# ATOMIZATION TO APPEARANCE IN ELECTROSTATIC ROTATING BELL COATING APPLICATION

Soumendra K. Basu, Robert Davis, Spencer Hochstetler,
Chip Williams, John Moncier, Arved Harding, and Kevin McCreight

Eastman Chemical Company, Kingsport, TN 37662, USA

Presented at the 15th International Coating Science and Technology Symposium,
September 13-15, 2010, St. Paul, MN[1]

## Introduction

Electrostatic, rotating bell (ESRB) application is one of the most important coating application techniques for industries with demanding specifications for optical attractiveness of coatings, such as automotive. The ESRB process involves production of droplets using a high-speed rotating bell, which are subsequently transported to the substrate being coated via shaping air [1-3]. An electrical potential is applied between the bell and the substrate which further helps droplet atomization and transport. This research investigates the effects of inertia, centrifugal force, drag force, and electrostatic force on the atomization mechanism and particle size distribution using an automotive OEM base coat formulation. Coating flow rate (CFR), shaping air flow rate (SAFR), bell speed (BS), and electrostatic potential (EP) were used as primary parameters to create various atomization conditions and particle size distributions. The atomization mechanism, ligament formation, and particle size distribution were measured using high-speed laser shadowography and image processing. The effects of governing forces and particle size generated on efficiency of droplet transfer to the substrate and optical appearance of the coatings were studied to generate operating windows for optimum process efficiency and appearance.

## Experimental

An internally formulated polyester-melamine automotive OEM metallic basecoat, and a commercial OEM clear coat were used for this study. The coatings were electrostatically sprayed using an ABB 6-axis robot controlled by an Allen Bradley PLC equipped with a Sames PPH607 65 mm serrated high speed rotary bell atomizer. CFR, BS, SAFR, and EP were each varied at three different levels to perform a 30 sample DOE using axial and corner points including 4 replicas for the center. The tip speed of the robot and overlap was varied to reach a 0.65 mil dry film thickness (DFT) in two identical passes for every DOE condition with

---

[1] Unpublished. ISCST shall not be responsible for statements or opinions contained in papers or printed in its publications.

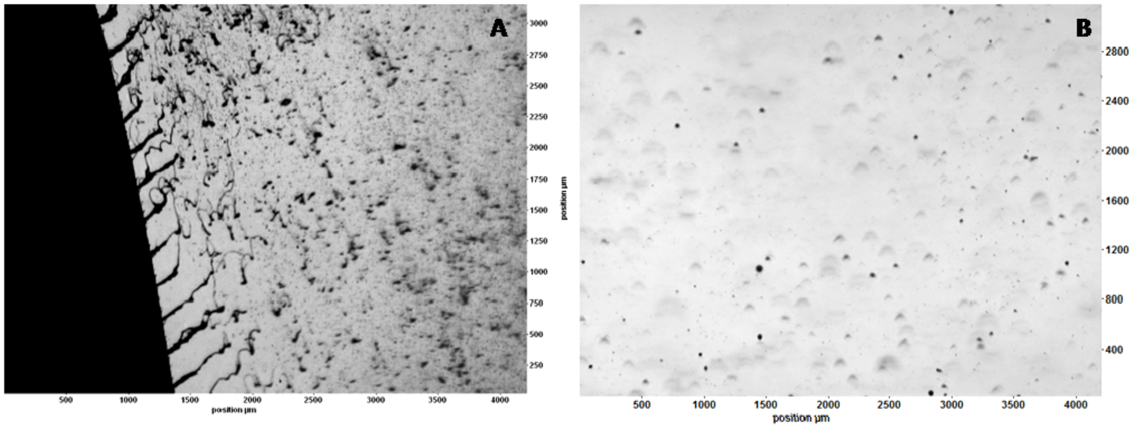


**Figure 1**: Representative micrographs of: A) ligament formation and particle generation through break-up of the ligaments at the edge of the rotating bell, and B) particle transport through air at a distance of ten inches from the face of the bell.

