

Anti-Bearding Two-Fluid Spray Nozzle Design for Tablet Coating Applications

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Abstract

Two-fluid spray nozzles used in table coaters are prone to collect deposits on the nozzle exit orifice, this phenomenon is known as bearding. Bearding effects the droplet size distribution, which has a direct effect on the process quality and reproducibility. The purpose of this work is to develop and validate a two-fluid spray nozzle design that would eliminate the bearding problem.

Objective

Two-fluid spray nozzles are commonly used in tablet coating applications to provide a finely atomized spray, which adheres to the tumbling tablets to form a thin, uniform coating. In aqueous film coating, coating uniformity is critical. Slight changes in coating uniformity or thickness can cause adverse effects to product quality and potential for substandard product. Hence any discrepancies in coating uniformity must be quickly corrected. These corrections often require shutdowns and cause a loss of productivity and profitability. Two-fluid spray nozzles used in tablet coaters are prone to collect deposits on the nozzle exit orifice; this phenomenon is known as bearding. This build-up can block liquid and air orifices, resulting in a distorted spray distribution. Frequent cleaning is necessary to ensure coating quality (Figure 1).

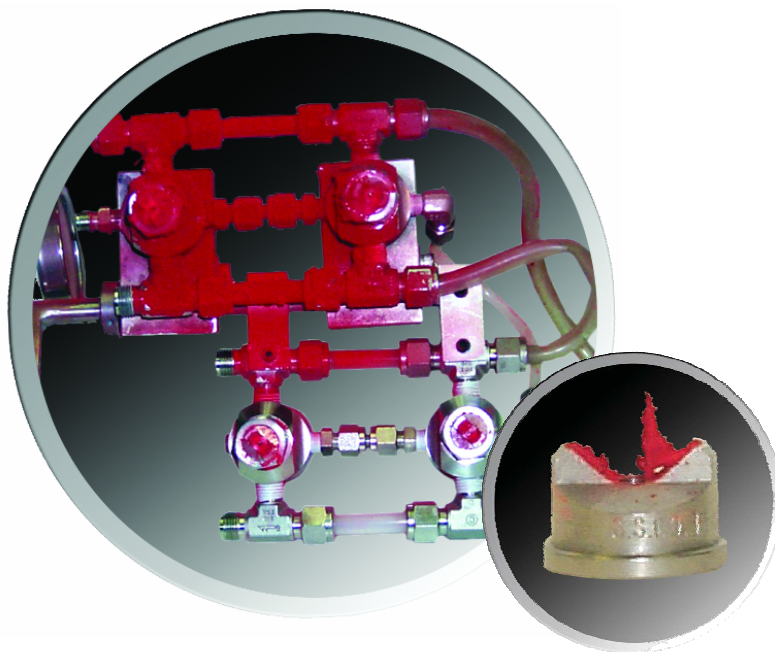


Figure 1 — Typical Bearding Effects

The purpose of this work is to develop and validate a two-fluid spray nozzle design that would eliminate bearding. By preventing this build-up and blockage, downtime and production costs would be greatly reduced.

General Requirements

- The nozzles must be able to operate in an atomizing air pressure range of 40 – 60 psi.
- The nozzles must be able to operate in a liquid flow rate range of 2 – 4 gph to comply with industry requirements.
- The nozzles must provide for a tight drop size distribution to maintain coating quality.
- The target drop size will be in the range of 40 – 80 μm . The drop size ensures the coating will adhere and dry in a sufficient amount of time.
- The nozzles should be able to operate for a span of one hour or more without need for maintenance.

Methodology

- Two types of nozzles were tested under laboratory conditions for comparison purposes.
- Drop size data was collected at a constant spray distance of six inches.
- The spray was traversed through the measurement area to provide a drop size average for the entire spray.
- All drop size testing was performed using a Malvern 2600 particle analyzer. A photo and schematic of the Malvern are shown in Figures 2 – 3.

