Precision Spray Control Can Provide Unexpected Benefits for Your Bottom Line

By Bill Kohley, Ph.D.

Introduction

Traditionally, the spray functions of a manufacturing facility have been controlled manually or with PLCs. Today, control strategies developed specifically for spraying are available that can result in annual savings up to hundreds of thousands of dollars. When your spray system isn't performing optimally, you can experience a wide variety of problems - all of which cost time and money. An inefficient spray system can cause quality control issues, unscheduled system downtime, increased maintenance time, and increased consumption of chemicals, water and electricity. The resulting cost of these problems can be surprising and, in some cases, staggering. The cost of wasted water alone can approach $100,000 annually in a system with relatively minor performance problems.

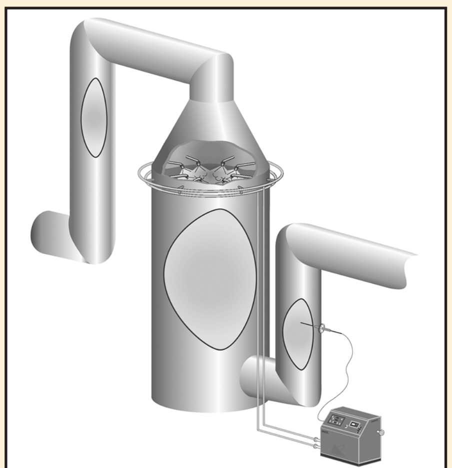

Fig. 1 - Typical Gas Cooling Application

While it is possible to program a PLC to perform sophisticated spray functions, dedicated spray controllers save valuable programming time with pre-defined, pre-tested control modules that are application specific. Spray controllers are able to optimize the performance of air atomizing nozzles and automatic spray guns because they provide very fast response times - up to 10 times faster than PLCs - and because they have nozzle performance data built in.

If product quality is affected by spraying or high-costs fluids are being sprayed, the benefits of precision spray control can be significant. Following is an overview of eight spray control strategies and application examples that have been proven to increase manufacturing efficiency and improve product quality.

Closed Loop Temperature Control

Gas cooling and conditioning is a common application for closed loop temperature control. This control strategy is used to spray fluid to maintain a constant temperature. The operator specifies the optimum temperature, and the spray controller uses a temperature sensor to constantly monitor and adjust the fluid pressure. Closed loop temperature control is capable of holding very tight tolerances, which is critical in meeting regulatory compliances, improving ESP performance and eliminating wet deposits in many manufacturing operations.

A two-stage gas cooling system utilizing closed loop temperature control allows a cement manufacturer to improve the efficiency of their ESP, meet opacity requirements and eliminate excessive maintenance and downtime due to wet walls. Responding to data from six temperature sensors, the spray controller calculates the exact liquid and air pressures required to maintain drop sizes and achieve efficient cooling. The first stage cools the gas temperature in the kiln hood from 1400°F to 650°F, and the second stage cools the gas temperature in the cooling tower from 650°F to the optimum temperature of 325°F. (See Figure 1).

Closed Loop Flow Control

Closed loop flow control maintains a constant flow rate by changing the fluid pressure. The spray controller utilizes a flow or pressure sensor to gauge how accurately the flow is maintained. Constant feedback between the nozzles and controller hold the flow rate steady and adapt the fluid pressure to compensate for nozzle wear and pressure drops in piping.

For a major manufacturer of fiberglass batt insulation, controlling overspray, and therefore flow rate, of a costly binder coating was a key factor in profitability and product quality. A turbine flowmeter in a closed loop flow system is used to control the flow rate for two banks of spray guns. Production line speed is represented by a remote analog input signal to the controller. As line speed and insulation thickness vary from a specified maximum value, the flow rate to each bank of spray guns is adjusted to maintain a consistent application rate. Efficient spraying of the coating allowed the manufacturer to keep production costs down while eliminating frequent customer complaints about airborne particles during installation of insulation. Applying the binder coating was a necessary product improvement that allowed the manufacturer to maintain market share. (See Figure 2).

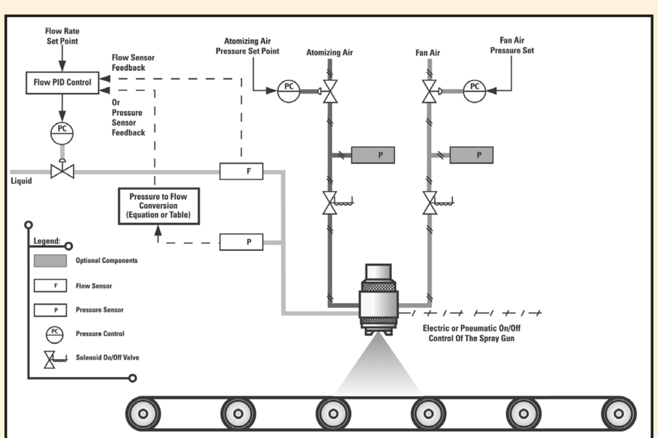

Fig. 2. Closed Loop Flow Control Diagram)

Open Loop Pressure Control

Open loop pressure control is used for spraying at a constant fluid pressure. The fluid pressure is a setpoint programmed by the operator. The spray controller maintains the pressure electronically using I/P converters and liquid pressure regulators.

