

Optical Analysis of Flat Spray Nozzles used in Coating Applications



En'Urga Inc.

1291-A Cumberland Avenue, West Lafayette, IN 47906



765-497-3269



765-463-7004

<http://www.enurga.com>



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Abstract

One of the key requirements for assuring a uniform coating thickness is a good nozzle that has no streaks or voids, and provides a uniform pattern distribution. This presentation will focus on a method of optical patternation that can be used to ensure nozzle quality.



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Importance of Spray Uniformity

- Spray quality is a necessary determinant of finish quality, film thickness uniformity
- Avoid “fingers” and voids in the pattern
- Nozzle design and development
- Nozzle quality control
- Finding matched tips

Current Methods for Spray Uniformity

- Spraying onto a substrate
 - Analyze pattern after paint dries
- Capturing an image of the spray
 - Analyze photos/digital images of pattern
- Mechanical patternation
 - Measures flow rate in sectors of the pattern
- Visualization of spray pattern



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Disadvantages of Current Methods

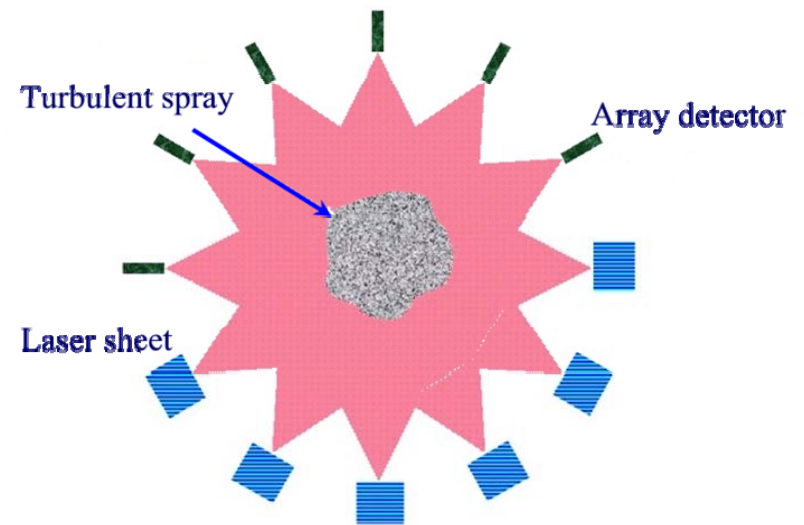
- Time consuming
- Labor intensive
- Limited spatial resolution
- Not suitable for on-line QC
- Digital imaging: 2-D used to measure a 3-D pattern
- Visualization: highly subjective



Statistical Extinction Tomography (SETScan®)

- Path integrated extinction of laser sheets
- Multiple view angles for non-axisymmetric turbulent flows
- Multiple slices to obtain high spatial resolution
- Local extinction coefficients obtained by statistical de-convolution

SETScan® Patternator



Interpretation of Extinction Coefficients

Extinction coefficient is equivalent to total surface area of all droplets within a specific volume (surface area/unit volume $\sim \text{mm}^{-1}$) when:

- Drop sizes $> 1 \mu$
- Obscuration > 0.005 and < 0.98
- Particles are spherical



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SETScan[®] Features

- Immune to environmental lighting
- Transient spray capture at speeds up to 10 KHz
- High accuracy (+/- 2%)
- High repeatability (+/- 5% on patternation number)
- Angular resolution up to 5 degrees
- Spatial resolution up to 0.25 mm
- Alignment of nozzle not critical
- Easily operated by technician



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Typical Measured Parameters

- Spray angle (major and minor for flat spray)
- Pattern displacement from nozzle center
- Horizontal integration (along the x-axis)
- Surface area distribution
 - Radial
 - Angular
- Color contour plot indicating absolute value of surface area per unit volume (mm^{-1})



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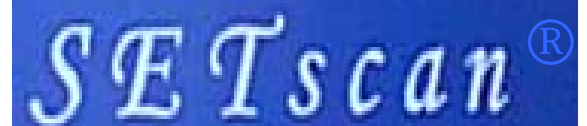
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Results

