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The What, Why & How of Powder Coating

A general overview of the use of programmable logic controls for automating powder coating systems

ITW Gema

Powder Automation: Programmable Logic Control

Improving the efficiency of a powder coating line is very important. Those companies taking the time to investigate and implement new tools and automation concepts will find their products being produced with a superior looking finish while realizing improved performance in finishing line operationing costs. Many users of powder equipment have taken the time to evaluate new spray gun, recovery booth technology and automation. Those that have invested in these items realize many benefits like improved film control, reduced material usage, lower operating costs and extended equipment life.

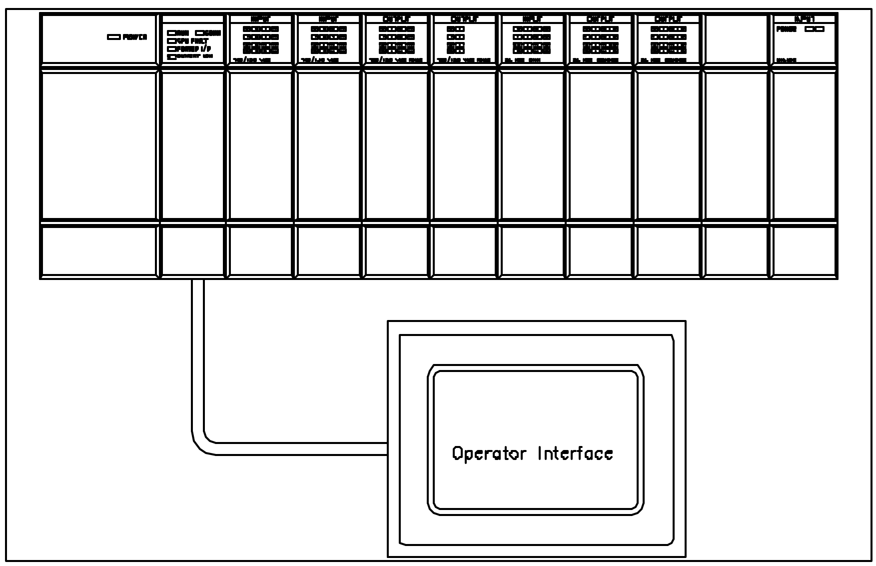
Another key to improving system efficiency is to utilize automation. Automation includes the use of a programmable logic controller (or PLC) to operate gun controls, gun positioning, airflow controls, and other system variables. The use of PLC's is more popular with many users of new powder paint and powder systems. But a large portion of the industry is not using automated controls to improve upon the efficiency of their systems. There is real value in having powder guns turn on and off or the value of powder guns moving in and out. Many users don't understand these advantages and chose to ignore them.

To help you better understand these values, this booklet contains valuable information about the use of programmable logic controls in powder coating systems.

PLC Definition

A simplistic definition is that a PLC is an industrial computer replacing complicated hardwiring with "soft" wiring. This soft wiring is a program that simulates an electrical circuit. A PLC consists of several components: a CPU (Central Processing Unit) and I/O (Input/Output) modules. The I/O modules provide sensory input and then controls output to the system components. Examples of the types of PLC inputs are push buttons, pressure switches, photo sensors, or relay contacts.

Example outputs can be indicator lights, relay coils, motor starters, while other types of devices that can be monitored and controlled are analog. Examples of these analog devices might be pressure sensors, position transducers, temperature sensors, and variable speed motor drives. In most cases the equipment controlled in a hardwired system is essentially the same as in a PLC system. The difference is the flexibility that is afforded. A typical hardwire system will require wiring modifications in order to alter the control of a component. Within a PLC controlled system, the only change would be to the program stored in the memory. For example, a typical relay has two to four control contacts. The relay is limited in the amount of control or logic it can perform. To expand the relay's functionality, additional relays would need to be added in parallel. Now compared to a PLC program, a "soft" relay can have hundreds of logical contacts and no additional wiring or component changes are required.

