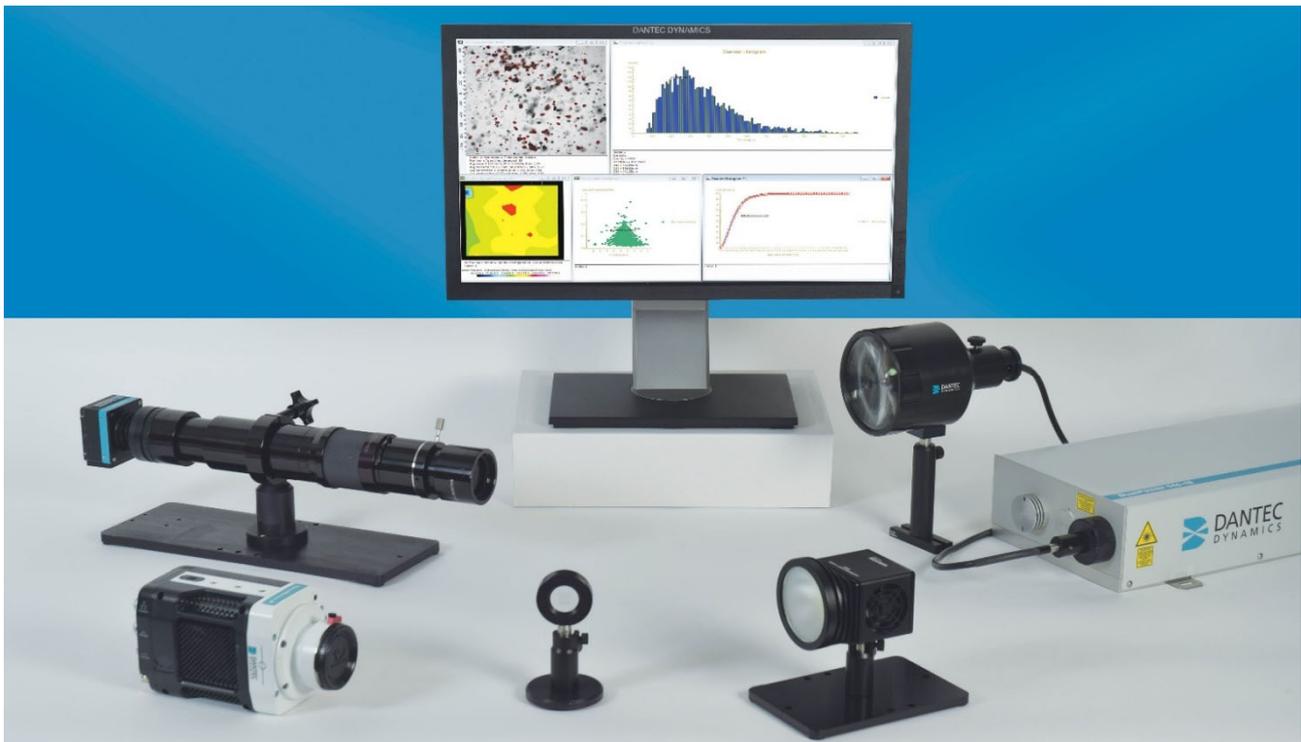DANTEC DYNAMICS

ShadowSizer system

Solution for characterization of particle size, velocity, shape, and more

For a wide range of particle sizing applications

The measurement of size and velocity is required for the complete understanding of multiphase phenomena which include sprays, solid particles in air or liquids, and bubbly flows with or without solid particles. Many multiphase applications benefit from being able to obtain information over an area rather than just a point in space to find spatial as well as temporally resolved results.

The ShadowSizer measurement solution is ideal for understanding complex multiphase flow processes such as spray break up, bubble growth, condensation, spatial particle size distributions, and size/velocity correlation. The ShadowSizer system is a complete solution that can directly measure the particle size, velocity and shape based on shadow imaging so there is no need to have spherical particles or information about the composition to obtain accurate results.

