POWDER FLOW CONTROL FOR AUTOMOTIVE SYSTEMS

David L. Moses
Powder Marketing Manager
Nordson Corporation
Amherst, Ohio

Presented at:
FINISHING '95 CONFERENCE AND EXPOSITION
September 18-21, 1995
Cincinnati, Ohio
Introduction

Powder coating applications have been increasingly accepted by the American automotive industry. In the past five years these applications have grown from under-hood and under-body parts to major body exterior applications. Powder anti-chip and primer surfacer coatings are in use on a number of the best selling cars, trucks, vans, and sport utility vehicles (see figure 1). Powder clear coat is the next major target of the auto manufacturers. The Low Emissions Paint Consortium, formed by Chrysler, General Motors and Ford, is building a pilot line in the Detroit area for the joint study of powder clear coats and the powder coating process.

There are two primary motivations driving the automakers to powder coatings in place of their traditional liquid coatings. Environmental legislation calls for a reduction in hazardous emissions from painting operations, and powder coatings are the only coatings that reduce emission levels to near zero. The vigor with which this legislation is enforced will largely determine the speed at which powder coating grows as an automotive process in the future.

The improvement in automotive coating quality and the resultant competitive advantage that durable powder coatings offer has emerged as the real motivator for continued growth of automotive powder systems at the moment. The insistence on quality has not been limited to the performance characteristics of the coating material itself. The entire process of applying powder has come under a scrutiny probably never seen before by the powder coating industry.
<table>
<thead>
<tr>
<th>Chrysler</th>
<th>Anti-chip</th>
<th>Leading edge, sills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belvidere Assembly Plant Belvidere, Illinois</td>
<td>Dodge/Plymouth Neon</td>
<td></td>
</tr>
<tr>
<td>Jefferson North Assembly Plant Detroit, Michigan</td>
<td>Jeep Grand Cherokee</td>
<td>Anti-chip Sills</td>
</tr>
<tr>
<td>Sterling Heights Assembly Plant Sterling Heights, Michigan</td>
<td>Chrysler Cirrus Dodge Stratus Plymouth Breeze</td>
<td>Anti-chip Full body</td>
</tr>
<tr>
<td>St. Louis Assembly Plant St. Louis, Missouri</td>
<td>Dodge Caravan Plymouth Voyager</td>
<td>Anti-chip Full body</td>
</tr>
<tr>
<td>Newark Assembly Plant Newark, Delaware</td>
<td>Chrysler Concorde Dodge Intrepid</td>
<td>Anti-chip Full Body</td>
</tr>
<tr>
<td>Windsor Assembly Plant Windsor, Ontario</td>
<td>Dodge Caravan Plymouth Voyager</td>
<td>Anti-chip Full body</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Motors</th>
<th>Primer surfacer</th>
<th>Full body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shreveport Assembly Plant Shreveport, Louisiana</td>
<td>Chevrolet/GMC S-10</td>
<td>Primer surfacer Full body</td>
</tr>
<tr>
<td>Linden Assembly Plant Linden, New Jersey</td>
<td>Chevrolet/GMC S-10 Chevrolet Blazer</td>
<td>Primer surfacer Full body</td>
</tr>
<tr>
<td>Moraine Assembly Plant Moraine, Ohio</td>
<td>Chevrolet Blazer</td>
<td>Primer surfacer Full body</td>
</tr>
<tr>
<td>Baltimore Assembly Plant Baltimore, Maryland</td>
<td>Chevrolet Astro GMC Safari</td>
<td>Primer surfacer Full body</td>
</tr>
<tr>
<td>Saturn Corporation Spring Hill, Tennessee</td>
<td>Saturn</td>
<td>Black out Door headers</td>
</tr>
</tbody>
</table>
Process Control

Focusing on the *application system*, automotive paint process engineers, application systems suppliers and coatings suppliers have worked to identify the process variables that ensure a quality coating is applied. Recognizing that a precisely and uniformly controlled deposition of powder is the key to a quality coating, engineers have focused on the variables directly contributing to the accuracy of the application. Following is a list of these process variables along with comments on the ways each variable is being controlled (figure 2).

**Figure 2 - Application Process Variables**

1. **Applicator Positioning**. Gun-to-target distance was often a simple visual check. For repeatable results, the positioning is verified in different ways.

   A. Fixed position guns must be checked by actual tape measurement or by a template on which the position and angle of each gun is marked. This is a manual check that is difficult to automate.

   B. Moving guns are mounted to automation machinery, and the position of the automation is verified automatically through the control system.

   As the applicators are cleaned and serviced, their positions must be rechecked before being put back into service.

2. **Electrostatics**. Electrical system diagnostics can be monitored through the control system. The current draw of each applicator device is a good indicator of the electrical health of that device.

   The actual voltage output of each device is still checked manually with a KV meter. That check is performed during routine service intervals.

3. **Spray Pattern**. A visual check of the spray pattern of each applicator verifies that in the pump, and particularly in the hose and on the nozzle of the device, powder buildup has not blocked or altered the spray pattern. This check is performed manually and requires some degree of experience and diligence to insure that this condition is within tolerance and does not change over time. Even then, it is an inaccurate and subjective check.

   A system of air purges and blowoffs has been developed that does an excellent job of dislodging powder buildup and keeping the guns operating between scheduled cleanings. These blowoff cycles are timed to activate automatically between jobs.