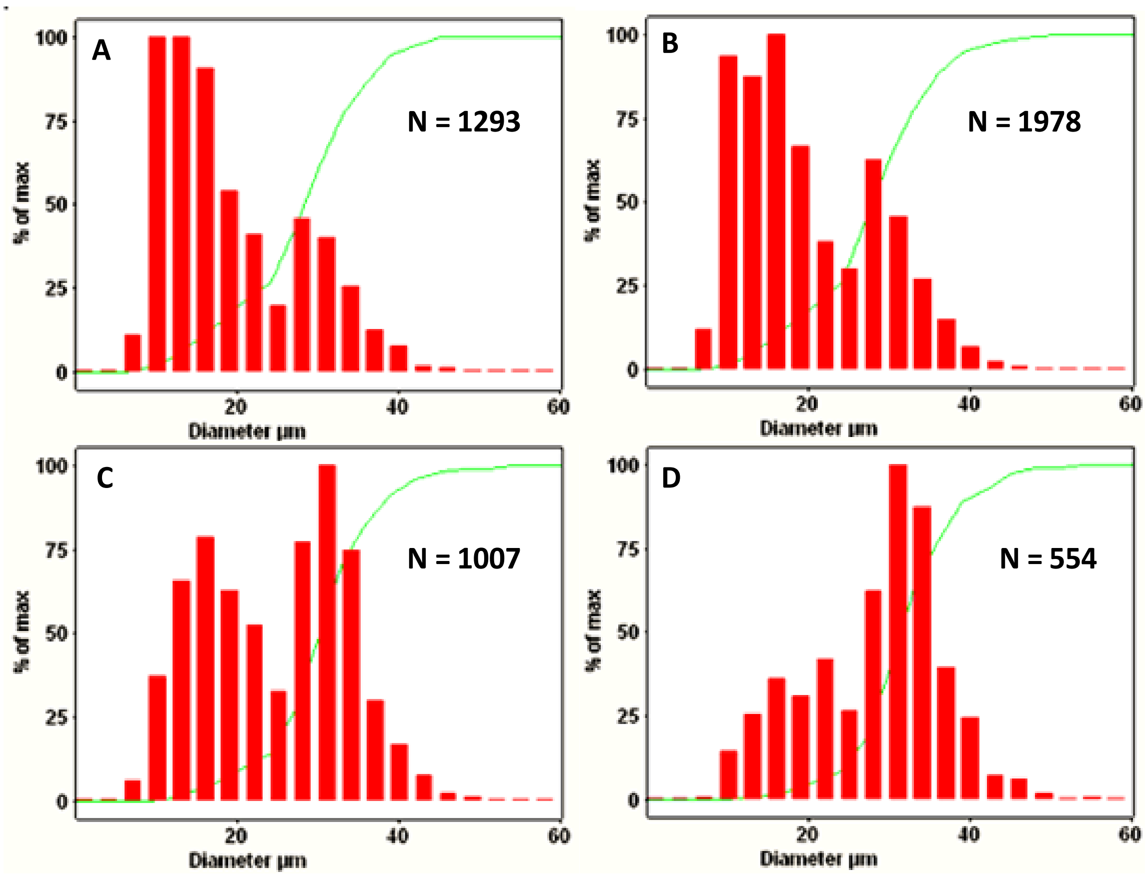


**Figure 2:** Typical normalized particle size distributions (PSD) at a distance of ten inches from the face of the bell. The PSDs were calculated from one hundred ~ 4000 µm x 3000 µm micrographs recorded at a distance of: A) 10% FW/2, B) 20% FW/2, C) 50% FW/2, and D) 80% FW/2 from the axis of the bell. The number of particles recorded (N) at each position is also indicated.

