Robspray

WHEN AND WHY TO SELECT PAINTING ROBOT

If a company is seriously considering a robot for its painting operation, there are two questions to answer. Is a paint robot truly the right automation choice for the application? If so, how would a robot impact the painting system's overall design and operation?

Spray painting methods are categorized into the three most common types:

Manual. A human operator with a spray gun.Hard Automation. Spray guns affixed to stationary gun arms or systems such as reciprocators, spinning guns or two- or three-axis positioners.Robot. Generally a six-axis programmable device capable of complex arm and wrist motion.

Many times a robot is suggested as the answer to a painting problem; however, this often happens without sufficient analysis of application requirements. Although robots are now faster, more flexible and easier to program, they are not the only or best solution for every application.

Sometimes users are so fascinated with a robot that they do not examine whether their parts can be painted more quickly and inexpensively with a less exotic technique.

Part Shape. Complex parts with recesses, curved surfaces and picture-frame-like qualities are great candidates for a robot. Others, such as flat sheet panels or those having simple geometry are handled easily with less expensive mechanisms. If keeping the spray gun normal to the part surface requires a great deal of articulation, then a robot is a consideration.

Part Variety. The variety of part shapes and sizes bears greatly on how best to paint them. A low-volume job shop where no two painted parts are the same would be a poor location for a robot. Robots handle a range of dissimilar parts painted at high production rates. For example, some automotive manufacturers require finishers to paint all plastic trim parts synchronously for better color matching. This is an ideal application for a robot.

Hard automation is a good solution for painting smaller sets of similar parts. A good illustration is an application where a small adjustment can allow a few fixed guns to spray both 15- and 16-inch diameter aluminum wheels. By adding upstream sensing equipment, hard automation accommodates a mixture of parts at a relatively low cost. However, future requirements may tip the balance in favor of robots if new parts, or styling changes would be difficult to achieve by adding or repositioning guns.

Cycle Time. A robot's quickness can be misleading. Since a robot moves faster than a gun applies paint, it is the painting speed that is the most significant factor. While robots can be outfitted with only one or two spray guns, it is common to have many spray guns in a hard automation system, allowing more paint to be applied in less time.

A good example of the difference in cycle time is the application of ceramic glaze to sanitary ware. Glazing robots using two spray guns require 70 seconds per piece because of the large amount of glaze that must be applied. With hard automation, a rate of 180 pieces an hour (or a 20-second cycle) is accomplished by using more than 20 spray guns on a variety of telescoping and fixed gun stands.

Line speed also plays an important role in the cycle time calculation, since a robot only paints the part as it passes through the work envelope. Another consideration is that some finishes require a high film thickness. A robot can use a complex spray path, alternately spraying different areas of the part to build film thickness without runs or sags.

A spray test determines the time required to achieve proper coverage and film build. However, a robot alone may not paint fast enough. The solution may be a hybrid system using fixed or moving guns to lay down paint on some surfaces and a robot to handle more difficult areas.

Capital and Operating Costs. According to robot suppliers, the top reason for purchasing paint robots is to eliminate labor costs. But to conclude that replacing people with robots will always save money is too simplistic. For single-shift operations where painting involves a low volume of parts that would require hundreds of programs, a robot may be too expensive to justify.

Similarly, robots are often costly compared with hard automation solutions. A high-quality reciprocator might cost $15,000 and a robot more than $100,000. A $100,000 robot that replaces a $30,000 worker per shift, three shifts a day, quickly pays for itself; however, a great deal of automation can be purchased for far less than $100,000.

When considering the cost of a robot, remember to include not only the cost of the basic robotic unit, but the additional expenses of integrating it into the paint system. These include items such as teach handles, protective covers, documentation, training, tool holders and interface electronics. Some manufacturers estimate the cost of an integrated robot at 30-50 pct over the cost of a basic robot.

Paint Savings. A person can paint as accurately as a machine, but it is the repeatability of automated spraying that saves paint. Once a robot is programmed, it coats millions of parts with little variation. Human operators tend to be less consistent and efficient with paint. It is surprising to see how often they trigger a gun to "make sure" it works, which adds up to a significant paint waste. It is also interesting how manual touch-up in one area inevitably results in overspray in another.

For specific operations, hard automation is even more efficient than a robot. Spray guns on a gun positioner are triggered precisely to apply paint in high-speed applications with almost no overspray. Hard automation systems paint even complex profiles inexpensively when using automatic masking.

Spraying less paint saves money, but it also means less maintenance, cleanup, lower filter costs and VOC emissions. There is an estimated 25-30 pct paint savings for automated systems when compared to human operators.

Technical Expertise. Adding complexity to a paint line carries some risk. The standard maintenance toolbox may not help when a robot malfunctions. Troubleshooting and repairing robots requires special training and a degree of sophistication not found in many smaller plants. When evaluating labor savings achieved by replacing manual painters, also consider the training and technical support needed to keep the robot working properly.