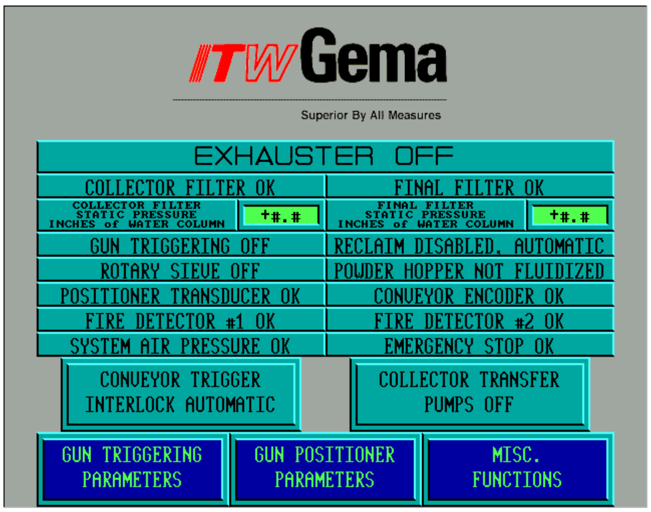


Example PLC Rack Configuration

But to look at a PLC unit as a relay/timer replacement is to miss a great deal of flexibility and customization capability.

A PLC can:
1. Handle complex information
2. Perform advanced math functions
3. Communicate with high-level computer systems

These capabilities allow for greater flexibility in a controlled system. This flexibility eliminates the dependency of decision making to be made solely on conditions of on or off. Also, data in the PLC can be manipulated, displayed, and applied to control variables. With the addition of color touch screens, touch pads, and touch keypads, system operations are enhanced. Operator interface with the day-to-day tasks are automated and displayed for review. Diagnostic feedback from the system provides the necessary tools for efficient corrections.



Example Powder Booth Status Screen

By applying PLC automation to a powder coating system, the user can significantly reduce operating costs and enhance the operability of the equipment. The following describes functions that can be controlled effectively by a PLC.

Powder Recovery

Using a PLC to control the powder recovery portion of the system can improve performance in a number of ways. Typically, the recovery system uses a motor driven fan assembly to draw powder into the recovery system, whether it is a cyclone separator or cartridge collector. The PLC controls the operation of the motor starter, on or off. The on/off status of the motor starter can be made dependent based on additional information collected by the PLC. For instance, a roll online/offline booth can be programmed so that the recovery system is started only when in the online or offline position. If the booth is between positions, the recovery system can not be started.

Some recovery systems employ a variable speed drive control to run the fan motor. The PLC can be used to automatically adjust the fan speed of the motor under various conditions. Examples include reducing the fan speed during temporary idle production, or increasing the fan speed for maximum draw during booth cleaning. The fan speed can also be automatically adjusted to provide a consistent airflow through the booth to compensate for changes in the static pressures of the collection equipment. This also eliminates the need for a mechanical airflow damper assembly on the recovery system.

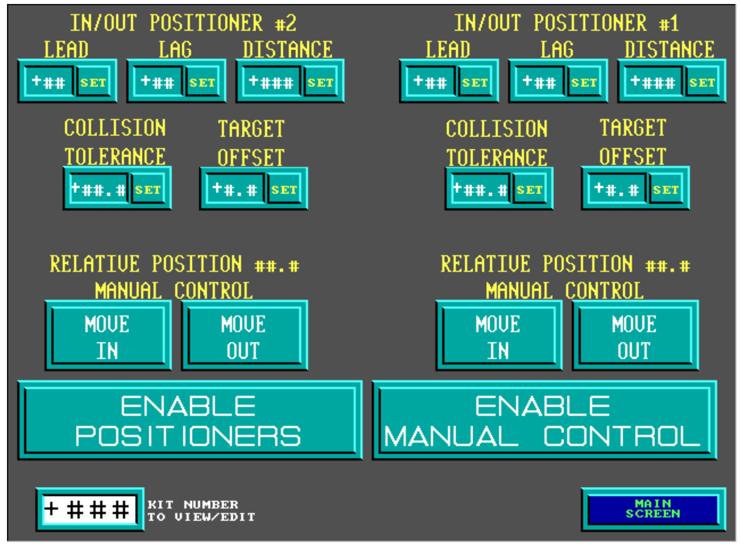
Static pressures on the collection filters can be monitored using pressure transducers that are interfaced to the PLC. Filter pressures can be displayed in a digital format on an operator interface screen, which eliminates needle type gauges. The pulse-down filter cleaning cycle can be programmed to occur when the filters reach a pre-determined pressure level and/or when a certain amount of product has been coated. This increases the performance of the filter media by cleaning only when required.

