Film-thickness control—know-how and vigilance are required
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A few years ago, a customer called about equipment difficulties he was having. When asked about film-thickness control on his line, he said: “We check our film thickness periodically using sample parts. The results fall exactly within our specification of 1.5 mils.”

A check of the sample parts confirmed that they were exactly within specification. Sad to say, a check of the production parts revealed a film thickness four times the specification. Dismayed at the findings, the customer asked, “How can that be?” The answer was simple: Workers at his plant had become exceptionally effective at coating samples within the specification. Unfortunately, they were not nearly as proficient at coating production parts. The situation is not uncommon. Many powder coating lines, especially those that have recently converted from liquid, cannot get control of film thickness on a consistent basis.

Film-thickness control—what’s at stake
Film-thickness control is important in terms of the cost of the applied material and the function of the powder coating.

Material cost. The cost aspect is obvious—the more you put on, the more you pay. When the customer quoted earlier got control of film thickness on his three lines, he saved $60,000 a year in material costs on each line. Total savings represented 50 percent of the company’s powder costs.

The reason this customer could apply four times the required amount of powder is that powder is not self-limiting except when back ionization occurs. Liquid coatings sag and run at high film builds, producing rejects and alerting workers that too much material is being applied. Powder, in contrast, can be applied at 10+ mils without causing rejects or tripping off workers that a problem exists. Consequently, if material costs are to be kept in check, workers must control powder film thickness vigilantly.

Powder coating function. Powders are formulated to provide certain mechanical and physical properties. Coating thickness affects these properties. For example, a powder that is formulated to be highly flexible to withstand post-forming operations will not perform correctly unless the film thickness falls within the levels specified. Other properties—such as hardness, surface appearance, and resistance to salt spray, impact, and chemicals—also are affected.

Thickness-measurement devices—what’s available for powder
A variety of mechanical and electronic devices are available to measure the film thickness of a cured powder coating. Though more expensive, electronic devices are more accurate and reliable than mechanical ones.

Devices exist for measuring the thickness of uncured liquid coatings but not for uncured powder. The naked eye will give a rough estimate of uncured powder thickness, however, providing the eye is well trained. To gauge the thickness of uncured powder, the tester scratches the coating with a sharp object such as a pencil, exposing the substrate. By examining the depth of the scratch, an experienced tester can tell that the coating thickness is between 2 and 4 mils, for example.

This method destroys the integrity of the coating, but the remaining coating can be blown off the part with compressed air. The part is then ready to be recoated.

Despite its limitations, this method is useful, especially when setting up application equipment on a production line. It quickly tells the tester how close the equipment is to producing parts that are within specification. This eliminates the need for waiting for parts to cure to get coating-thickness information.

Film-thickness specs—setting them for powder
Shops that have recently switched from liquid to powder can have problems if they set unachievable limits for powder film thickness. Attaining the lower limits possible with a liquid system, such as 0.8 mil, is impractical in current powder coating operations. When converting from liquid to powder, therefore, it is important to set film-thickness limits that are based on the experience and knowledge of the equipment supplier, powder supplier, and end user.

The equipment supplier and end user will seriously need to consider part configuration in setting practical specifications for film thickness. It is easiest to control film thickness on rounded parts (round tubing and wire goods, for example) since they have few edges and no corners. Theoretically, the film thickness on all areas of a rounded part should be the same. Given this, the thickness specification can be narrow and still be easy to meet.

This is not the case with parts that have complex configurations—for example, those that have many edges, corners, or both. Boxes are perhaps the most complex parts...
because they have more edges and corners than other parts. The presence of edges and corners increases coating thickness. The thickness specification for complex parts should be wide, therefore, and should clearly spell out the coating-thickness limits for various areas of the part. For example, the specs for the flat surfaces of a complex part might be 1.5 mils, whereas those for the surfaces near a Faraday cage might be 3.0 mils.

Edges, corners, and boxes increase the thickness of the film build in the following ways:

**Edges.** Part edges are better electrostatic targets than flat surfaces are. Films develop more quickly on them than on nearby flat surfaces, creating a discrepancy between film thickness at the edges and on the surfaces. In addition, when a coating is applied to both sides of a part, electrostatic wrap will double the film thickness on the part edges because the wrap will extend approximately 1.5 inches on the back side of the part.

**Corners.** The film thickness on part surfaces adjacent to a corner will usually be higher than they are in the corner itself because of the Faraday cage effect.

**Boxes.** To coat the back wall of a box, the gun must penetrate the box. In doing so, the gun will coat the side walls of the box twice (in and out), doubling the film thickness on them.

**Thickness control—who and what is involved**

**Powder formulation variables.** Variables in powder formulation and manufacture affect film thickness. The most important are the grind, or particle size, of the powder; the flow characteristics of the formulation; and the color and hiding power of the powder. The powder supplier controls these variables and typically matches them to the end user's specific requirements as follows:

**Particle size.** If the end user's application requires a high film build, the manufacturer will typically supply a material that has a large particle size, which will build quickly on the part surface. Conversely, if the application calls for thin film builds, the material vendor will most likely supply a powder with a finer grind size.

**Flow characteristics.** When a powder is formulated to have high flow characteristics, it will be relatively easy to control thin film builds. Conversely, when a powder is formulated with low flow characteristics, thick film builds will be relatively easy to control.

**Hiding power.** Certain colors hide (cover) the substrate at lower film thicknesses than others—black, for example, hides better than white. Manufacturers formulate hiding power into a powder. A low-hiding powder is one that requires a minimum film thickness to cover the substrate.

**Application system variables.** During equipment setup, the equipment vendor and end user can regulate system variables to control film thickness consistently. These variables affect film thickness the most:
- Number of spray guns
- Placement and type of powder pattern
- Gun-to-target distance
- Powder output of the guns
- Electrostatic voltage
- Gun-motion speed and stroke
- Part temperature at time of coating
- Part ground
- Environmental conditions in the coating room
- Bent part hangers and part true-ness

Consistent control of these variables yields consistent film thickness.

**Consistent control—automated equipment can help**

Automated equipment operates consistently, which can improve film-thickness control. But its high initial cost means that its purchase must be justified in terms of potential savings in powder use and in a lower reject rate. Four major types of automated equipment are available to control film thickness: Gun motion devices (single- and multi-axis); powder-output controllers; remote powder-pattern controllers; and PLC controllers.

**Reliable control—daily tracking is required**

Even after the powder supplier has formulated a powder that meets the end user's film-thickness specification, and the equipment vendor and end user have regulated the system variables, work remains to be done. To be sure film builds are within specification consistently, it's necessary for the end user to track film thickness daily. Tracking involves taking thickness measurements on production parts that have been processed within the day. The results should be charted to establish the trend of the consistency of the coating operation. One person should take ownership of the process of film-thickness control and be responsible for tracking the results.

Daily tracking provides information that variables in the coating process have changed and are producing film builds that are out of spec. This tells the person responsible for controlling coating thickness that it's time to adjust the equipment settings to bring film thickness back into spec. Daily tracking is the way end users can ensure that their process will consistently produce the coating quality that their operation requires.

**Endnotes**

1. The accepted unit of measure for film thickness is the mil; 1 mil = 0.001 inch.

[Editor's note: The article "How to set up your system for a new part," *Powder Coating*, August 1991, contains information on regulating these and other system variables.]