Selecting a Robot Type. Painting robots are available in either hydraulic or electronic designs.

Hydraulic robots were once the dominant machines used in painting applications. Today, they comprise most of the used robot business, but are greatly outnumbered by electronic counterparts. While they offer high load capability, this is less vital in paint applications where one or two spray guns do not present serious weight problems. Hydraulic systems provide simpler solutions for meeting explosion-proof standards, since power cables to electronic servo motors can be eliminated. Their primary advantage is as a lower cost alternative to electronic robots.

Electronic paint robots use high-speed, precision electric servo drives for movement. They achieve faster movement and more precise positioning than hydraulic units. Without the need for hydraulic connections, electronic robots are also more modular and require less mechanical maintenance.

Both robot types require attention to cleanliness and proper preventive maintenance, as well as a well-trained, and technically knowledgeable support staff. The type chosen for a particular application will depend on the specific operational parameters and budgetary considerations.

Testing. Before purchasing any robot paint system it is important to test its ability to paint the required parts. Such a test can reveal the expected cycle time; the complexity of the programming task; and the precision required for workholder design. A good finishing systems house will have the ability to set up a test and demonstrate this capability.

Coating Material Compatibility. The coating material may dictate some limitations. Ceramic glaze and porcelain enamel, for example, are destructive to the sensitive mechanisms found in many wrist designs.

Robots spraying solvent-borne material must adhere to explosion-proof electrical requirements. This necessitates wiring suitable for hazardous locations for connections to the robot. Robots intended for liquid paint applications usually feature air purge systems to meet these safety requirements.

In powder applications, it is sometimes necessary to add additional protection to prevent powder from migrating into critical robot components. Rubberized boots placed over servo motors and kept under positive air pressure will help prevent powder related failures.

Load Restrictions. Make certain that the robot is able to hold all the required equipment throughout the operating cycle. Robot payload specifications should reference a payload at a known offset.

Speed. While it may be tempting to want the fastest robot available, it is important to consider the maximum speed at which paint can be applied. Typically, pattern distortion occurs around five ft per second, so a robot that can move faster has limited benefit for spraying. Again, a spray test to determine cycle time for your part, coverage and film build is an important first step.

The Work Envelope. The work envelope, dictated by the reach of the robot (less the combination of gun and wrist distance when spraying inward), determines the maximum part size. In continuous conveyor systems where the robot tracks the conveyor, the work envelope limits the maximum cycle time for each part.

Most manufacturers provide detailed information regarding the physical work envelope of their robots. In some cases, the robot can reach below its own base. For a floor-mounted robot this provides no benefit, but mounting the robot on a pedestal will extend the reach of the robot considerably, providing greater flexibility.

The Conveyor. The robot expects a part to be presented in a well-defined position. Therefore, the robot must know where the part is and how fast it is moving. A limit switch tripped by the workholder triggers a signal to the robot controller. Placing this switch outside the spray booth allows the robot to paint the part as it enters the spray booth.

Conveyors typically fall into two categories: indexing or continuous running. Indexing systems move a part into position, stop, then the robot sprays the part. These conveyors are programmed to achieve the required cycle time and provide smooth acceleration and deceleration. However, an indexing system provides the simplest means to paint the part since it is not a moving target. During dwell time, the part can be rotated in place.

Continuous running systems require hardware and software to inform the robot about the part position as it moves. Encoders are commonly used for this. Relative, or incremental encoders on conveyor drive shafts calculate the conveyor position from a known "home" position. This digital timing information is sent to the robot controller. Once the robot control receives the information, the software calculates the appropriate translation of the robot's coordinates. The robot can then "track" the part using these changing coordinates.

Part Fixtures. A person's eyes, brain and hands work together to correct for the unexpected. If a part is slightly askew, a spray painter can compensate for the problem. Since the robot is "blind," it assumes that the part is oriented in a specific way consistent with its stored painting program. An improperly positioned part will not be painted correctly. Because of this, the workholder should present parts in a uniform, precise manner. Bent spindles, swaying hangers, slippage or poorly racked parts cause quality problems.

Attachments should provide stability to limit rack swaying and rotational movement. Where rack rotation is required, positive engagement of a sprocket or star-indexer assures that the rack turns smoothly and predictably. An accurate chain-driven rotator with variable-speed motor provides smoother and more reliable rotation than simple belt-driven systems.

A locating pin attached to the sprocket serves as an electronic "flag." When this is detected with a photoelectric sensor or proximity switch, the spinner turns the part until the pin's presence is sensed. The spinner is then stopped in the desired position. The rack should be designed in a way that rigidly fixes the orientation of the part along all axes.