4. **Powder Feed**. Experience with advanced powder formulations has shown the need for a number of developments to allow for consistent and reliable powder feed to the
applicators. The powder feed hopper is the heart of the entire feed system and constitutes the single most critical element. A system usually consists of several feed hoppers, each supplying several applicators. Unless a stable, consistent supply of powder is maintained, the process cannot proceed.

A. Consistent fluidization is established and maintained by the use of a mechanical device to discourage the formation of "chimneys" of air. Chimneys form as the direct result of the inability of the fluidizing air to diffuse uniformly through the powder. This characteristic of the powder requires the use of a forced entrainment device which continuously backfills these chimneys as they begin to form. By preventing the formation of chimneys at the point of origin we are able to establish uniform fluidization and maintain the powder in a stable fluidized state.

B. A constant level of powder in the hopper assures that an adequate supply of material is available to support spray operations between fill cycles. It also provides a consistent feed condition to allow the powder pumps to perform identically at each spray cycle. Redundant level control systems are now in place to insure that this key condition is always present. A load cell is positioned under the hopper and it is backed up by high and low level proximity sensors. Load cells under the various hoppers help direct the transfer of powder throughout the system based on loss-in-weight control techniques.

5. Powder Delivery. Control of air to the powder feed pumps is precisely maintained by the use of voltage-to-pressure pneumatic transducers. These transducers are controlled by the central system controller and assure the operator of repeatable pressures for every spray cycle. They also insure that any changes to system operating parameters are accurately and quickly implemented.

With these process variables under control, the next step is to tie together those components which would constitute a flow metering and closed loop powder flow control system. Only then will we have true control over the application process.

Flow Control

Powder flow control has always been handled as a manual system. Flow is established, coating is applied and baked and the results are measured. Adjustments to flow are then made to achieve the desired film build. Periodic checks are made to verify that results are being maintained.

The Problem

This could be called the "trial and error" system. It has the advantage of being simple and inexpensive, at least in terms of equipment investment. But there is a high cost in terms of production time wasted and in repairs or rework of the parts that are coated during the "dialing-in" process.

And it needs to be repeated if the coating moves out of specification for any reason.
The Solution
A system is now being introduced (patent applied for) which automates the powder flow control process. It integrates elements of the existing powder feed system with a flow meter.

Historically, powder flow control development efforts have centered on the discovery or invention of a flow meter that is accurate enough to provide the basis for the entire control system. That is where the development effort usually bogs down. Measuring the flow of powders of various chemistries, particle sizes and densities over a wide range of flow rates is difficult enough. Add to that a shift in particle size in the system over time and it is just too much for a measuring device to handle -- at least with today's measuring technologies.

So, how does the new flow control system work? By combining flow metering technology with a load cell to produce a system that is not only able to monitor flow but is also able to account for changes in the system over time and calibrate itself -- automatically. Following is a list of attributes of the flow control system (figure 3).

Figure 3 - Powder Flow Control System Attributes

1. Robust - Able to survive in a plant environment with a minimum of maintenance.
2. Non-intrusive - Does not intrude into the powder flow path. Will resist plugging and buildup.
3. Consistently accurate - Measuring sensors are accurate device-to-device.
4. Retrofittable to existing systems.
5. Unaffected by tribocharging of powder as it passes through the system.
6. Able to handle a full range of flow rates - at least 90 to 600 grams per minute
7. Flexible - Able to measure any anticipated powder chemistry, specific gravity, particle size.
8. Automatically self-calibrating as powder characteristics change over time and as system components wear.
9. Fail safe - If the sensors fail for any reason, the system can keep running until a convenient maintenance interval is reached.
10. Safe - Factory Mutual safety approvable.

Elements of the Flow Control System
Key elements of the flow control system are shown in the sketch (figure 4). The newly developed flow meter is an in-line sensor that measures powder flow and reports it to the system controller. There is a separate flow meter for each applicator device in the system. These flow meters are located after the powder feed pumps and before the applicators.

The load cell under the final feed hopper measures weight loss from the hopper and reports it to the system controller. This weight loss represents the powder sprayed by the applicators. The load cell also reports weight gain during the hopper fill cycle.
The control system compares the flow of powder reported by each flow meter. It then notes the loss in weight measured by the load cell and apportions that weight loss to each applicator device. The result is actual powder flow. The controller compares flow for each device to the target set point and calculates whether any adjustment is needed.

Adjustment commands are communicated to the pneumatic transducers which control air pressures to the feed pumps. Revised pump control pressures change the flow for the applicator that is out of the desired flow range. The flow meters check the results and the controller confirms that flow is once again within the process control limits.

The flow control system compensates for any changes in the powder characteristics over time. It also is able to automatically adjust for wear to system components that can affect flow, such as pump throats. An automatic self-checking calibration cycle is conducted periodically to assure that flow meters are reading accurately and consistently.

Conclusion

The combination of powder flow metering technology with load cell technology in the automotive powder coating system results in a flow control system that provides substantial process control improvement. The production manager now has a degree of process control in his powder coating system that was previously available only with the liquid paint processes in his paint shop. With this improved confidence in the process, powder coating is one step closer to becoming the coating of choice for more applications in the automotive industry.
POWDER FLOW CONTROL SYSTEM

Figure 4

Patent Applied For

465