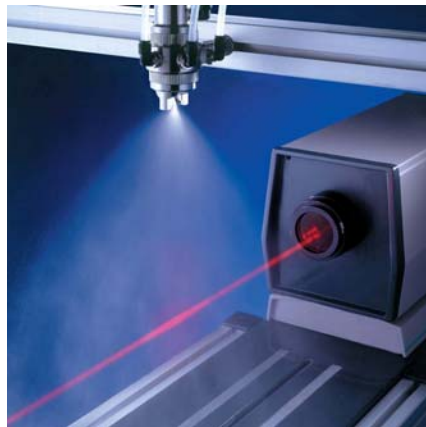


Figure 2 — Malvern 2600

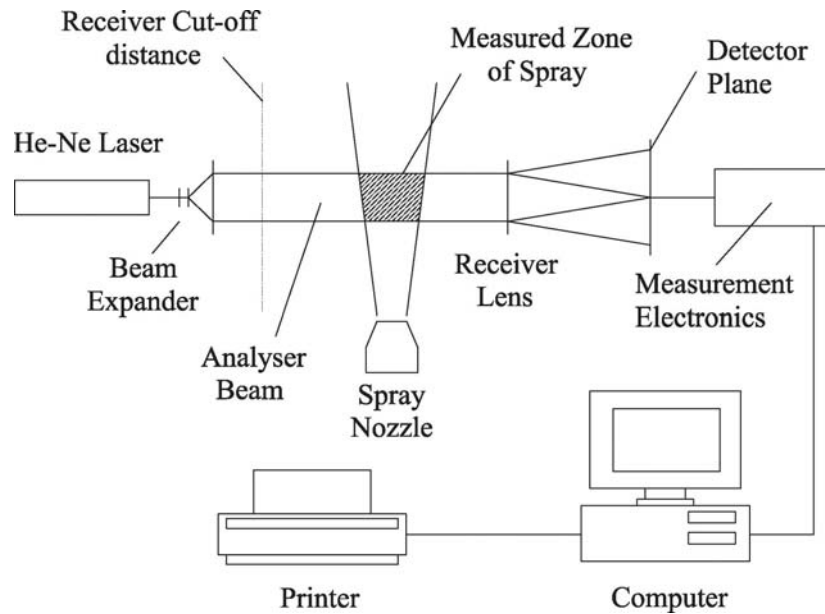


Figure 3 — Laser Diffraction Experiment

- Baseline testing was performed with water. All subsequent testing was performed using a 20% Opadry[®] II solution, from Colorcon[®].
- The $D_{V0.5}$ Volume Mean Diameter (also known as VMD), D_{32} Sauter Mean Diameter (also known as SMD), and $D_{V0.9}$ were used to evaluate drop size data.

Test Nozzles

A standard Spraying Systems Co. 1/8VAU-SS+113-SS air atomizing nozzle was evaluated for the baseline condition. This nozzle is an internal mix two-fluid atomizer. A photo of this nozzle is shown in Figure 4.



Figure 4 — 1/8VAU-SS+113-SS Air Atomizing Nozzle

A Spraying Systems Co. 1/8VAU-SS+113AB-SS air atomizing nozzle was evaluated for anti-bearding effectiveness. This nozzle has been developed to provide more desirable air currents, which eliminate small particle conglomeration at the nozzle orifice. A photo of this nozzle is shown in Figure 5.



Figure 5 — 1/8VAU-SS+113AB-SS Air Atomizing Nozzle

RESULTS

Flow Rate Testing

- The nozzle flow rate increased with an increase in liquid pressure (Figure 6).
- This trend is expected due to the increase in velocity of the liquid through the nozzle orifice caused by additional liquid pressure.
- Liquid flow rates of the standard nozzle are virtually identical to the flow rates of the anti-bearding nozzle.

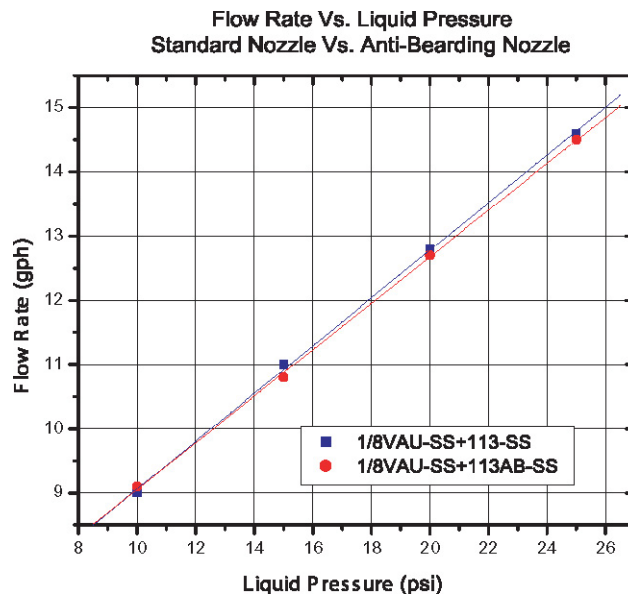


Figure 6

Effect of Liquid Flow Rate Pressure

- Drop size was shown to increase with an increase in liquid flow (Figure 7).
- This trend was observed for both nozzles tested. Drop size variance between the two nozzles was determined to be within instrumentation error.