Key benefits
- Wide range of applications: droplets, bubbles, solid particles – static or in flows
- Instantaneous measurement of region in space at low or high frequencies
- No prerequisite information about the particles is required
- Intuitive and easy to setup and use - what you see is what you get
- Particle size range down to 5 µm

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Easy to use shadow sizing measurement solution

The ShadowSizer solution for mapping of size, velocity and shape in two-phase flow processes is very much "what you see, is what you get". Therefore, the system is very easy to operate – in fact, just as simple as taking a picture. The solution consists of an application specific camera and a backlighting source such as LED, or strobe with laser light. That together with a PC and our DynamicStudio software enables both image acquisition and analysis within same platform. For the camera, two different long distance microscopes are offered, both of which are coupled with various objectives to satisfy different applications.
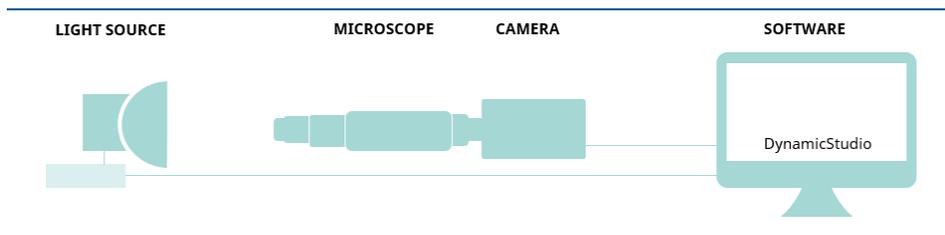
System setup including light source, camera with long distance microscope, software and electronics

Working principle

A light source is used to back illuminate an object and a camera acquires the shadow image. For a particle flow, a short light flash and accurate synchronization device are used to freeze the particle motion. The image is analyzed with an advanced segmentation algorithm to extract particles' size and shape information. The velocity information is extracted via a dedicated particle-tracking algorithm.

The solution in brief

The system includes a high resolution CCD or CMOS camera, long range microscope lens, light source, calibration target, and software. The solution can be configured by selecting various cameras, optics (camera lens) and illumination devices to fit your application in the best possible way in terms of matching the measurement range of flow velocity, measurement area and particle size.

Light source

Two different light sources are offered – an LED backlight illumination unit or a ShadowStrobe – for illuminating the measurement object from back side. Both light sources are speckle free, able to provide a very uniform and bright background, and are easy to control through the software.

LED backlight Illumination Unit

- High intensity, non-coherent
- Both pulsed and continuous illumination
- Pulse duration as short as 2 µs and it can operate with repetition rates up to 100 KHz
- Compact, simple connection and space saving
- Cost effective

ShadowStrobe optics

- The optics are used with lasers and coupled via a flexible liquid light guide
- Wide choice of lasers available with various power output and repetition rate
- Required for high speed sprays or flows up to several hundred meters per second
- Variable illumination area by means of focus adjustment

LED Backlight Unit with diffuser to ensure uniform illumination

ShadowStrobe light source with a liquid light guide

Camera

A wide range of CCD and CMOS cameras is available to meet your application requirements. The FlowSense EO CCD cameras are cost effective while still maintaining very low noise level, while the SpeedSense series of CMOS cameras are able to address applications requiring high frame rate up to twenty thousand images per second.

Please consult separate data sheets on our FlowSense/HiSense cameras and SpeedSense cameras.

SpeedSense and FlowSense EO cameras

Long Distance Microscopes

A long distance microscope is needed to measure small particles at relatively long working distances, to avoid contamination from the measurement object (e.g., a spray) to the camera. Two types of long distance microscopes are offered to obtain the high image magnification required. Each of them can be coupled by different objectives, to achieve various magnifications.

The Type I is very easy to handle, and it has an adjustable aperture. In addition, its diffraction-limited field is as large as 43 mm (diagonal), which make it adaptable to all image sensor formats. The Type Q offers higher magnification, required for measurement of smaller particles with less field of view.

Long Distance Microscope – Type I

- Max. Magnification ratio : ~2.2
- Objectives: 2
- Features: Easy handling; adjustable aperture; adaptable to all image sensor format

Long Distance Microscope – Type Q

- Max. Magnification ratio : ~12.5
- Objectives: 4 (can be via various combinations)
- Features: Large magnification ratio; multiple options of objectives

Both types of long distance microscopes are delivered together with a dedicated scale calibration target. Mounting units for the long distance microscope, camera and

Long distance microscope, Type I and Type Q

illuminations are also included. In general, the selection of the correct microscope depends on the minimum particle size to be resolved. As a rule of thumb, at least 4 pixels in the image is needed to resolve one particle. As an example, if the pixel size of the camera is 5 µm and the magnification ratio is 1.5, the minimum droplet/particle size can be resolved as 5 x 4 / 1.5 ≈ 13 µm. For a quick overview of measurement range depending on camera, long distance microscope and light source, please see table below.