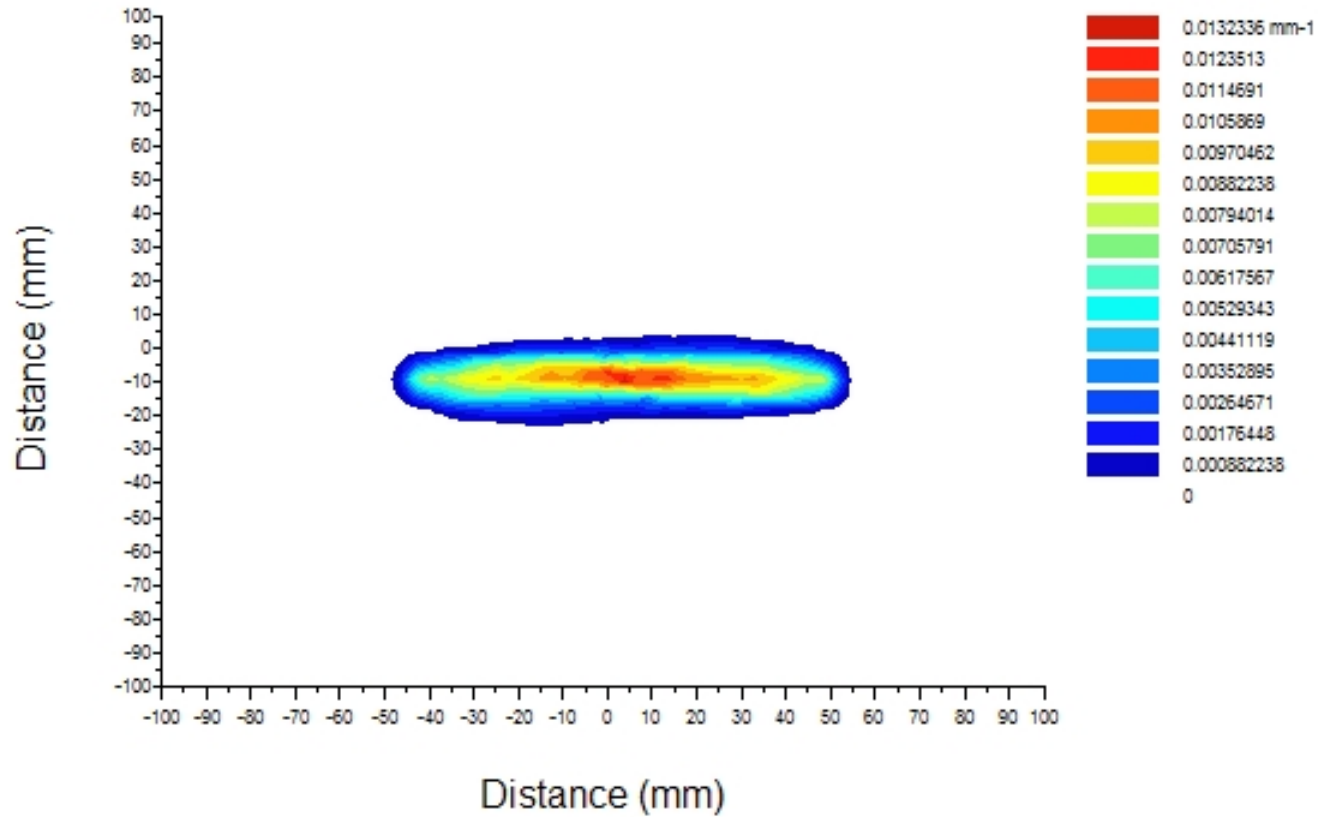


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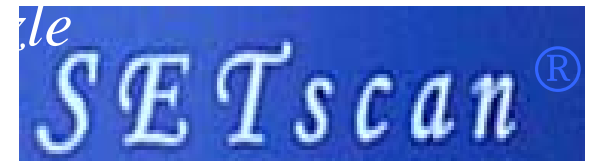