Communications. In robot paint systems, bi-directional communication needs to be established between the robot controller and the system PLC. Usually a start command passes from the PLC to the robot. While the start command could be delivered directly from the sensors to the robot controller, other events are often triggered from the same signal, such as the pneumatic solenoids.

On systems where different parts are painted, a part ID is also provided to the robot controller so that the right paint program is executed. Operators enter the part ID into a keypad terminal as parts are loaded onto the system. In more automated systems bar-code readers or vision systems are used. The system PLC tracks each part and its ID through shift registers as it travels through the system. The robot controller also communicates back to the PLC with status information on the robot and its purge system, as well as fault conditions such as over-travel limits and other problems.

Collision Avoidance. The robot manufacturer usually provides several means to avoid collisions. In some robots, an internal rubber bumper is placed at the extremes of motion.

A second level of protection is a software limitation. The robot controller is programmed with a horizon that becomes a boundary for the painting program. This is intended to prohibit programming the robot to an unsafe position. Finally, a limit switch in the robot provides a mechanism to disable the robot entirely if the other mechanisms are defeated or fail.

Spray Booth Design. The first consideration of the spray booth design is whether the robot can fit into the booth. Robots need ample clearance to paint within the designated work envelope. Often the booth needs to be much wider and deeper than a standard automatic booth.

Allow sufficient room around the robot for access to components requiring periodic maintenance. Whenever possible, provide observation windows to monitor robot operation.

Robots can operate in an environment heavier in contaminants. A recirculating ventilation system allows the booth air to be used longer before turnover, sending less air that is more VOCs concentrated to the abatement system. This lowers abatement costs and presents fewer regulatory problems. Recirculating booths also require less air make-up. In environmentally controlled booths, this means less expense for heating and air-conditioning make-up air.

Path Programming. Most electric painting robots offer several means of programming the spray path.Point-to-Point Programming. Movements are programmed by entering the coordinates of each successive point. Beginning from a home position, the robot is programmed as to which direction and how far to move to the next point. Along with the move, the program instructs the spray gun to spray or not. This type of programming is slow and tedious for complex paths requiring many interim steps. Ordinarily, this type of programming is performed using a teach pendant, which is a small hand-held electronic console that can be brought into the spray booth for programming. Lead-Through Programming. Many robots allow the programmer to physically move the robot arm through a path while the robot controller memorizes the movement. This is a quick way to program the path. The program can then be refined with additional point-to-point instructions. A teach handle is required to accomplish lead-through programming. The teach handle is outfitted with buttons to toggle the recording off and on and to make movement of the robot arm easier.Off-Line Programming. With some robots, painting is simulated off-line with graphic three-dimensional operator interfaces. The path is executed, evaluated and fine-tuned off-line so that system downtime is minimized and greater transfer efficiency is achieved. Much development is currently taking place to enhance these programs so that a CAD (Computer Aided Design) drawing of the part can be imported, and a self-optimizing routine that creates the most efficient spray path. Many systems permit programming various spray parameters, color changes and entering analog values for atomization air, fan air, and flow rates.

Gun Mounting. Spray guns should be mounted for easy removal for repair and maintenance. The mounting should also hold the gun rigidly in a preset position, since the paint program is based on a known spray gun position. Care should be taken to avoid damage to fluid delivery and air hoses.

Gun Cleaning. Most robots are integrated into systems that use a variety of colors. The robot can be programmed to clean the spray gun for either periodic maintenance or color changes by spraying the gun into a purge bucket.

Robot Safety. Robots, driven by powerful electric motors, have caused injuries and even deaths. To prevent accidents, spray booth doors should have safety interlocks to stop the robot whenever the booth door is opened.

Particular caution should be exercised when programming the robot. In one instance, an operator was pinned against a spray booth wall and crushed to death by a robot because he had defeated the safety switch on the teach pendant.

Also, use caution when programming robot movement, especially "tool coordinates." Tool coordinates are referenced from the spray gun tip, which constantly changes with respect to absolute coordinates in the spray booth. Because of this, programmers have experienced unexpected results when programming in tool coordinates due to the difficulty in keeping track of changing reference frames.

The choice of technology for painting parts depends upon a number of technical and economic factors. A broad range of solutions from manual spray stations to multi-robot installations is available. Using sophisticated interfaces and fast, precise motion systems, hard automation and robotics provide significant advantages for many spray paint jobs. Sometimes the best solution is a combination of technologies.

There is no substitute for putting together a knowledgeable team from the start. This team should include the paint supplier, application equipment supplier and a turnkey systems house familiar with all aspects of integrating a painting robot into a complete finishing system.

When robots are used, careful thought should be given to the overall system design to accommodate and maximize the robot's benefits. Part fixturing, conveyor design, system PLC selection, spray booth design, programming tools and safety systems should all be engineered with the robot in mind.