SIZE SHAPE ANALYSIS FOR MEASURING DUST DYNAMICS AND PARTICLE SIZE

APPLICATION NOTE SSA-002 (A4)

Non-Invasive Particle Sizing through Imaging

Real-time measurement systems can be used for many particle sizing applications, but certain applications may require other methods in order to obtain an accurate reading. For example, when looking at re-suspension of particles for filter tests transport loss of micron and supermicrometer particles in the sampling instrument can lead to errors when determining the size fractional efficiency (ISO/TS 19713:2010; Tsai and Pui, 1990). For applications such as this, a non-invasive method for evaluating the size distribution should be applied. The TSI non-invasive imaging technique of Size and Shape Analysis (SSA) can be used for this application. For this experiment, the SSA system was tested in order to determine the suitability of this technique for sizing particles on the order of several microns in size.

Size Shape Analysis (SSA)

In the current experiment, NIST traceable particles of nominal size 2 microns and 4 microns were aerosolized, sent through a nebulizer, a neutralizer, and a dryer before being expelled through a jet into the measurement region of the SSA system. A pulsed Nd:YAG laser light source was used to illuminate a background diffuser. The particles of interest were between the TSI 8MP CCD camera and the background and the images obtained by the cameras consisted of the “shadows” of the particles. A specialized microscope lens was used on the camera which gave a magnification of 14x. An image of the SSA setup used in this application can be seen in fig. 1.

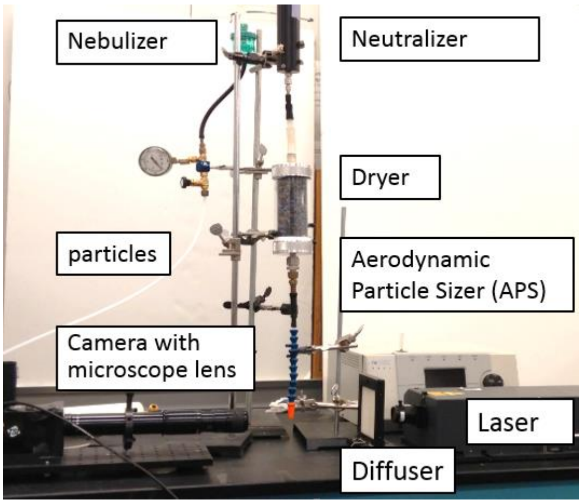

Fig. 1. Experimental setup

The particle size of the 2 micron particles was ~5 to 6 pixels in diameter, and the magnification was such that each pixel equated to 0.32 microns.

Results

TSI's Insight 4G™ software was used to analyze the images and the results were compared to the NIST-stated size. A table of the results for this experimental setup can be seen in fig. 2. As the table illustrates, the size as measured by SSA tended to be larger than the actual size of the PSL particles. For the 1 micron particles, the SSA-measured size was approximtely 53% higher; for the 2 micron particles, it was 28.9% higher; for the 4 micron particles, the SSA-measured size was 19.5% larger; and for the 30 micron particles, the SSA measurements were 3.1% higher.

NIST Traceable PSL	Measured By SSA	Difference
1.0 µm	**1.53 µm**	**53.0%**
1.97 µm	**2.54 µm**	**28.9%**
4.0 µm	**4.78 µm**	**19.5%**
30 µm	**30.9 µm**	**3.1%**

Fig. 2. The PSL particle size as measured by SSA, showing the difference in measured vs. actual size

For larger-sized particles, the percent difference decreases as the number of pixels per particle increases. The plot in fig. 3 shows the decrease in percent difference as the particle diameter increases.