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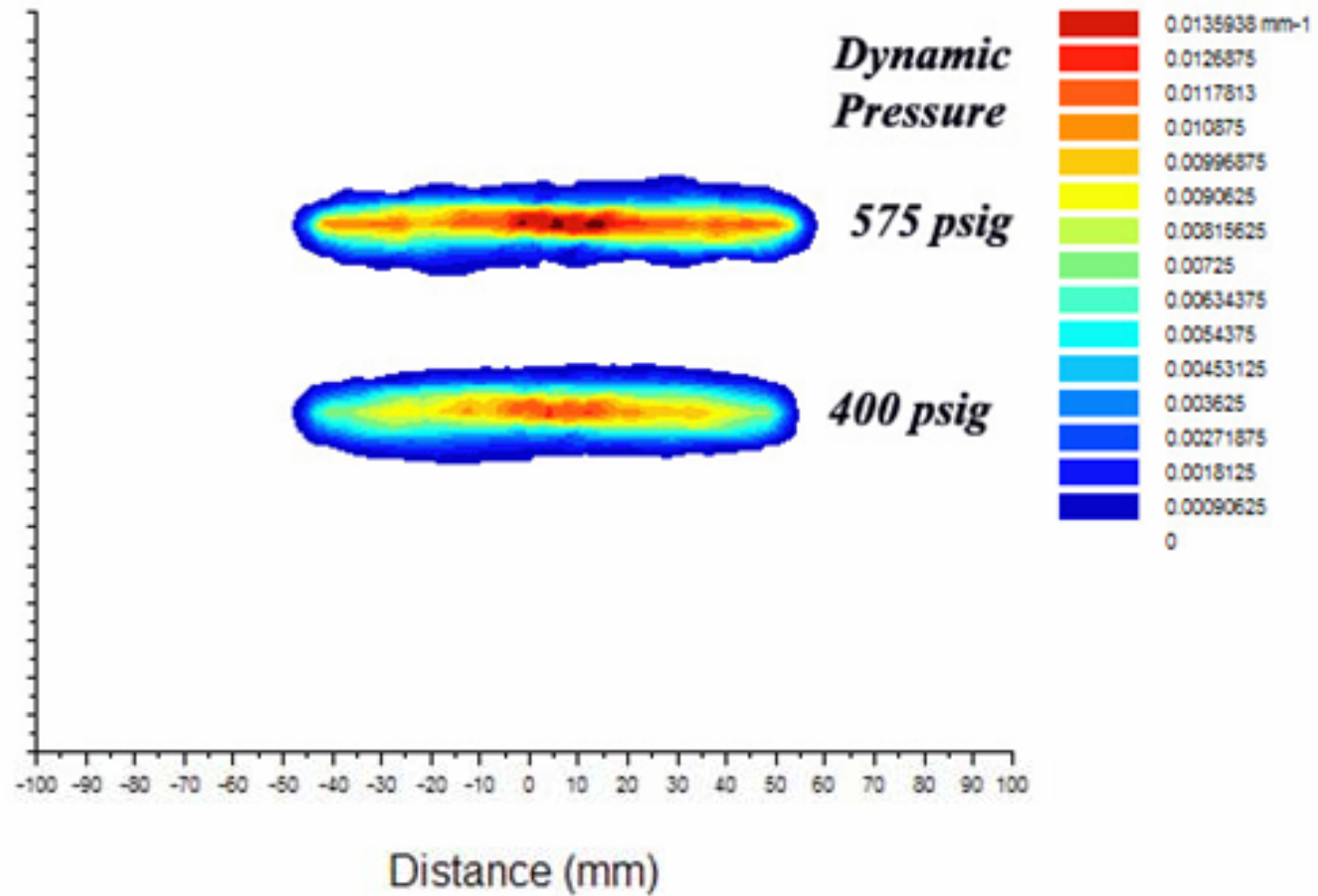
“Good” Flat Spray Nozzle



