Progress in Paint Application Technology

Photo courtesy of BASF Corporation.

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Powder or liquid. Waterborne or solvent-based. Thermal or radiation cure. Decorative or protective. Architectural, industrial, or automotive OEM. No matter what type of coating, where it is used, and its primary purpose, the performance of a paint job depends not only on the formulation but also on the effective application of the coating. And both the equipment and operators play a key role in achieving a successful coating process.

Numerous types of application technologies exist, and selection of the most appropriate method and specific equipment for a given coating operation can have a significant impact on its cost and overall performance.

The consequences of poor selection can be significant. Inefficient paint application processes based on poor layouts and designs can result in millions of lost dollars per year through high rejection rates, increased scrap, and additional material and labor costs. Greater waste and pollution control expenses are often common, and quality issues can be related to poor application processes as well.

Because there is such a wide variety of options, it is often a challenge to choose the most effective system. Liquid coatings can be applied with brushes, using spray technology, or via continuous methods such as roll, curtain, and air knife technology. The application of powder coatings is typically done via electrostatic spray technology. UV-cured coatings, which can be solvent-free, water-based formulations or powder materials, can be applied in a variety of ways. There is also the choice between manual and automated application systems.

The most effective application technologies provide high transfer efficiencies with minimal waste and rapid color changes while creating a coating with the desired appearance, durability, and other characteristics. "Cost, whether viewed as cost per unit or cost per gallon or cost per cycle, has become a critical issue," notes Larry Robertson, general manager with Azimuth

Spray Systems, LLC (www.spraysystemsonline.com), a business-to-business e-commerce site for professional paint application equipment. He expects it will only become even more critical in the coming years.

"Manufacturers are looking for more efficient and cost effective ways to produce finished products in order to remain competitive with production operations moving to lower cost regions of the world," states Jeff Hale, director of sales and marketing with ITW Cema. "As a powder application equipment supplier, we are working to understand each of our customer's strategies and then design customized, creative solutions that meet their specific needs."

Adoption of automated systems appears to be one approach for many industrial coating operations. According to Mark Freels, who is responsible for sales and marketing for paint business development in the Robotics Division of ABB Inc., many industrial sectors—electronics, aerospace, and alternative energy, for example—are following in the footsteps of the automotive industry, which was a very early adopter of robotics and automated paint application technology. "The global economy has introduced increased competition, and these manufacturers are looking at robotics and automating their processes as a means for maintaining cost competitiveness."

To meet these growing demands, ABB recently introduced two different application systems. The IRB52 compact paint robot launched in February 2008 is specifically designed as a low-cost robotic solution for general industrial applications. For the automotive OEM sector, ABB developed the IRB5500 robot that operates in a much narrower booth (up to 20% smaller), providing tremendous energy savings. In addition, the robot is designed specifically to work with the new RB1000 bell atomizer that has an adjustable spray pattern from 6–18 in. or more. "With this atomizer, the same number of parts can be painted with half the equipment, because the RB1000 can cover twice as much area in one pass as traditional atomizers. Combined with the energy savings of the smaller booth, the advantages are truly significant," Freels says.

Durr Systems Inc. has also introduced robots designed to operate in a reduced booth footprint. The Eco RP E elevated robots provide increased application flexibility and are designed for easy installation in brown field plants, according to Einar A. Endregaard, director of application engineering with Durr Systems, Inc. Application Technology.

The need to reduce costs and improve efficiencies associated with the liquid painting process is not new; however, the means to achieve this objective are evolving. "Every year more and more companies discover the cost savings associated with electrostatic guns, which can often double the transfer efficiency over conventional air spray guns. With the use of electrostatic technology firmly rooted in many industries, in the manual applicator arena we now see a greater emphasis on operator comfort, which has led to a revolution in ergonomically designed guns," says Kevin Jagielski, worldwide marketing manager for finishing equipment with Graco.

Introduction of wet-on-wet processes is another way that coating formulators and applicators in the automotive OEM sector have found to reduce the cost of painting operations. This technology eliminates application steps and associated oven passes, enabling car manufacturers to significantly reduce material, labor, and energy costs and increase throughput at the same time, according to David Fischer, global business manger for DuPont's Automotive OEM Coatings business.

DuPont's EcoConcept finishing system, which combines two coating steps into one waterborne basecoat, won a 2007 PACE award. Benefits of the process include reduction of greenhouse gas emissions, lower energy consumption, and higher productivity. Volkswagen has installed the EcoConcept system at its Puebla, Mexico, and Pamplona, Spain, plants and is considering its use at a paint shop that is to begin operations in Russia in 2008.