A building products manufacturer uses open loop pressure control to apply a resin coating to gypsum boards. Spray operation begins when the spray control system receives a permissive trigger signal indicating that the production line is in operation and photoelectric sensors mounted over the conveyor detect the front edge of the boards. The controller delays the spray gun actuation until the boards reach the spray nozzles. A pulse signal from a tachometer mounted by the conveyor adjusts the spray pressure so that changing conveyor speed or stopping in the middle of a spray will not affect the coating. Precise spray control has improved product quality by ensuring the proper coating and has also enabled this manufacturer to save on resin usage.

Open Loop Flow Control

Similar to closed loop flow control, open loop flow control is used for spraying at a constant flow rate. The flow rate is a setpoint programmed by the operator. The spray controller calculates the required fluid pressure needed to maintain the desired flow rate and adjusts the system accordingly. Closed loop flow control has the ability to hold tighter tolerances than open loop flow control because it uses feedback from a flow or pressure sensor and can compensate for nozzle wear and pressure drops throughout the system.

In the manufacture of roofing mat, a soap solution is sprayed onto the product to increase runnability and prevent sticking. The soap solution contains suspended solids, which frequently clog nozzles, resulting in scrapped product and customer complaints regarding poor product quality. One manufacturer uses open loop flow control to ensure proper coating. A minimum flow rate is set in the spray controller as a fault point. When the flow rate drops to the minimum, a general alarm sounds notifying the operator that a nozzle has plugged and requires immediate attention. An I/O box contains lights corresponding to each spray header which are illuminated to indicate the specific header that contains the plugged nozzle. Precise spray control eliminated product quality problems for this manufacturer. (See Figure 3).

Open Loop Flow Pulse Width Modulation

Like open loop flow, this control strategy is used for spraying at a constant flow rate. Open loop flow pulse width modulation (PWM) also sprays at constant fluid pressure by varying the duty cycle. PWM flow control involves switching the spray gun on and off several times per second at a controlled rate. The time that the gun is on divided by the total cycle time gives a percentage called the duty cycle. At an 80% duty cycle, the flow will be 80% of the maximum flow rate at a given pressure for the nozzle. Pulse width modulation can significantly reduce airborne mists and overspray, and it provides an extremely high flow turndown ratio (10:1 or more) that can be achieved at a single pressure.

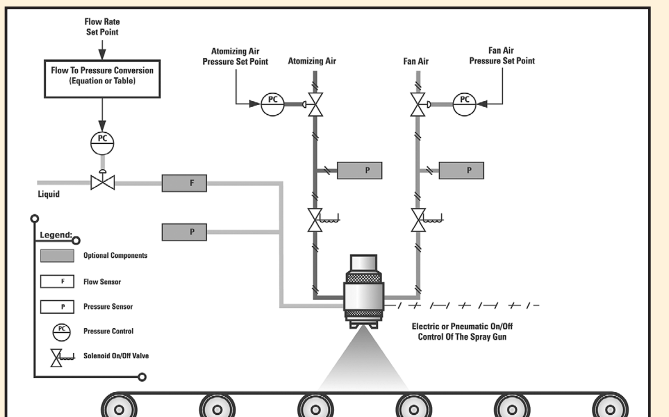

Fig.3. Open Loop Flow Control Diagram

In gluing metal sheets to each side of door panels, a door manufacturer found that applying a fine spray of water activated the glue and improved the laminating process. During lamination, the conveyor belt speed varies by a factor of 150. Adjusting sprays for this wide range of line speeds and various application rates requires a nozzle turndown ratio of 1:1000. An advanced PWM algorithm allowed the manufacturer to spray at the optimal flow rates using only one set of nozzles. (See Figure 4).

Open Loop Batch Control

Open loop batch control enables a manufacturer to quickly change spray parameters for multiple spray applications on a single line. This strategy is effective when spray volume needs to be precisely controlled based on product size, shape, position, etc. As many as 16 different sets of parameters, or batches, can be set consisting of liquid pressure, atomizing air pressure and fan air pressure.

A plastics injection molder uses open loop batch control to spray a mold release agent in varying thicknesses throughout each area of a mold. A spray gun is mounted on a robotic arm, which passes through the press cavity opening between molding cycles. Spray parameters are automatically adjusted based on the location of the robotic arm in the mold. Heavier release coatings are sprayed on certain portions of the mold by programming higher air/liquid pressures. Other areas get a light coating, while some are not sprayed at all. For this manufacturer, precise spray control ensures proper part ejection and high product quality. Cycle time efficiency of the robotic system is also improved, which increases production. (See Figure 5).

Open Loop Speed Control

Open loop speed control is very useful in conveyor operations for spraying at a constant application rate. Fluid pressure varies and is calculated by the spray controller based on the desired application rate, belt speed, spray width and nozzle characteristics.