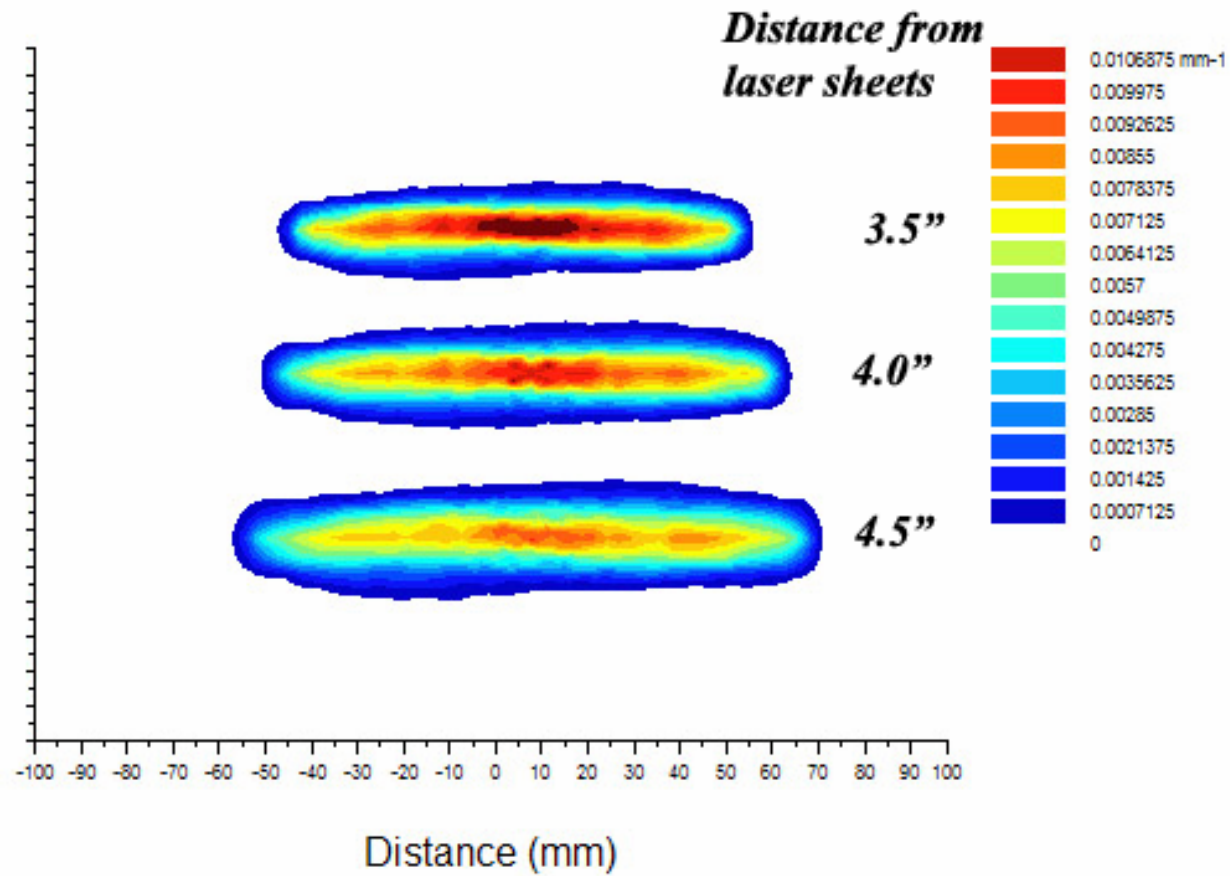
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“Good” Nozzle vs. Pressure