The transfer of powder within the powder coating system can be controlled by the PLC to optimize powder utilization. Reclaimed powder from the recovery system can be transferred to the feed hopper based on the level of the powder in the hopper. In addition, virgin powder can be introduced to the feed hopper as required. By using the PLC to control the transfer, reclaim to virgin mixtures can be controlled to provide a consistent finish quality. When recovering powder from multiple sources, such as booth wiper dropouts, the transfer can be cycled to prevent overloading the system with reclaimed material. Also, multiple powder transfer modes can be programmed into the PLC and selected by the operator through the operator interface.

Powder Delivery

Probably the most popular area of the powder coating system for PLC control is the application of the powder itself. Automating this process can show immediate savings in powder utilization and component wear. In most cases, this process can be easily retrofitted to existing systems. Finish quality is improved by optimizing the operation of the powder application guns. The most common implementation is automated triggering of the powder coating guns. Two methods for automatic triggering are “Zone Triggering” and “Style Triggering”.

Zone Triggering



Example of in / out positioning

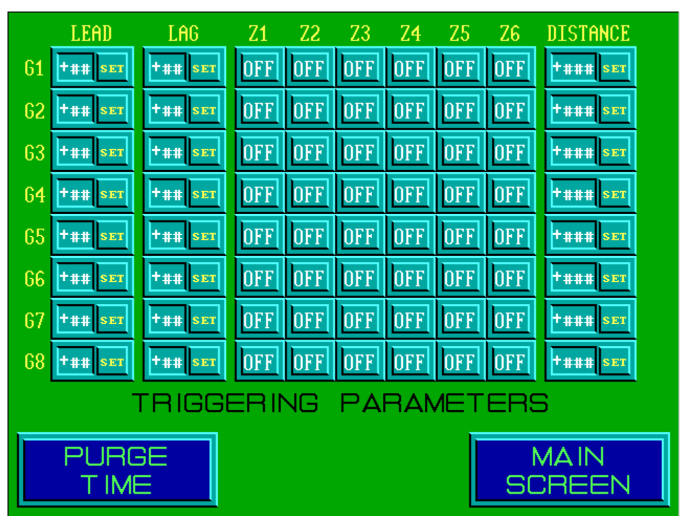
Zone triggering refers to triggering the guns based on the part profile. A typical application uses photo sensors to scan the product as it enters the powder-coating booth. The photo sensor information is stored in the PLC and creates a digital "image" of the product. This information is stored in a logical shift register and moved through the PLC memory in sync with the conveyor travel. An encoder mounted to the conveyor is used to supply conveyor movement information. As the product approaches the powder coating guns, the data in the PLC shift register is analyzed. Each gun can be individually triggered based on its proximity to the product. The gun is triggered on when the product reaches a preset distance to the gun. This distance can be positive or negative and is in relation to the leading edge of the product. The gun is triggered off when the product trailing edge reaches another preset distance to the gun. Again, this distance can be positive or negative. By modifying these "Lead" and "Lag" distances, the application can be optimized to improve transfer efficiency and powder deposition.