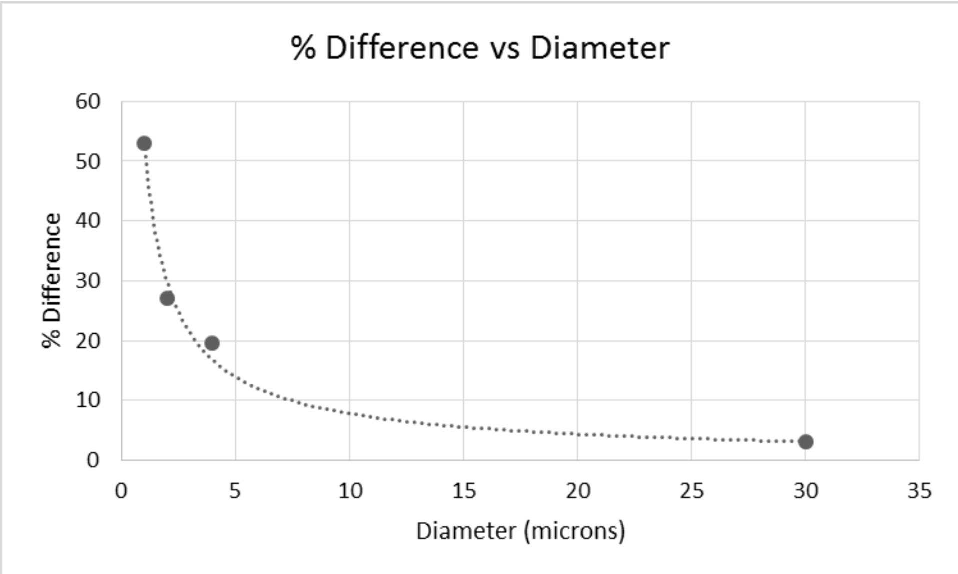

Fig. 3. Plot showing the percent difference in measured vs. actual diameter

The SSA technique was also used to investigate the particle size distribution for ISO 5011 dust injectors using A2-grade dusts. A raw image can be seen on the left side of fig. 4, and a size histogram can be seen on the right.

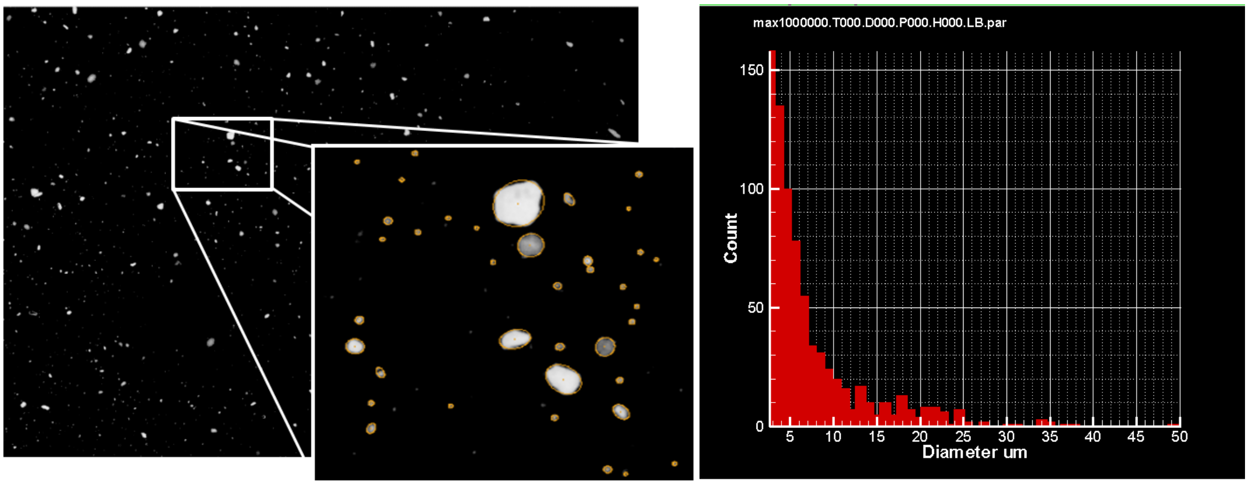

Fig. 4. *Left*, Sample image, (*inset*) zoomed in region showing the identified particles circled in orange. *Right*, a particle diameter histogram of the dust particles.

Summary

This application note has covered size measurements of particles in the range of 1 to 30 microns. SSA worked well for both spherical and irregularly-shaped particles. For a magnification of 14x, NIST traceable particles were measured and at 1 microns the SSA measurement uncertainty was 53%, and decreased to 3.1% for 30 micron particles.

References:

For more information and examples of these techniques being applied, please refer to the following publications:

Kang S, Chen S-C, Lai WT, Pui DYH (2015) "Investigation of dust dynamics using imaging techniques," *34th Annual American Association for Aerosol Research (AAAR), Oct. 12-16, 2015.*

ISO/TS 19713 (2010). Road vehicles — Inlet air cleaning equipment for internal combustion engines and compressors.

Tsai CJ, Pui DYH (1990) Numerical study of particle deposition in bends of a circular cross-section – laminar flow regime. *Aerosol Sci. Technol.,* **12:** 813-831.

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USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 1 41 19 21 99	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

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