“Good” Flat Spray Nozzle vs. Distance

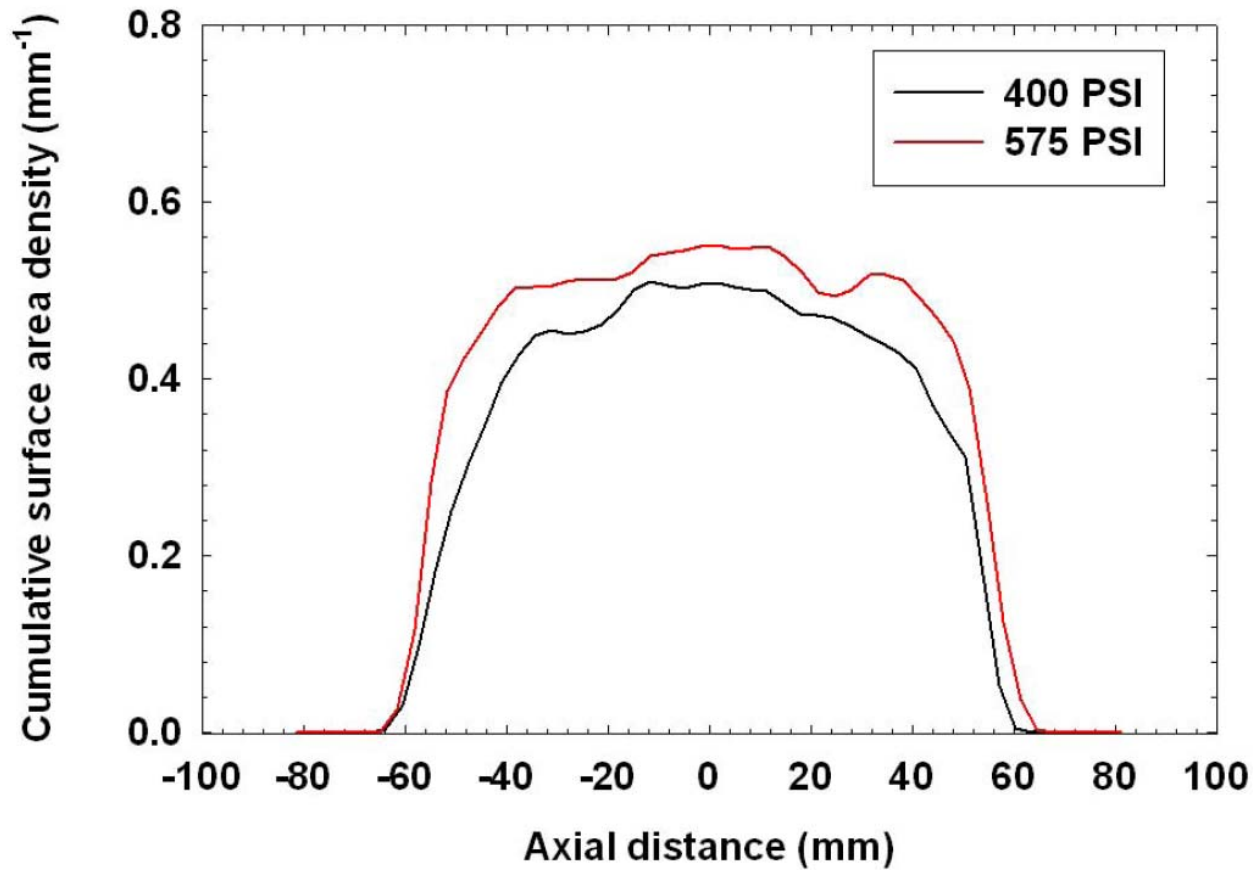


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Horizontal Integration



Spray Angles

<i>Nozzle</i>	<i>Major angle (degrees)</i>	<i>Minor angle (degrees)</i>
“Good”	56.25	17.53
“Worn”	58.03	18.29

Summary

- SETScan® Patternator can be used to quickly quantify the spray patterns using
 - Color contour plots of S.A./volume (mm^{-1})
 - Horizontal integration
 - Spray angles
 - Patternation number
 - Angular or radial surface area/volume distributions

