbalanced chemical concentrations, bad rinse wa

Getting ready for the future

Cunningham has specific plans for the company's future. The company is experimenting with coating thermally broke aluminum. When aluminum is thermally broke, a slice of the aluminum is cut out and filled with epoxy glue or sealant. When the insulated aluminum is formed around a vehicle window, it doesn't become cold, even if it's cold outside. "It's created a whole new process for us," Cunningham said. "It's still on the drawing board, in the head-scratching stage."

After spending 2 years initially perfecting the powder coating process, Cunningham doesn't anticipate that the company will begin coating a lot of thermally broke aluminum in the very near future. Meanwhile, he enjoys spending his time in the shop. Sometimes he just stands and admires the powder coating operation, remembering those first hard years. "We're a small little shop out in the middle of nowhere, but we come up with some pretty neat stuff," he said. **PC**

Surface preparation chemicals: ***Novamax Technologies (Canada), Oakville, Ontario. 905/469-1616.*** **#402**

Surface preparation chemicals: ***Oakite Products (Canada), Calgary, Alberta. 403/236-3338.*** **#500**

Application equipment: ***Nordson, Amherst, OH. 216/988-9411.*** **#403**

Powder coatings: ***Protech Chemicals, St. Laurent, Quebec. 514/745-0200.*** **#404**

Conveyor components: ***Rapid Industries, Louisville, KY. 502/968-3645.*** **#480**

Conveyor components: ***Wilkie Bros. Conveyors, Marysville, MI. 810/364-1820.*** **#481**

clogged or misdirected nozzles, and other factors left unattended will certainly cause rejects, regardless of topcoat quality. If allowed to operate unchecked, the surface preparation system would turn from a valuable asset to a huge liability in a short time.

A properly done control and maintenance program dramatically reduces rejects caused by failures in surface preparation. System control variables include the following:

- Time

- Temperature

- Concentration

- Impingement

- Rinse-water quality

You can titrate your pretreatment solution to determine concentration strength and easily keep track of it through statistical process control. Regular testing and immediate recording of results allow the system to operate in a tight range of parameters as determined by your pretreatment chemical supplier.

Surface preparation systems require a good deal of maintenance for a variety of reasons, including extended equipment life, quality performance, and efficient operation. In each stage, the pumps, nozzles, and burners also need proper attention. The objective is to deliver parts with clean, dry surfaces and proper phosphate coating weights to the powder coating booth as quickly as possible.

To meet this objective, a few guidelines should be followed. A maintenance schedule and logbook should be kept to track the regularity of additions of make-up water, chemicals, and replacement parts. This helps the systems manager determine when the next chemical change or tank cleaning is needed. Following is a list of maintenance checks for your surface preparation system:

- Check regularly for spray nozzles that are out of position, damaged, or missing as a result of fallen parts from improper racking. A misdirected nozzle from a rinse stage can overflow a chemical stage, diluting the chemical concentration in a matter of minutes.

  Check regularly for clogged nozzle orifices. Clogging increases the pressure of the unclogged nozzles. Too much pressure is undesirable. In some cases, excessive pressure causes spotting and uneven phosphate coating weights. It can also blow parts from the racking system.

- Inspect and grease the pumps regularly to ensure proper pressure to the nozzles.

- Clean pump screens daily to prevent lint from gloves, rags, and other materials from entering and clogging the pump, header pipes, and nozzles.

- Keep drains free of scale and foreign matter to prevent overflow of wastewater into the work area.

- Install interior grids to prevent falling parts from entering the holding tanks. This allows the systems operator to retrieve the parts easily between breaks. We affectionately refer to an unprotected solution tank as *the Bermuda rectangle*. Parts fall in and are never seen again.

- Replace air-intake filters on burners regularly to ensure clean efficient fuel consumption and maximum control of solution temperature in the holding tanks. Filter airborne contaminants from the intake airstream; otherwise, the contaminants will burn and create excessive buildup inside the burner tube, which causes inefficient heat exchange.

Most custom powder coaters process a variety of substrates. Shops that don't have the necessary surface preparation equipment typically find surface preparation control difficult to impossible, as well as costly, labor intense, messy, inconvenient, time consuming, and troublesome. As a result, these shops often take shortcuts and sacrifice quality.

In any quality metal finishing operation, proper surface preparation isn't optional. Historically, surface preparation has caused more premature field failures than any other segment of the finishing process. Suppliers of surface preparation chemicals and equipment offer options and solutions to many of today's surface preparation and substrate requirements. Consult these suppliers at the time of system design and keep them in the loop throughout the start-up and service life of the system. Surface preparation is the area where most shops get into trouble at one time or another. Keep it organized, clean, and in control.