A meat packing plant uses open loop speed control to spray ascorbic acid on trays of pork. Because the ascorbic acid is listed as an ingredient on the package, it is critical that each tray is sprayed. Previously, the plant had manual laborers applying the product, however manual labor costs were high and spray coverage was inconsistent. A simple delay timer was insufficient for this application because the controller must shut down the conveyor or trigger an alarm if the guns fail to spray.

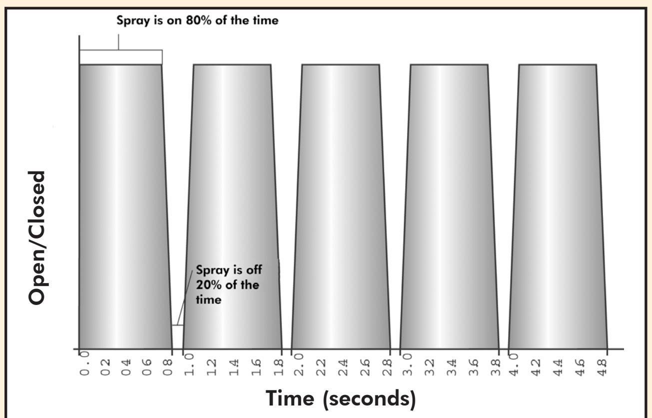

Fig. 4. 80% Duty Cycle

The automated system receives a trigger signal from a photoelectric sensor and a 4-20 mA signal from the encoder registering conveyor line speed. Liquid pressure is automatically adjusted and each tray is sprayed with the correct amount of ascorbic solution, regardless of conveyor speed or tray spacing. Flow switches on each spray gun ensure there is flow through the guns. In the event of a "no-flow" situation, an alarm notifies the operator. This highly reliable spray control system provides more uniform coverage and paid for itself within six months due to labor savings. (See Figure 6). An alternative to open loop speed control is Open Loop Speed Pulse Width Modulation. Similar to open loop speed control, this strategy maintains a constant application rate but uses a constant fluid pressure. The controller adjusts the duty cycle in order to maintain the application rate. (See Figure 4).

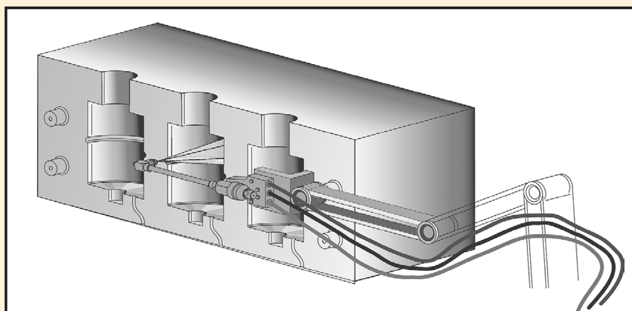

Fig. 5. Batch Control Application

Conclusion

These spray control examples demonstrate that optimizing your spray system can result in unexpected bottom-line benefits. Spray systems are often perceived to be very simple, however, spray nozzles are precision components designed to yield very specific performance under specific conditions. Just because a nozzle is spraying doesn't mean that it is working properly, and it certainly doesn't mean that your spray system performance is optimal. Automated spray systems can quickly pay for themselves through productivity gains and lowering other costs such as labor and production consumables. In assessing your current system performance, begin by evaluating your costs for water, chemicals and electricity. Also, consider environmental issues such as byproduct disposal and emission costs. Evaluate labor costs by asking the following questions: Are you spending too much time operating or monitoring your system? Is manual intervention required to adjust nozzles for batch or process changes? Is excessive cleanup required due to overspray? Finally, evaluate your scrap rate. Even a slight increase in your reject rate can be extremely expensive, and if your product quality is affected by your spray process, precision spray control may be able to reduce your scrap rate.

To learn more about spray system optimization, contact your nozzle manufacturer for help. They should be able to conduct a no-cost audit of your system to pinpoint the source of the problem and make recommendations for correction and ongoing prevention.

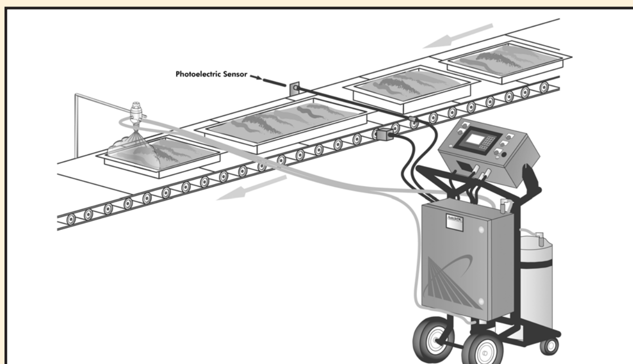

Fig. 6. Typical Conveyor Spraying Application

About the Author

Bill Kohley is the vice president of AutoJet Technologies, the spray control division of Spraying Systems Co., Wheaton, IL. Contact him at 630-665-5000.