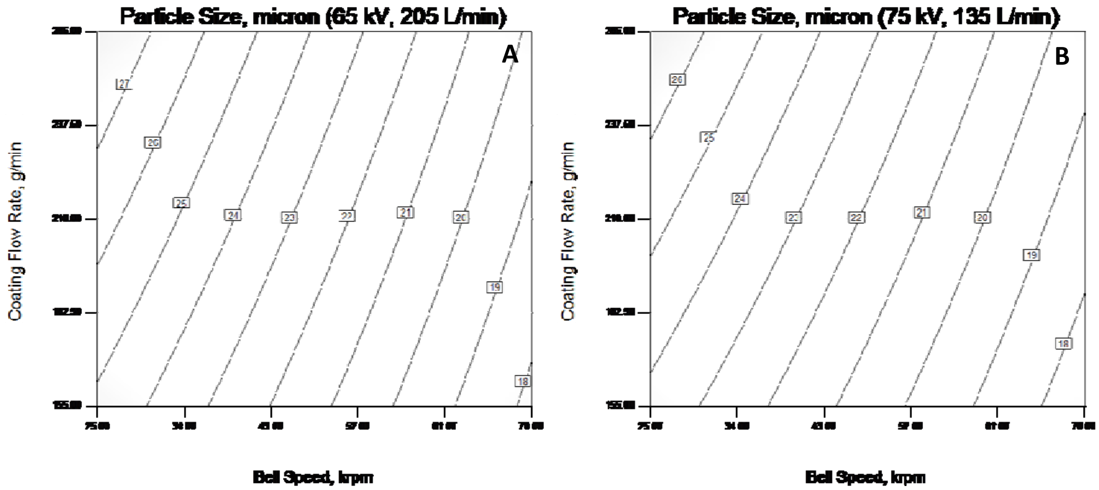


**Figure 3:** Mean particle size as a function of BS and CFR for A) low EP & high SAFR, and B) high EP and low SAFR. The particle sizes indicated on the top of the contours are the arithmetic mean of all particles recorded at 20% FW/2, 50% FW/2, and 80% FW/2.

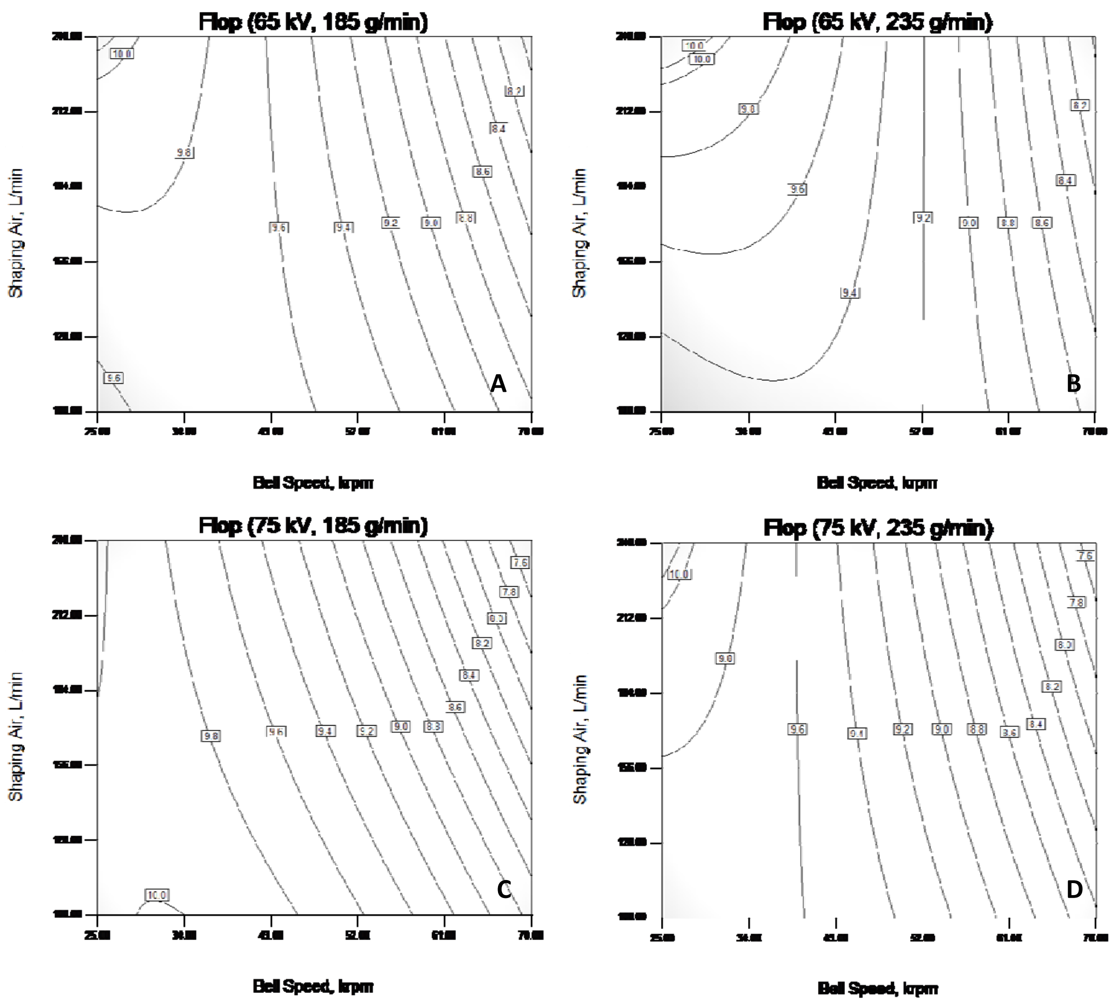


**Figure 4:** Appearance (flop) as a function of BS and SAFR: A) low kV & low CFR, B) low kV & high CFR, C) high kV & low CFR, and D) high kV & high CFR.

