Effect of Powder Particle Size and Charging Efficiency on Film Build and Surface Finish

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Abstract: Powder coating, a solvent-free technique, is influenced heavily by powder particle size and electrostatic charging efficiency. This study investigates how these two factors affect film build and surface finish using epoxy-polyester hybrid powders categorized into fine (<20 µm), medium (20–40 µm), and coarse (>40 µm) sizes. Coatings were applied to steel panels using a corona-type spray gun under consistent voltage and flow conditions. Post-application, panels were cured and evaluated for film thickness and surface roughness. Fine powders yielded the smoothest surface (Ra = 0.8 µm) but had the lowest film build (35 µm) due to reduced charging efficiency (55%). Coarse powders achieved higher film build (65 µm) but resulted in rougher finishes (Ra = 2.0 µm). Medium particles offered a balanced performance with adequate surface finish (Ra = 1.2 µm) and film build (50 µm). Charging efficiency increased with particle size, highlighting the trade-off between deposition and surface quality. This study suggests that optimizing powder distribution and charging parameters can significantly enhance coating outcomes.

Keywords: Powder coating, Particle size, Electrostatic charging, Film build, Surface roughness, Epoxy-polyester

I. Introduction

Powder coating is an increasingly preferred finishing method due to its environmental benefits and efficiency. It involves applying thermosetting powders to grounded substrates using electrostatic spray guns, followed by thermal curing. Critical process parameters include powder particle size and electrostatic charging efficiency, which significantly influence film build and surface finish.

Smaller powder particles improve surface coverage but suffer from poor transfer efficiency. Larger particles deposit more efficiently but can cause surface defects. Charging efficiency, crucial for powder adherence, also varies with particle size. This study aims to analyze the combined impact of these parameters on powder coating performance to guide industrial application optimization.

II. Literature Review

Mikeska (2001) discussed how particle size influences deposition and coating characteristics. Posner and Sacks (1989) studied the charging behavior of different powders, revealing a correlation between particle size and charge uptake. Ashtiani (1999) emphasized optimizing electrostatic systems for varied powder types. However, few studies simultaneously examine both particle size and charging efficiency. This research addresses this gap by providing a comparative analysis using uniform application conditions.

Indeed, expert guidelines increasingly recommend CGM in elderly patients — for example, the 2023 ADA Standards emphasize CGM to reduce hypoglycemia in older type 1 diabetic. Overall, CGM has become a new standard in optimized diabetes care.

III. METHODOLOGY

3.1 Powder Classification Epoxy-polyester powders were classified into three size ranges:

- Fine: <20 µm
- Medium: 20–40 µm
- Coarse: >40 µm

3.2 Equipment

- Corona-type electrostatic spray gun
- Steel panels (100 mm × 150 mm)
- Magnetic induction film thickness gauge
- Surface profilometer (ISO 4287)
- Tribo-electrostatic measurement setup

3.3 Procedure Each powder type was applied under standardized conditions: 70 kV voltage, 25 cm spray distance, and fixed flow rate. Coated samples were cured at 180°C for 15 minutes. Film thickness and surface roughness were measured post-cooling.

3.4 Ethical Considerations No human or animal subjects were involved. Standard safety protocols were followed during powder application and oven curing.

IV. RESULTS AND DISCUSSION

Table 1: Film Build, Surface Roughness, and Charging Efficiency

Particle Size	Avg. Film Build (µm)	Surface Roughness Ra (µm)	Charging Efficiency (%)
Fine (<20 µm)	35	0.8	55
Medium (20–40 µm)	50	1.2	70
Coarse (>40 µm)	65	2.0	80

4.1 Film Build Coarse powders resulted in the highest film build due to greater mass and momentum, facilitating better deposition. However, the film uniformity was compromised.

4.2 Surface Finish Fine powders exhibited superior surface smoothness, effectively covering surface irregularities but required multiple passes due to low deposition efficiency.

4.3 Charging Efficiency Charging efficiency improved with particle size. Larger particles interacted better with the corona field, increasing deposition rates. However, excessive buildup affected surface quality.

4.4 Optimal Range Medium-sized particles offered the best trade-off, achieving acceptable film build and finish, making them suitable for most industrial applications.

V. Conclusion

This study confirms that particle size and charging efficiency are interdependent variables affecting powder coating performance. Fine powders enhance aesthetics but lack deposition efficiency. Coarse powders improve film build at the cost of finish quality. Medium particles offer a practical compromise.

Recommendations:

- Employ controlled or bimodal particle distributions for optimal results.
- Adjust spray parameters based on powder characteristics.
- Monitor charging behavior during powder selection.

Limitations:

The study did not account for the effect of particle morphology or environmental factors like humidity.

Future Research

- Investigate particle shape (spherical vs. irregular)
- Evaluate the impact of additives on charging efficiency
- Study advanced spray gun designs for fine powders

VI. References

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