The trend for consolidation of process steps will only increase in the future, according to Fischer. "Everyone in the marketplace is looking to consolidate steps throughout the process as a means for saving money. Each OEM manufacturer has its own issues and is currently deciding what is the right solution for its operations and for maintaining its brand image. We do expect, though, that primer-basecoat-clearcoat consolidation will become more widespread."

DuPont is currently working with all of its customers on concepts related to consolidation of the coating application process. David Fischer is quick to point out, though, that no matter what changes are made, customers will not accept any decrease in color quality and availability, ability to incorporate special effects, general appearance, durability, or any other performance characteristics.

Wet on-wet processes have created some challenges for paint application equipment manufacturers. Durr Systems has focused on making sure its rotary atomizers can meet the requirements of paint flow, droplet size during atomizing to control wetness, and flash off and process control in general, according to Endregaard. "There is more of a challenge with coating appearance and curing characteristics due to limited time to flash off solvents," adds Steve Wirtz, liquid application development manager with PPG Industrial Coatings.

Wet soak-in characteristics in multiple wet applications and brightness issues for metallic/TRI coats are

Wagner System, Inc.'s SuperCube spray booth.

very important to understand in order to develop a good design of a painting line. Advancement in curing technologies, particularly IR oven designs, have helped. "Layout wise, 3-wet systems represent challenges to implement in existing plants due to size constraints, booth configurations, etc., but with flexible robot-based systems, these challenges can be overcome," Endregaard remarks.

Other than the introduction of new processes such as wet-on-wet systems, most improvements in paint application technology tend to be minor in scope, and many can be related to the move to greener, more environmentally friendly technologies.

Formulation changes have been key drivers. "The biggest change in recent years has been application technology to accommodate waterborne paint," asserts Carl Vickery, an applications technologist with BASF Automotive Refinish Solutions. Waterborne paint requires different nozzle set-ups for some spray guns, and airflow is critical during the flash-off period.

Resin rheology improvements have also been made to assist with flow and atomization characteristics of coatings with higher solids and different, non regulated solvents, according to Wirtz. "The higher solids levels in combination with lower HAPS levels have required manufacturers of application equipment to engineer spray guns that atomize the fluid very well, using minimal air pressure," adds BASF Automotive Refinish Solutions application specialist, Bob Tadayesky. Higher solids materials also often have conductivity that may require new metering concepts in order to function under high voltage, according to Endregaard.

One such highly concentrated product now on the market was launched by BASF. The Carizzma® line of automotive refinish paints are more concentrated than typical automotive refinish formulations, allowing painters to use much less material to achieve the same color intensity, according to Tadayesky.

For liquid coatings, new pumps have been introduced that can reduce energy consumption. Pneumatic pumps have been the industry staple, but this is not the only option, according to Jagielski. "Cost savings can be realized in upgrading pneumatic circulation and supply pumps to more efficient, intrinsically safe electric or hydraulic pumps that can cut energy consumption in half." This evolution has led to Graco developing the new EFlo line of electric pumps.

Other technology trends include the need for feed back from painting equipment. Examples include plural component machines such as Graco's ProMix II that monitor paint usage, supply pumps such as Graco's NXT that tell how many cycles have been run, and pumps that automatically shut down when they run out of material. "The industry is clearly evolving to provide more efficient solutions to the painting process," Jagielski asserts.

Increasingly stringent environmental regulations are also leading to advances in technology for radiation-cured coatings on metal surfaces and for UV-cured coatings on three-dimensional objects, according to David Harbourne, president of Fusion UV Systems, Inc. BASF won the Presidential Green Chemistry Challenge Award in 2007 for its UV-cured primers, which provide very high transfer efficiency, resulting in proper film build and often the need for only one coat, according to Tadayesky.

For powder coatings, application technology has adapted to formulations containing bonded metallic products with superior application properties compared to blended metallic products, according to PPG's North American Industrial Powder Coatings technical service manger, Dave Szymczak. Development of resins that cure at lower temperatures (250–300°F) and better control particle size distribution to improve transfer efficiency have also been important.

The need to reduce emissions and improve environmental controls has been another driver. Engineers at the University of Kentucky's Institute of Research for Technology Development (IR4TD), in conjunction with Toyota and Trinity, developed the Vortecone wet scrubber system for capturing paint overspray. Accord

ing to Kozo Saito, director of the institute and the Tennessee Valley Authority professor in Mechanical Engineering at the university, its capturing efficiency is much higher than traditional systems and its energy consumption is significantly reduced.