The photo sensors typically represent the "Zones". If a booth has five photo sensors, aligned vertically, it is said to have five zones. By assigning active zones to each gun, a gun will only trigger when the product has passed through the respective zone. This allows only the guns needed for a given product to be triggered, which again improves transfer efficiency.

Style Triggering

Style triggering is most effective for product that requires guns to be triggered at precise locations on a product or multiple times across a product. Rather than scanning the product to determine the leading and trailing edges only, sensors are used to identify the specific product style. When the product reaches the correct proximity to the gun, a triggering recipe is called up within the PLC and the gun is triggered accordingly. Style triggering does not rely on the part profile for triggering and is generally synchronized with the product carrier. Multiple style recipes are stored in the PLC and are entered through the operator interface. It is not unusual for a system to have over 100 styles available.

A typical issue with triggering a gun off is the residual powder that remains in the powder hose. When the gun is triggered on again, this residual powder can "snowball" and create an initial surge of powder from the gun, rather than a smooth pattern. Purging the gun immediately after a trigger cycle clears this powder from the hose. When the PLC triggers the gun off, it also turns on a secondary air source to the powder lift tube pump. This air is applied only to the supplementary port on the pump and not to the conveying port. As a result, air is flowing through the powder hose without creating the venturi required to lift powder from the hopper. This prevents the



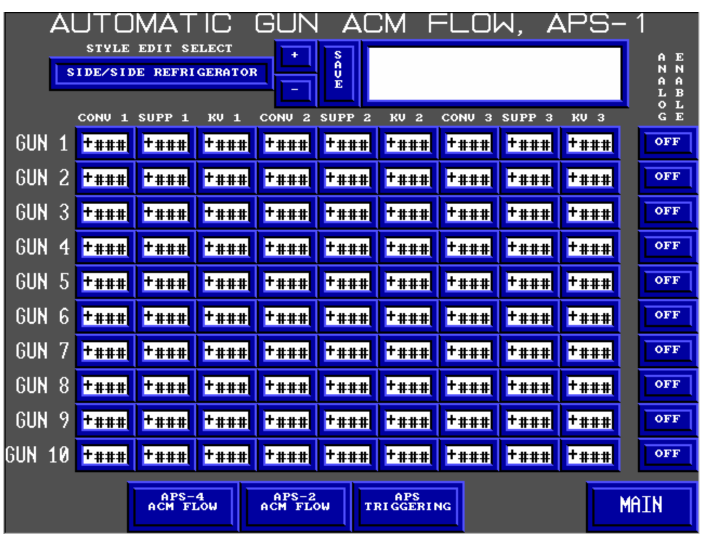
Example Zone Triggering Screen

residual powder from settling in the powder hose, which in turn prevents the “snowball” effect. The amount of time that this purge air is applied is adjustable through the operator interface. More time may be required for longer hose lengths. If a gun needs to be triggered while it is purging, the purge cycle is canceled and normal triggering resumes.

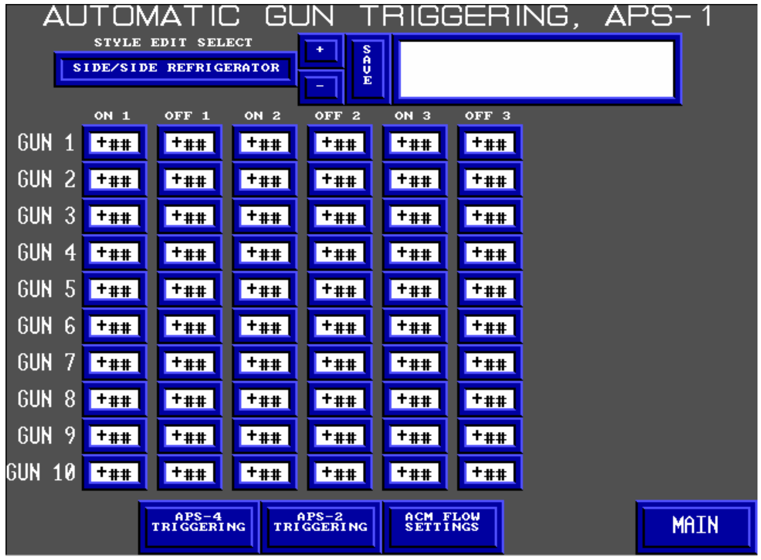
Advances in powder gun control units provide users with additional flexibility in automatic triggering. Dual-level powder output controls can be used to select between two separate preset powder flow levels. The levels can be selected based on the product being coated. Incorporating dual-level powder output with a style based triggering system is the most common usage.