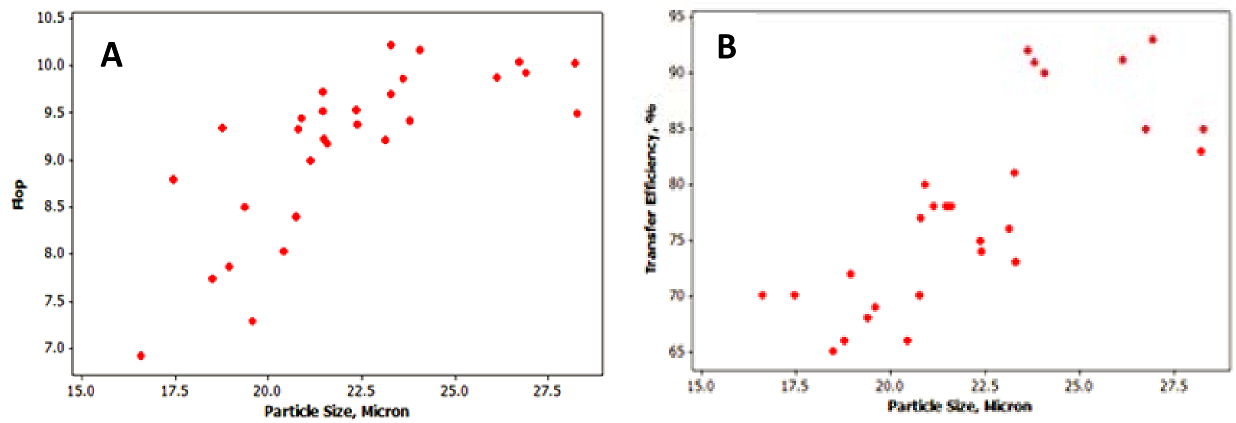


**Figure 5**: Effect of particle size on A) coatings appearance (flop), and C) transfer efficiency (percentage of the coating dispensed reaching substrate).

various fan widths (FW). The clear coat was applied at a 1.7 mil DFT in two identical passes. The particle size was measured by shadowography using an Image Pro X CCD camera, LaVision GmbH, Germany fitted with a Questar QM1 telescopic lens (Questar Corp. PA) with 20-60 inch focal length. The background illumination was provided by a NewWave Research (Fremont, CA) Solo Nd:YAG class 4 laser through a high efficiency diffuser. Image segmentation and particle size measurement were performed using LaVision DaVis 7.2 software. Color and flop were measured using an X-Rite model MA86II multi-angle spectrophotometer and surface smoothness was measured using a BYK-Gardner wave-scan. The particle size and appearance data were fitted to second order surfaces using Design Expert to produce contour plots.

## Results & Discussion

The particle size measured by shadowography (Figure 1) show that the particle size distribution and particle number density changes significantly across the FW (Figure 2). The bimodal distribution is likely generated by primary and secondary break-up of ligaments formed at the edge of the bell (Figure 1A). The mean particle size sampled uniformly across the FW decreases with increasing BS and increases with increasing CFR, while SAFR and EP have minor impacts on particle size. The data presented in Figure 4 show that for this coating system, increasing BS reduces flop in coatings with equal DFT. Increasing SAFR at low BS increases flop and at high BS decreases flop, while CFR and EP have minor effects on flop. The reduction in flop with increasing BS may be due to the fact that increasing BS reduces particle size (Figure 3), which, in turn, reduces transfer efficiency (Figure 5). Therefore, unless tip speed is reduced or overlap is increased (as done in this study) higher BS would result in lower DFT, which would be expected to improve flop at DFTs above that required for hiding. The data in Figures 4 and 5 suggests that as long as equal DFT is maintained any operating parameters (including higher BS) that generate bigger number average particle size would create higher flop.

## References

[1] Colbert, S.A.; Cairncross, R.A.; J. Electrostatics 64 (2006) 234-246.
[2] Im, K.S.; Lai, M.C.; Lui, Y.; Sankagiri, N.; Loch, T.; Nivi, H.; J. Fluids Engg. 123 (2001) 237-245.
[3] Domnick, J.; Scheibe, A.; Ye, Q.; Part. Part. Syst. Charact. 22 (2005) 141-150.