Advances are being made in spray booths as well. For solvent-based systems, there is a growing trend to recirculate spray booth air to increase volatile compound concentration, which results in improved abatement efficiency and lower emissions. "The move to super high solids formulations when combined with increased spray booth air recirculation to improve abatement efficiency leads to the need for conducting all maintenance activities outside of the spray booth, which in turn leads to the use of more automated systems," notes Endregaard.

In the automotive industry, there has been a strong push to achieve more with less. "The development of higher capacity rotary atomizers equipped with stronger turbines for increased paint flow, new bell cup atomizing concepts for one-pass instead of two-pass processes, and paint robots with higher performance to complement the reduced number of atomizers has been the response from equipment manufacturers," says Endregaard.

The green movement has also contributed to the increased interest in automated systems, according to Freels. "Robotics has always been green. When you remove people from the spray booth, you get improved film build tolerances and better specification of triggering, which can save up to 15–30% in sprayed materials, plus reduce the cost of recovery and waste. The air flow to the booth can also be lowered, providing 30–40% savings in energy consumption."

Consumer markets are also driving some changes in application technology. The desire for a wider array of colors on all types of consumer products has resulted in the need for much quicker color change capability. "Color change has always been an issue, but is now more so than ever," explains Hale. "Extreme" color changes are becoming more commonplace. Azimuth Spray System's Larry Robertson also notes that there has been an increase in small batch custom colors with greater use of pre-dispersed pigments.

A separate issue is the increased use of special effect pigments. This formulation change has required the development of application equipment (special metering systems and atomizer bell cups) that can withstand the abrasive nature of these materials.

Additional color changes carry their own environmental challenges. "We believe that paint losses and solvent/water usage during color change are in fact just as critical as a high transfer efficiency, and can contribute considerably to emission issues as well as cost per unit," notes Endregaard.

Durr Systems has developed several new products to overcome these challenges. The EcoBell 2 ICC has color valves directly integrated into the rotary atomizer, reducing paint loss to 2–3 mL per change as well as reducing solvent consumption. The company has also developed rotary, revolver-style color changers. The new in-arm voltage block system for Durr's RP E robots allows direct change applications for waterborne primers and basecoats, allowing for higher efficiencies.

The new Magic Compact and Magic Cylinder booths from ITW Gema are designed specifically for multiple color changes in a single shift. When used in conjunction with the company's OptiFlex spray guns, applicators can achieve high frequency color changes in a short time and in an environmentally friendly way, according to Hale.

The Wagner PrimaCube powder coating booth system allows a multi-color operation when using a cyclone recovery system and powder center for powder supply. Both Wagner's PrimaTech and DigiTech application systems feature the new HiCoat C4 powder gun technology for dramatically increased transfer efficiency, according to the company.

All of these changes, of course, must be made without affecting the quality and performance of the coating, and preferably result in enhanced characteristics.

Car painted with BASF's Carizzma line of automotive refinish paints.

Wagner's FlexControl *plus*.

"Equipment vendors must advance the atomization designs at higher fluid flow rates to keep up with requirements to process at faster production rates while still meeting high quality standards," notes PPG's Steve Wirtz.

Both coatings formulators and equipment manufacturers are quick to note, though, that there are several other factors that can affect the coatings process beyond the formulation and the application technology. The proper training of painters is absolutely critical to successful paint application, according to BASF's Carl Vickery. Endregaard adds: "With today's modern (complex) systems, proper operator training becomes more and more important, and qualifications in robotics are now normal for most installations."

Training can even be more important than purchasing new equipment, according to Robertson. "Proper training can make or break the cost of a coating operation. It will determine whether or not the paint gets on the part or into the booth. With trained operators, processes make much more efficient and effective use of the coatings and the equipment."

For powder applications, process control is necessary for obtaining consistent high quality finishes, according to Szymczak. Operators must understand the system variables and also be able to perform maintenance on a preventive basis. Having a good project leader that can facilitate teamwork and encourage continuous communications will also help ensure that action items get addressed in a timely manner.

End users should also pay more attention to proper handling of coatings. According to Robertson, simple steps such as properly conditioning coatings (with respect to temperature) prior to application will improve performance. Rotating stock so the oldest material is used first and making sure that paints are properly mixed are other minor activities that can have a significant impact.

There is also still much to be learned about the properties of coatings that could improve the application process. "We have a lot yet to learn about the material properties of paint, including viscosity, surface tension, wettability, curing characteristics/history, rheology, the evaporation process, the atomization process, and temperature and humidity dependencies," asserts Saito. For 2K and 3K materials, more knowledge of mixing performance and pot life would be helpful.