Analog

More recently, analog gun control units have become available. These units allow a PLC to control the powder air controls and/or the kV settings across the range of the gun control unit. This can be highly effective in a style-based system with a high number of different styles. Powder output and kV can be altered by the PLC as the product passes the powder gun.



Example Analog Gun Control Screen



Example Style Triggering Control Screen

Reducing edge build and reinforcing other areas are the primary uses for this method. Powder outputs and kV can also be automatically adjusted based on formulas applied to variables within the system.

Gun Positioning

Coating performance is greatly affected by the position of the gun in reference to the product. If the product width varies greatly, guns need to be repositioned for proper target distance. Allowing the PLC to control this function reduces the workload on the user and enhances performance. Typical applications use light curtains to detect the width of the product as it enters the powder-coating booth. In a zone triggering system, the product passes through the booth, the guns are positioned in or out to maintain an optimal target distance. The positioning equipment can be pneumatic or electric motor driven. Positioning parameters are entered into the PLC through the operator interface similar to the zone triggering parameters, although normally not having negative values. This prevents the guns from being in a position that could cause a collision.

Style Based

In a style based system, the positioning devices may be programmed to override the actual profile of the product. Also, if the positioning devices have more than a single axis, the guns can track with the product as it passes. Inserting guns into cavities and recesses is a common application. Articulated robots are sometimes employed to target difficult areas. Program parameters are passed to the robot controller from the PLC as the product style changes.

Product Identification

Automatic gun triggering and positioning is dependent on the accuracy of the product identification. Photo eyes, light curtains, ultrasonic sensors, and others are employed to supply information to the PLC. Selecting the appropriate equipment is very important. The product mix to be identified determines the sensing method needed.

Photo Eyes

Most systems use photo eyes for identifying the vertical length of the product. When the product breaks the photo eye beam, input is registered in the PLC. The PLC uses this input data from the group of photo eyes to determine the zone or style configuration. In a style-based system, the photo eyes are arranged to detect surfaces on the product that are unique to that particular style. There are cases where photo eyes are not adequate to sense the product reliably. Typically, a photo eye beam is broad and forgiving for alignment. If the product to be coated is very narrow, the photo eye beam may "bleed" around the product. Apertures can be installed on the photo eye lenses to narrow the beam to increase sensing resolution. Laser type sensors are also available to increase sensing reliability.

Light Curtains

Another case where photo eyes may not be practical are when narrow products are presented in a horizontal manner. If a product is to be recognized, it must break the photo sensor beam. If the product passes between the beams, it is not sensed. Light curtains are often employed to resolve this issue. A light curtain is an array of tightly spaced photo eyes, typically 3/8" to 3/4" apart, and can sense over a large, linear area. Light curtain controllers supply information to the PLC. This information can be supplied in many forms, from a linear voltage signal to serial data. Using light curtains is becoming more popular due to the product sensing flexibility.

Hanger Flags

In style based systems it is sometimes not possible to sense differences between products reliably. The product mix may have only minor differences that the photo sensors or light curtains cannot detect. In these cases, a hanger flag can be employed. This flag is designed to be detected as a unique style relating to the product on the hanger. Normally, this flag is a flat plate with a series of holes. The number of holes determines the number of styles available to be sensed. Photo eyes are arranged to detect the presence or absence of the holes and a style number is determined through the binary equivalent of the hole pattern.