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Dry-off and preheat. After cleaning and phosphatizing, parts must be dried. A postheat oven or a cure-oven section dries the substrate before powder application. Substrate temperature control at the application booth affects the transfer efficiency of the overall system. The control of part surface temperature at the time of powder application will become even more important as progress in wood and other nonmetallic applications develops.

Powder application

Another crucial part of the powder coating process is powder application. This involves four key areas: the powder material, powder delivery system, powder charging system, and powder collection booth.

The powder material. Most applicators assume that all powder is fresh, new, and ready to be introduced into the process as soon as it's received from the supplier. Unfortunately, many on-line problems occur because of improper transportation, handling, and storage of the powder material. In addition, powder that has been in house for a time may lose some of its desired properties. For example, powder that has passed its expiration date, or has been exposed to heat for a time, may exhibit some or all of the following:

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- Poor fluidization
- Agglomerated particles
- Reduced gloss
- Excessive orange peel or textured appearance
- Pinhole formation

To ensure that all materials received are of good quality, the applicator should check the date of manufacture at the time of delivery. It's also a great idea to do first-in first-out, or FIFO, inventory control. The manufacturing date, lot, and box numbers are clearly marked on each powder box (sometimes in code) and should be included with job processing information for each order processed. This information is valuable when tracing a powder-related problem.

Powder received near its expiration date should be checked for quality before introducing it to the finishing system. A simple preproduction check can give finishing line personnel valuable insight to possible powder-related problems before on-line rejects occur.

Powder delivery system. Powder delivery is the process by which clean, dry air is carefully mixed with the proper ratio of powder and delivered to the gun tip via the feed pump and hose at just the right velocity. Adjusting the fluidizing air, the flow-rate air, and the atomizing air at the gun control console determines powder delivery. Each air source affects the air-to-powder ratio at the gun tip. For example, the fluidizing air mixes the air and powder in the feed hopper.

To ensure proper powder dispersion without clumping, screen powder into the hopper. The flow-rate air adjustment uses venturi air to create a vacuum in the feed pump, which forces air and powder from the feed hopper into the feed hose. The atomizing-air control introduces more air directly into the feed hose at the pump to increase air volume and velocity and change the powder cloud pattern at the gun tip. Each of these controls plays an important role in the transfer efficiency of the powder delivery system.

Powder charging system. This system depends on the proper delivery of the powder coating. To understand the powder charging system, you need to have a basic understanding of electrostatics. Many publications are available on this topic (see the Editor's note at the end of this article). It's a good idea to develop a good understanding of how electrostatic attraction differs from other forms of electricity.

Powder applicators should be trained by application equipment suppliers in the proper use of the control variables and maintenance details required to keep the guns operating at their peak. Applicators should also understand that more isn't always better when it comes to powder charging and delivery.

The charging of powder particles isn't magic. Some people find the electrostatic attraction of powder particles to metallic and nonmetallic surfaces as somewhat mysterious. In the negative coronacharging system, an electrostatic generator creates a charging field. The intensity of the electrostatic charge is related to the control console setting that reads in kilovolts (kV). Proper adjustment and control of the charging system and adequate grounding are essential for the highest first pass transfer efficiency. You need to consider substrate composition and geometry when setting the kV controls.

Often, the powder charging system will be overwhelmed. For tribocharging, or friction charging, sy tems, the powder flow rate and velocity directly affect the amount of friction the powder has in the charging tubes. Too much velocity may blow powder off the parts. This happens when the amount of energy produced by the airflow overwhelms the positive electrostatic attraction of the powder particle to the neutral substrate. Proper control of the powder application equipment makes the difference between profit and loss—it pays to be in control.

Powder collection booth. Powder containment during application isn't optional. It's the law. In Southern California, for example, the South Coast Air Quality Management District is serious about powder containment. Powder materials must not be allowed to escape into the environment. Several powder coating companies have had to detail automobiles that were contaminated by powder escaping from their plants and fusing onto the finish of the vehicles.

The purpose of the powder booth is to contain the powder in a controlled environment under conditions that allow for the highest first pass transfer efficiency. The collection booth must be designed, installed, and maintained to contain the powder within the booth away from application personnel and to keep the powder and air ratio safely below the lower explosive limits.

The objective is for the operator to control the environment in the application booth in such a way that the powder is efficiently attracted to the part. To do this, operators must be trained to properly operate and maintain the collection equipment (and all other powder coating equipment).

