Electromagnetic brush powder coating: From the lab to commercial production

Peter Kloppers *EMB Technology*

Application of powder coatings on flat substrates by a process called electromagnetic brush*, or EMB, might change the future of the powder coating industry. The process can apply powder coatings on flat conductive and nonconductive substrates such as coils and sheets at relative high speeds with a very controllable and even powder layer. The first installation of an EMB process is now a fact, with a pilot production line applying powder on flexible flat substrates. This article traces the principles of the process, explains the background and initiatives, discusses the benefits of the process, and touches on the relevant issues for implementation.*

The EMB process can revolutionize the coatings industry in three ways. First, it can replace wet coating on flat reel-to-reel or sheet applications, resulting in lower solvent emissions and reduced energy consumption by the coating industry. Second, it can significantly reduce the cost of coating per square yard. And third, it can produce a higher quality of coating in terms of thickness variance without loss due to overspray.

When this process succeeds, it will greatly impact the environmental load of coating processes on our planet. Industry might change radically as well because investments related to an EMB process are much lower than those required to build a conventional coating line. Decentralized low-investment miniplants flexible and capable of doing small order sizes close to there main customers are likely to appear, taking work from the existing centralized high-investment coating plants, which can only run economically on large orders.

Meeting new targets for reducing solvent emissions isn't easy for the coatings industry. Each year 200,000 tons of solvents are directly or indirectly emitted to our environment by the coatings industry. As a result, it's important for all of us to reduce this amount. Governments all over the world are putting pressure on the coil coating industry to reduce emissions. Obviously, powder coating is a good alternative for wet coating and seems to be a way to meet the demand to limit solvent emissions. Nevertheless, most industrial initiatives for applying powder coatings on flat substrates didn't meet the economical laws of gaining profit and delivering quality products. Advanced spray coating lines generally require high investments, are difficult to maintain, suffer from poor-quality film thickness, operate at low speeds, and require a high level of operator skills. Some promising advancements didn't work out because they were either too complex to make commercially viable or too expensive to gain a reasonable return on investment.

EMB technology, on the other hand, seems to be a simple process, requiring limited investment and floor space. The EMB unit can be built on a surface of 40 square feet (sq ft) and can be integrated into existing lines. As a result, it's relatively easy to start up pilot production situations, giving EMB technology high potential for a breakthrough in the coatings industry.

A typical catch-22

Why did it take so long for EMB technology to accelerate to the commercial production stage? The reasons are based on a typical catch-22 and explained by the following:

- The process was invented and patented by DSM[1]. Generally, to operate this process a license from DSM is required. Although this license fee is affordable and reasonable regarding the expected profits for the user, companies hesitated to commit because there was no real proof of concept—until now. However, DSM has stated that it doesn't invest in hardware and leave the initiatives to the marketplace, which means no machine or pilot plant was financed—until now.

- Although numerous companies in the industry seemed to be willing and enthusiastic to develop their products to create profitable applications, no machine builder was prepared to take the high risk to develop an EMB coating prototype without an actual order for a system.
- Without a machine producing daily products and operating in a production setting, coil coaters didn't want to invest in new technology and a license fee for what could be just a dream.
- Governments, although aware of the potential and feeling the pressure of reducing VOCs in their countries, generally require so many forms and answers to unanswerable questions before subsidizing new technology that no machine builder has the time to overcome the hurdles set before them.

This catch-22 is typical for innovative concepts. In reality, the cycle can only be broken by someone doing something either very stupid or very clever.

Cleverness wins

The EMB process uses copier principles to apply powder coating. It took DSM at least 3 years to accomplish a basic proof of concept at very low speeds with a mini-machine that had a web width of about 3 inches. After this relatively successful attempt, a lot of energy was put into transferring the principle to a modified OCE laser printer. By 2002, it was possible to coat substrates attached to the drum at speeds around 300 feet per minute (fpm). This copier was used for trials at various plants. Although it showed that the principle could work, the machine had a lot of problems because it was still a copier and not an application machine for powders.

To accelerate the process, DSM organized an EMB conference in 2002 to build a consortium with powder coatings manufacturers, raw materials suppliers, and coil coaters to finance further development of the machine. Unfortunately, the consortium didn't develop, and no machine builder was prepared to take the risk.

At the time, I was working as managing director for a company that built machines for laminating, cutting, and coating equipment for the large format print industry. Through my work, I came in contact with DSM. After intensive study of the EMB process, I decided in 2003 to build a real prototype for a customer who worked for a leading company in the electronics industry. The purpose of this 24-inch-wide machine was to have a test machine for coating on a special film in a reel-to-reel situation. This was to replace my customer's liquid-based process and extend the product portfolio with next-generation products. Shortly after the delivery of this machine, my company was sold to a new shareholder who needed to focus solely on large format printing, leaving EMB out of its business concept.