For instance, a plate with a four-hole pattern can represent up to 16 styles, whereas a plate with eight holes can represent up to 256 styles. Additional photo eyes are employed to detect the presence of the product on the hanger. This is a very reliable method, but it does require the proper flag to be matched with the product, typically done at the loading area.

Another method of style detection for the coating process is to retrieve the style type from the conveyor system. When the product is loaded, the style information is entered into the conveyor system PLC and tracked throughout the line. When the product enters the powder-coating booth, this style information is retrieved by the powder booth PLC from the conveyor PLC. Again, photo eyes are used to detect the presence of product on the hanger.

Operator Interface

There are multitudes of configurations for operator interfaces. A control system is no longer limited to just push buttons and indicator lights. Real time data from the PLC can be displayed, monitored, and modified through a graphical type interface in a format that is easily understood by the operator.

Selecting an interface depends on the needs of the application. Simple interfaces range from text based, line display terminals to graphical terminals. These are used for data manipulation and alarm enunciation. Often, these terminals can be implemented to read data from multiple PLCs within a system. More sophisticated systems may

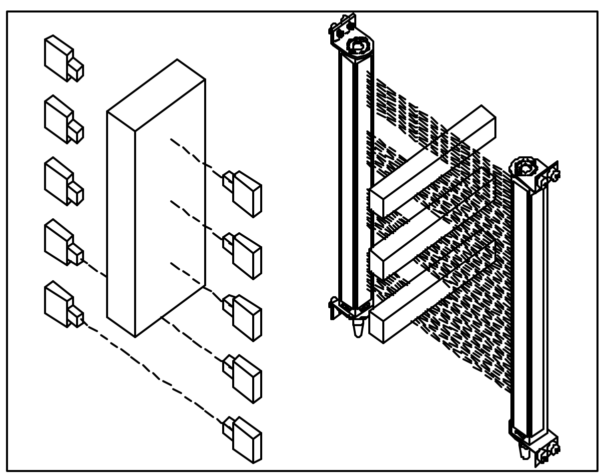


Photo Eye and Light Curtain Applications

employ a PC (Personal Computer) based interface. These systems offer the user a much higher level of functionality and connectivity. Because the interface is a PC, data from the PLC can be written to a mass storage device, such as a hard drive. Recipe data also be stored on the PC and written to the PLC on an as needed basis. The logging of system status, history, and faults to the PC greatly enhances the maintenance of the system. By interfacing the PC to a network, PLC data can be read into other remote PCs. Data can be read directly into common PC application programs, such as spread sheets. PLCs used in conjunction with PC computers will greatly increase the systems capabilities by increasing data acquisition, storage and trending information needed today by many companies for SPC and or internal ISO 9000 reporting.

Security measures can be employed on the operator interface to prevent unauthorized modification of PLC data. Passwords are employed to restrict access to given areas. Access to these areas can be logged to the PC as a permanent record. Using a PC for an interface can also greatly improve the appearance and usability of a system. Color displays and animated graphics help to provide information in a user-friendly manner.

Programmable logic controllers offer a unique feature to the complete system, however, they are not without their faults. The controller is subject to things like lightening strikes, or even psyhcial damage. If the system is designed without redundant manual hand off controls, and the PCL is damaged, your system can be rendered inoperable until a replacement is installed. Having current program back-ups on hand is important so that replacing your PLC can happen quickly. A nationally supported manufacturer can usually help you find a replacement within a day.

Summary

As stated in the beginning of this document, improving the efficiency of a powder coating line is very important. And those companies taking the time to investigate and implement any of the new tools and automation concepts will find their products being produced with a superior looking finish while realizing improved performance of the finishing line. But those that choose to do nothing in regards to automation will continue to find their operational cost spiraling out of control.