Powder containment for reuse is optional and highly recommended whenever possible. Many powder users are now realizing the financial benefits of collecting powder for reuse. With the advanced technology in the design of collection booths, equipment manufacturers have given operators controls with which to increase or decrease the air draft. This is useful for tasks such as booth cleanup.

Powder curing

Thermosetting powder coatings must reach a certain temperature for a determined amount of time for the powder to properly cure. Your suppliers should give you the recommended time and temperature for curing each powder coating. Different powder formulations require different cure temperature and oven dwell time.

When exposed to heat, the powder melts, flows, gels, and finally cures. The dwell time in each of the four stages of cure can be altered by controlling the atmospheric temperature of the oven, the surface temperature of the substrate by preheating, or both. If the time in the oven is decreased, the temperature may be increased to ensure complete cure. Proper control of the substrate time at temperature is important. Testing should be done to find the most appropriate cure window, or time at temperature. Surface and atmospheric temperature recording devices are available to eliminate the guesswork related to substrate time and temperature.

Following are some factors to consider when determining and controlling the cure schedule for a powder coating on a part:

- Powder manufacturer's cure recommendations (time at temperature)
- Total oven dwell time
- Atmospheric oven temperature
- Oven parameters (airflow and other heat-related oven conditions)
- Substrate composition
- Substrate mass
- Substrate geometry

Keep your system safe, keep your system clean, and keep your system in total control.

Line operators, under pressure to increase productivity, occasionally increase line speeds without considering the reduced time at temperature. As a result, they are at risk of undercuring the powder coating. Undercured powder doesn't perform to the formulator's standards and leads to rejects or premature field failures.

Individual job settings and controls

Once line operators determine the system control parameters and clearly understand the system control variables, they can focus on individual jobs and applicable limitations.

One of the first issues a good line manager should focus on is determining the *limiting factor.* This is a single factor that will limit the rate at which a job is processed. For example, a 12-inch by 12-inch, flat, 22-gauge, cold-rolled steel part cures at a faster rate than a 6-inch by 6-inch by 6-inch block of solid steel.

The limiting factor in this case is the oven dwell time as opposed to the rate at which the parts could be cleaned or properly coated. When setting line speeds, all too often the powder application time is the only consideration. If the total process can't perform all the necessary functions completely, quality suffers.

Job process tracking

Each job and part number should have a job process work sheet. For original equipment manufacturers, this is generally an important cost accounting consideration and is almost always a part of the total manufacturing process flow. OEMs record and track job processing standards for processing and scheduling purposes as well as costing. Custom coaters can use this same technique when processing repeat orders and similar parts.

Job process tracking may not be a difficult task for the custom coater with a single line. However, shops that have several lines or have systems at various locations must be able to track the status of orders in house throughout the process to effectively communicate key issues to the customers in real time.

Computers are great for job process tracking when many jobs need to be tracked simultaneously. Quality standards can be checked at various intervals and documented as the process progresses, not just when the job is complete. Often, the customer calls to find out the status of an order in process and wants the information immediately. The customer who receives accurate information regarding the progress of an order in a timely manner is much more likely to be comfortable with the finisher's capabilities and impressed with the finisher's professionalism.

Job process recording

The recording of jobs is simply a matter of developing a detailed history of jobs completed. This information is valuable to the cost accounting department and the job estimator. Job-history details can be reviewed and discussed with line personnel, thus eliminating much of the guesswork in determining the cost to process similar new jobs.

A good job estimator will review in-process data after a job to determine if the estimated production rates and material use were correct. Proper documentation, tracking, and review ensures that the company is making money job after job. Don't let the profitable jobs carry the nonprofitable ones. This sends a false message to the customer and doesn't help you, the customer, or the industry in the long run.

Job process recording is also necessary when the customers require a certification of conformance. These document and certify processing details as they're completed and accurately list all quality control documentation. Customers are comfortable with custom coaters who can prove that predetermined quality standards are being checked throughout the process.

Conclusion

Process control in any powder coating system is a full-time job. The ever-changing variables in the system make process control a continuous challenge for the finishing line manager and system operators. Variables in substrates, equipment, powder coatings, and people require continuous monitoring to ensure quality daily.

Employees must be trained to first understand and identify the variables within the system and continue to learn about all other factors that influence quality. The equipment doesn't run itself—an investment in education for all employees is an investment in the future success of your business. Keep your system safe, keep your system clean, and keep your system in total control. **PC**

Editor's note

For further reading on topics in this article, see the "Index to Articles and Authors 1990-96," *Powder Coating,* vol. 7, no. 9 (December 1996): pp. 23-31.

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