"The demands for mixing accuracy, process reliability, surface quality, fast effective color changes, a reduction in material consumption etc., in relation to multicomponent coatings, have increased enormously in the last few years," adds Jerry Trostle, general manager of Wagner Systems. The company's family of mixing and dosing equipment is designed to meet the needs of a wide range of industrial applications. The Intellimix 4, Intellimix 3, FlexControl *plus*, and FlexControl systems contain a variety of technical features and are modular so that each system can be custom fitted to a given coating operation and additional options can be retrofitted at a later time if required.

For UV coatings, David Harbourne notes that an improved understanding of adhesion, particularly to plastics and to metals that will undergo further post coating process steps prior to becoming a final product, would be valuable.

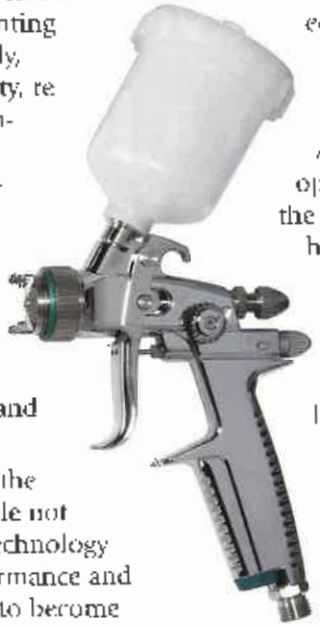
On the powder side, the development of systems that better handle smaller particle distribution products would be welcomed. "Formulators are limited in the particle sizes and distributions that can be utilized to create a coating film; improvements in smoothness or film thickness control, which could improve coatings economics, could be possible if smaller particle sizes could be employed," explains Szymczak. He also believes that analysis of particle size distribution in real time at the application booth would give operators better capability for making adjustments needed to maintain consistent performance and minimize coating rejects.

Other application challenges exist that are not directly related to material properties. Many of these issues are specific to certain coating technologies or market segments.

In the architectural coatings arena, especially residential repainting, overspray continues to be a challenge. "The overspray concern results in contractors using brush/roll or homeowners deciding to wait on a big repaint job due to the project duration required if the job can't be sprayed," explains Greg Olson, director of worldwide product marketing for the Contractor Equipment Division of Graco Inc. "There is a big op-

portunity to increase the number of jobs (and amount of paint sold) if there were paints with little or no overspray when spray applied."

The company is working to address these issues with the creation of products that allow painting contractors to be more profitable. Specifically, Graco is looking to increase sprayer versatility, reduce down time due to maintenance, and increase productivity, according to Olson. Its FinishPro family of sprayers combines traditional airless capability using proven piston pumps with the added capability of air-assisted airless with an onboard air compressor and AA gun, allowing contractors to perform more types of jobs faster. New MaxLife coatings on critical wear parts of pumps dramatically increase wear life, too, and significantly reduce downtime.



With respect to radiation-cured coatings, the biggest challenge is communicating to people not currently using UV/EB processing that the technology has the capability to improve product performance and reduce manufacturing costs, enabling them to become environmentally responsive while improving profitability, according to Harbourne.

The trend toward lower and lower VOC limits will likely continue to present application challenges as well. "As coating formulators develop new paint formulations that meet these changing regulations, the inherent rheology will be different and will require modifications to existing application technology," says Tadayesky.

Overcoming these various challenges will require that all parties involved, from formulators to equipment manufacturers to end users, work together to develop coatings and application technology that minimize cost and environmental impact, while maximizing efficiency and performance.

For Graco, this type of relationship is very important. "Historically, many paints have been designed to perform very well when brushed or rolled, and sometimes the paint parameters that make it good for brush or roll are actually detrimental to the sprayability of the paint," comments Olson. "We have worked with manufacturers to understand the paint properties important for good spray atomization and also on formulation parameters that can enhance equipment life due to wear properties of paints."

David Harbourne would like to see more cooperation between formulators of rad-cure coatings and equipment suppliers. "It is an imperative that for the timely, successful developments of UV/EB curing processes, the chemistry and equipment supplier work hand-in hand. An improvement in this aspect of the development process would significantly impact the rate of conversion to UV/EB processing," he asserts.

Einar Endregaard believes that in the past application equipment developers worked more closely with paint formulators and these valuable relationships offered a lot of impetus for development of new application technologies. Today, however, these types of relationships tend to be reduced due to a lack of available funds and resources.

Mark Freels notes one example where cooperation between equipment manufacturers and coating formulators remains strong. "Coating producers and applicators are looking for higher flow rates and bell cup rotation speeds (up to 70,000 rpm). ABB and other equipment suppliers are working closely with both groups to develop atomizers that will perform at this level while still maintaining or even improving the quality of the finishes produced." CT

Dürr System's Eco RP E elevated robots.