I left the company in 2004, and together with Dennis Engelsma, who owns a construction machine building operation, I formed a new company and bought the EMB drawings from my former employer. This new company was founded to make EMB machine building a reality.

Believing strongly in the potential of EMB, Engelsma and I were aware that the best way to accelerate EMB was to create a flexible, reliable platform that innovative coaters, printers, powder suppliers, and raw materials suppliers could use to create new applications and products.

In the meantime, our customer was very successful with the prototype and decided to order a 31-inch-wide pilot production machine to powder coat products on a serial basis. It's expected that this customer will order more

FIGURE 1

Tribo-electrostatically charged powder particles and carrier particles are guided along a rotating drum containing magnets on a fixed static position.

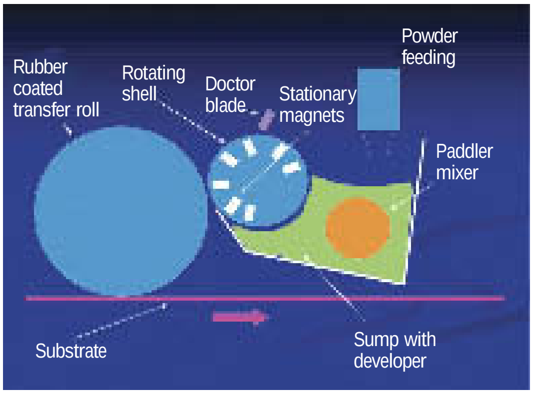
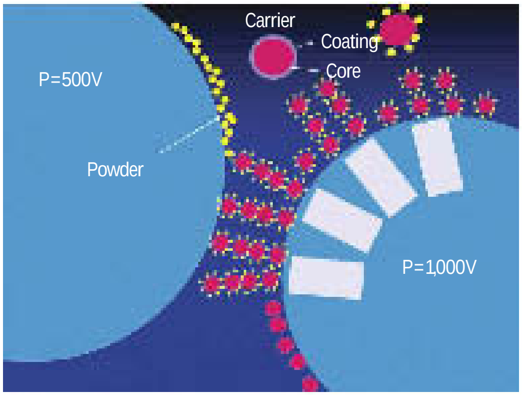


FIGURE 2

Powder particles move to the substrate and carrier particles remain on the drum by magnetic force.



machines soon for production plants worldwide. The pilot production machine was delivered, commissioned, and taken into production this past spring.

The first customer's application contributed enormously to the steep learning curve we went through building our machine. Intensive exchange of information, rapid feedback, and close cooperation with this customer made it possible to change the prototype and pilot machine regularly, learning even more from the process. This brought us all the knowledge and confidence to test other applications with EMB and regain the investments we had made.

The EMB process

Similar to processes generally used in copiers and printers, the EMB process uses powder particles mixed with carrier particles, which are simply particles with an iron core coated with an insulating layer. The mixing process causes the powder particles to become tribo-electrostatically charged against the carrier particles. Numerous powder particles connect to one carrier particle. This combination is called a *development system*.

These development systems are guided along a rotating drum containing magnets on a fixed static position, forming a magnetic brush on the drum. This brush on the rotating drum is then cut to the right proportion by a doctor blade. When this brush comes along the electrically charged substrate, the powder particles from the development system move to the substrate by electric force. The carrier particles remain on the drum by magnetic force, and then float freely back to the mixing system to reconnect to new powder particles. Figures 1 through 4 show how the system works.

When powder coating a flexible substrate, the substrate is directly guided along the brush over a substrate drum. When powder coating an inflexible or conductive ferromagnetic material, the powder is transferred via a semiconductive transfer drum to the substrate by a different level of electrostatic fields between brush drum, transfer drum, and transfer drum and substrate. For instance, 1,500 volts (V) on the brush drum, 500 V on the transfer drum, and zero V on the substrate.

The first production machine

The EMB unit (Figure 5) is 6$^1/_2$ feet wide, 6$^1/_2$ feet deep, and 5 feet tall. It can run mechanically at speeds of 200 fpm and has a web width of 31 inches. The system is designed to operate as a standalone unit on existing lines.

For the first application, the unit came with a servo-driven web transportation unit consisting of two wind-off units and one rewind unit for film. The system was integrated with a fast-melting oven system. The total line surface for the installation was 25 feet.

The customer is satisfied with an application of 2.75 mils of powder at a speed of 65 fpm, which would be 0.6 mil at a speed of 165 fpm. Although higher speeds can be reached, this combination of powder and carrier isn't yet optimized for it. Currently, the deviation in applied film thickness is ±3 percent. The machine is equipped with a touch screen (Figure 6) and readout of all relevant parameters.

