Transfer Efficiency of Powder Coatings

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A Technical Brief Prepared by
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Transfer efficiency in powder coating application and recovery systems can be separated into two distinct areas:

1. Application or first pass transfer efficiency.
2. System or overall transfer efficiency.

Application transfer efficiency is a measure of the performance of the spray gun(s), and system transfer efficiency is a measure of the performance of the total powder coating application and recovery system.

APPLICATION TRANSFER EFFICIENCY

Application transfer efficiency (ATE) is defined as the ratio between the amount of powder actually deposited on the part intended to be coated, and the amount of powder sprayed during that spray operation. The ratio is usually expressed as a percentage and the amounts of powder are usually determined by weight.

ATE can be measured over any given length of time and/or any number of part coating cycles, but is usually measured over a short time or even just one cycle. ATE may be measured using strictly controlled apparatus in a laboratory environment to evaluate gun design and performance, or it may be similarly used to measure the performance of powder guns as part of a total powder coating system environment.

The importance of a high ATE is that it minimizes the amount of oversprayed powder coating material generated. A higher ATE also results in reduced equipment wear and maintenance requirements, can produce improved finish quality, and may allow for greater production throughput, for a given system.

Calculation of ATE, in its most straightforward form, is as follows:

$$\text{ATE} = \frac{\text{Weight of powder deposited}}{\text{Weight of powder sprayed}}$$

or,

$$\text{ATE} = \frac{W_d}{W_s}$$

To express ATE as a percentage, then,

$$\text{ATE} = \frac{W_d}{W_s} \times 100$$

Test methods for ATE revolve around accurately determining the weight of powder both sprayed and deposited (W_d and W_s) while minimizing disruption of, or influence upon, the spraying process being measured. Two basic methods are in use, each with variations, advantages, and disadvantages.

METHOD A:

1. Weigh part to be coated.
2. Weigh porous bag empty.
3. Trigger spray gun to coat properly grounded part, recording time required to coat part.
4. Making no changes to any factor that may influence the powder output rate, trigger spray gun into a porous bag for an equal amount of time (a vacuum cleaner bag is frequently used.
5. Weigh porous bag with powder.
6. Weigh the part with powder coating.

In this case,

W_d = (Weight of the part with powder coating)
 − (Weight of the part without powder coating)

and,

W_s = (Weight of bag with powder)
 − (Weight of bag empty)

The advantage of this method is that it can be performed quickly, requiring just one part coating cycle to generate a result, and that it can be performed with minimal amounts of powder. The primary limitation is that it has a certain degree of inaccuracy resulting from the following:

1. The actual powder used to coat the part is not directly measured.
2. The porous bag used to collect the powder, no matter how porous, creates a back pressure that affects the test powder output.
3. The use of a single part may not accurately duplicate production results.
4. Attaching the porous bag to the spray gun in such a manner as to prevent powder leakage is very difficult.

Running a series of such procedures, and averaging the results provides the most accurate ATE value.

Additional items to be considered using this test method are as follows:

- Inclusion of part hanger in calculations (if part hanger is included then its cleanliness and configuration must be representative).
- Care should be taken in handling the uncured part prior to weighing to minimize powder loss.
- Curing of the powder coated part prior to weighing may affect the accuracy of the test results due to loss of volatiles contained in the powder.

METHOD B:

1. Weigh part(s) to be coated.
2. Fill powder feed hopper.
3. Weigh powder feed hopper.
4. Powder coat part(s).
5. Weigh powder feed hopper.
6. Weigh part(s) with powder coating.

In this case,

W_d = (Weight of part(s) with powder coating)
 − (Weight of part(s) without powder coating)

and,

W_s = (Weight of feed hopper before spraying)
 − (Weight of feed hopper after spraying)

Note that the powder feed hopper must be isolated from the powder recovery system. Allowing reclaimed powder to re-enter the powder feed hopper will affect the weight measurements of the feed hopper contents.