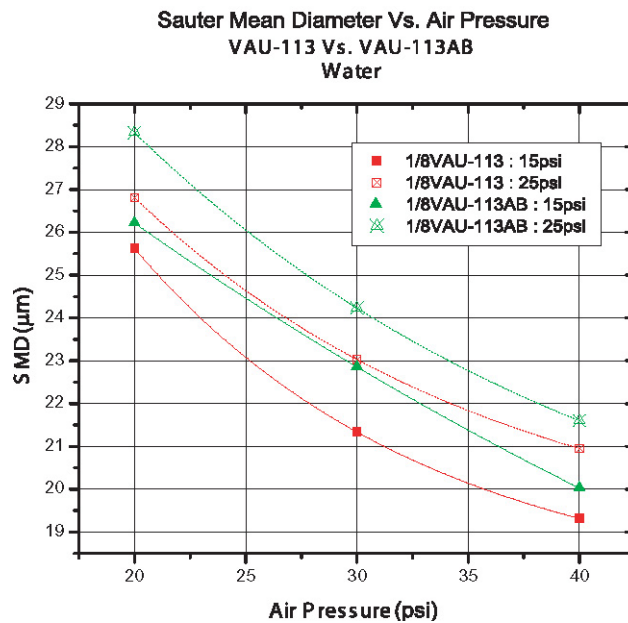


Figure 7

Effect of Air Atomizing Pressure

- Drop size was shown to decrease with an increase in atomizing air pressure at constant liquid flow (Figure 7).
- Additional air pressure results in a finer break-up of the fluid stream due to greater air velocity, thus reducing drop size.
- This trend was observed for both nozzles tested. Drop size variance between the two nozzles was determined to be within instrumentation error.

Effect of Liquid Viscosity

- Drop size was observed to increase with an increase in fluid viscosity (Figures 7 – 8).
- This trend is expected due to the increased resistance of the viscous fluid to atomization.

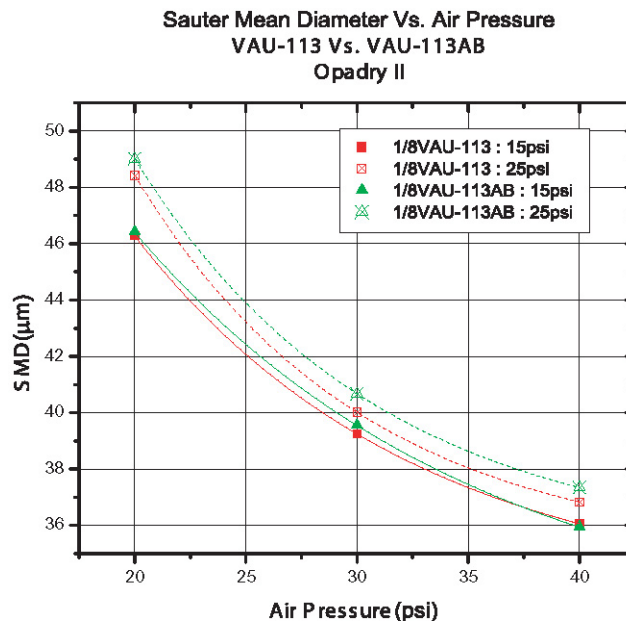


Figure 8

Laboratory Trial Observations

- Both nozzles were tested for 60 minutes to determine bearding rates (Figures 9 – 10).
- The VAU-SS+113AB-SS nozzle was perceived to have a lesser amount of bearding as compared to the VAU-SS+113-SS nozzle.
- The VAU-SS+113AB-SS nozzle has a protruding fan forming orifice, and an extended liquid orifice. By atomizing and forming the spray away from the face of the air cap the likelihood of build-up on the face of the air cap and around the atomizing air annulus is greatly reduced.



Figure 9 — 113AB air cap (forward, left) and 113 air cap (back, right) after 60 min. laboratory trial.



Fig. 10 — VAU-SS+113AB showing greatly reduced bearding after 1 hour during clinical trial.

Conclusion

An anti-bearding nozzle, 1/8VAU-SS+113AB-SS, was developed and validated in this work. The anti-bearding nozzle shows identical spray characteristics to the standard nozzle designs used in coating applications: liquid flow rates, air consumption, and drop size. Initial testing reveals that this new design is able to operate for over four hours with no signs of bearding.

This is a significant improvement over the current designs, which exhibit bearding after only 30 minutes. By alleviating bearding, this nozzle will reduce maintenance intervals and down time, increasing productivity and profitability.