Technical support and maintenance is possible by modem. The programs are capable of interacting with a lab-view system, making it possible to log, track, and trace all required parameters of a job done. The lab-view system also allows the process operator to run the machine independently.

The design takes into account that key parts can be exchanged and retrofitted without much effort. This is very important because of the steep learning curve and makes it possible to implement new ideas with little costs.

FIGURE 3

A sample brush

FIGURE 4

A brush and coated substrate

The possibilities to adjust the system make the machine very flexible for various kinds of powder-carrier combinations. A job change from one powder-carrier mixture to another can be done in less then an hour.

Technical challenges

The challenges in designing the EMB process were numerous but were concentrated on the following aspects:

- To distribute the new replenished powder equally and evenly over the web width
- To mix the powder particles with the carrier thoroughly without damaging the carrier and without heating up the system
- To maintain a constant ratio between carrier and powder in the mixture
- To design and rotate the brush drum, which is heavily loaded on one side with particles, at a very constant speed with almost no deformation
- To design magnets with the right configuration and position in the system
- To cut the fast-moving brush accurately with the doctor blade at high speeds
- To apply a very controlled electrical field on the different components
- To establish and maintain an adequate flow of the development system, fresh powder, and recirculating carriers along the different components
- To prevent powder from entering into the sensitive machine parts and production room
- To meet all safety standards and keep an effective machine at the same time

With great help from a lot of experts, suppliers, and technical institutes, these challenges where resolved to make it possible to produce a high-quality powder-coated product reliably and predictably. It will take some months of systematic trials for a certain application to discover its limits. Configuration of more EMB units behind each other will also certainly lead to speeds beyond 330 fpm. Wider web widths also seem possible. At this stage, a web width of 31 inches has proved itself in a production setting. The design of the machine is already mechanically prepared for 50 inches. Time will tell how the process behaves on larger web widths.

Potential applications

All coating processes on flat substrates from reel or as sheet or panel can be subject to EMB coating as long as it's possible to lead an electric field through the substrate. This includes plastics, wood, medium-density fiberboard (MDF), flexible films and cardboard for the packaging and labeling industry, paper, printed materials, metal films, sheets, and coils. Theoretically, even a thin concrete panel could be coated. Besides these applications, the EMB process could be very useful in security printing and in applications that require a thick layer of coating.

Existing powder coating plants for flat substrates currently using powder guns can benefit from the higher speeds possible by EMB coating. Overspray doesn't exist, and film thicknesses can be much lower than those applied with traditional spray equipment.

The next step

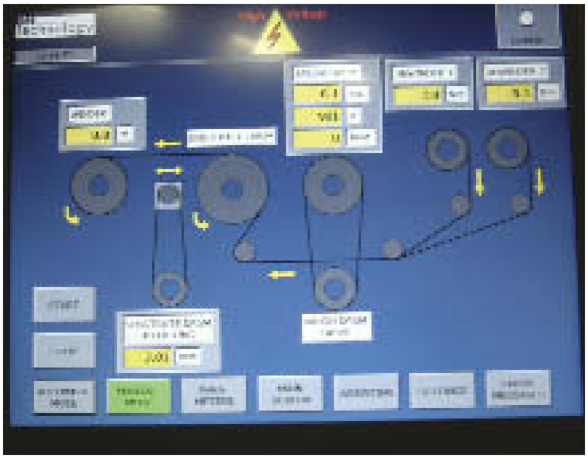
The next step in the development of EMB is for innovative coaters to recognize the potential for its use and start to develop applications in pilot situations. Because the investment level of an EMB system is very low compared with that of a liquid coating line, the next step can be expected

Figure 5

The first production electromagnetic brush machine

Figure 6

The electromagnetic brush machine includes a touch screen and readout of all relevant parameters.



soon. It's expected that some projects for coating on steel and aluminum will start before the end of this year.

EMB makes it possible to apply powder coatings at higher speeds and at thinner and more uniform film thicknesses than ever before. With the first delivery of a pilot production machine, this technology has moved from the laboratory into commercial use. This will contribute to more applications for the powder coating industry—and open doors into new markets. PC

End notes

1. DSM, P.O. Box 615, 8000 AP Zwolle, The Netherlands

Editor's note

For further reading on the topic discussed in this article, see *Powder Coating* magazine's Web site at [www.pcoating.com]. Click on Article Index and search by subject category. Have a question? Click on Problem solving to submit one. To receive the magazine's weekly Q&A newsletter, scroll to the bottom of the home page and send us your e-mail address.

Peter Kloppers is technical director for EMB Technology, Stationsweg 14, 1702 AE Heerhugowaard, The Nederlands; telephone from the US, 011-31 6 460 082 89 or 011-31 6 460 082 80; fax from the US, 011-31 72 571 85 23; e-mail [p.kloppers@emb-technology.nl]; Web site is [www.emb-technology.nl].