The primary advantage of this method is that the measurement of the powder output is both direct and nonintrusive to the process, and thus the resulting amount-of-powder-sprayed value can be more accurate; however, because the amount of powder used for any given part can be small when compared to the total weight of the hopper and powder combination, it is usually necessary to powder coat a number of parts in order to consume sufficient powder to accurately measure the amount sprayed. Thus the limitations of this method are that it is not necessarily a one-part measuring process and it can require a larger volume of powder to get an accurate result. Also, the hopper available may simply be too large to reasonably weigh.

An alternative method exists for determining the amount of powder deposited on the part. This procedure utilizes a number of film thickness measurements of the coated and cured part to obtain an average value for the film thickness for the whole part. This value and the theoretical coverage formulas are then used to determine the weight of powder required to give that average film thickness over the area of the part.

This method can be inserted into either of the tests described above, and may be preferable in those situations where weighing the part is not practical; however, this method of determining the weight of applied powder has serious restrictions in that it is not a direct measurement process and thus is prone to built-in error. A complex object shape that prohibits numerous and direct film thickness measurements over the great majority of its surface will result in unacceptably large errors both in arriving at an average film thickness, and perhaps even a determination of the area coated. This problem can be even more complicated if the part is not to be 100% coated, as it is very difficult to get an accurate film thickness value in areas where the part has only been dusted.

Note that when using ATE values in making safety or performance related powder recovery system design calculations (for example, determining booth air flow requirements), it is necessary to ensure that the parameters of the test methods, or assumptions, by which the ATE is derived include any system design factors or operational requirements that may have an effect upon the resulting system's actual ATE.

SYSTEM TRANSFER EFFICIENCY

System transfer efficiency (STE) is defined as the ratio between the amount of powder deposited on the parts to be coated and the amount of powder consumed by a powder coating application and recovery system during the same period. This ratio is usually expressed as a percentage, and the amounts of powder are usually determined by weight.

The time base for determining STE is usually longer than for ATE, as it is intended to measure the overall system operating efficiency. The STE, in modern powder coating application and recovery systems, will be a higher percentage number than the ATE for the same system because oversprayed powder is received and reused. The percentage numbers would indicate, for example powder losses from unrecovered powder, powder leaks and spills, and powder lost to part hangers. It may also be desirable to consider powder lost on parts rejected due to powder coating system quality problems. STE can be used to evaluate both the design of a system and its current operational condition with regards to its need for maintenance.

The importance of a high STE is to derive maximum benefit from one of the major economic advantages of powder coating, which is the ability to recover and reuse oversprayed material. The higher the STE, the more economically the system is operating.

Calculation of STE is as follows:

$$\text{STE} = \frac{\text{Weight of powder deposited on parts}}{\text{Weight of powder consumed by system}}$$

or,

$$\text{STE} = \frac{W_d}{W_c}$$

To express STE as a percentage, then,

$$\text{STE} = \frac{W_d}{W_c} \times 100$$

As this is frequently a long term measurement, the W_c is usually determined by, for example, a count of the number of powder containers used. To produce the most accurate result, the containers should be weighed load by load. Powder in the system at the start of the test, and remaining at the end, must be either weighed or estimated. W_d is usually determined by weighing sampled parts with sufficient frequency to ensure a credible result. The results are then averaged and multiplied by the total number of parts coated during the test. W_d for the course of the test is thus obtained.

Although simple in principle, both ATE and STE values can be put to reproductive and correct use only if all the variables and test parameters involved in their determination are understood, properly controlled, and reflect the actual operating conditions of the system to which the resulting transfer efficiency values are to relate. **MF**

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COVER

Ties together the powder coating and aluminum finishing themes of this issue. White semi-gloss powder coated aluminum extrusions accent the Stadtgarten Shopping Center in Mannheim, West Germany. Photo courtesy of International Paint Powder Coatings, Inc., Houston, TX.