		FlowSense EO 4M		SpeedSense M320	
		LDM Type I	LDM Type Q	LDM Type I	LDM Type Q
FOV (mm x mm)	LED	6.8 mm x 6.8 mm	3.2 mm x 3.2 mm	8.7 mm x 5.5 mm	3.2 mm x 2.0mm
	Laser				
Min. size (µm)	LED	13.5 µm	5 µm	18.2 µm	8.3 µm
	Laser				
Max. velocity (m/s)	LED	< 10 m/s		< 10 m/s	
	Laser	< 200 m/s		< 200 m/s	

Measurement range – for various hardware combinations. The FOV and Minimum Size are calculated based on the maximum magnification of the Long Distance Microscope. The maximum velocity is calculated based on particle with 200µm – lower maximum velocity must be expected for smaller particles.

Software

The ShadowSizer software is an add-on to DynamicStudio, the innovative, flexible and easy to use software platform for imaging-based measurements. The hardware configuration is easy thanks to the use of plug and play devices and dynamic wizards. The software platform assists you throughout the entire process from setting up the system, through data acquisition, processing and presentation.

Image analysis and data processing

The acquired images containing particle shadows reveal geometric information for each particle. An advanced and robust edge detector ensures that the correct geometry and size is measured. For each detected particle the following parameters are measured:

- Position
- Velocity vectors
- Shape factor
- Area
- Eccentricity
- Equivalent diameter
- Perimeter
- Equivalent volume
- Major/minor axis length
- Orientation
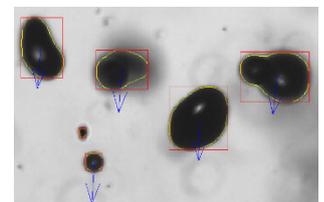
Droplets in water spray with velocity vectors and boundaries

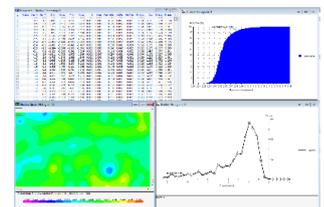*Spatial distribution, cumulative histogram and table for data analysis*

Particle velocity is determined using the particle displacement information between two successive images. The results are computed by using our Particle Tracking Velocity (PTV) algorithm.

ShadowSizing images need to have high SNR and high contrast for best results. To this end, DynamicStudio has an extensive image processing library (IPL) that can be used to pre-process the images such that quality results can be obtained in the sizing analysis section of the software. The ShadowSizing software includes statistical analysis as well as graphical displays in the form of histograms and spatial distribution plots. The data can be exported in several formats or used with our MatLab(R) link for further user defined analysis needs.

Ordering information

The typical components for the ShadowSizer solution are listed here. For additional information on other relevant cameras, lasers etc., please contact your local Dantec Dynamics representative.

Category	Item	Item no.
Light source	LED Back Illumination Unit	9080X7303
	DualPower 65-15 Laser 2 x 65 mJ at 15 Hz, 532 nm	9138A7533
	DualPower 15-1000 Laser 2 x 15 mJ at 1000 Hz, 527 nm	9138A7511
	ShadowStrobe Optics for laser beam diameter <4 mm	9065X0551
	ShadowStrobe Optics for laser beam diameter 4-6.5 mm	9065X0561
	Liquid Light Guide, max. 4 mm beam	9080M1351
	Liquid Light Guide, max. 6.5 mm beam	9080M1361
Camera	FlowSense EO 4M-32 2048 x 2048 px, 32 fps	9081C0141
	SpeedSense Lab 310 camera 1MP 3260 fps, 12GB	9084C5031
	Spacer Kit for SpeedSense Lab-series and TR ShadowSizer	9081X0101
Microscope	Long Distance Microscope, type I, incl. Calibration unit and Mounting unit	9081X0111
	Long Distance Microscope, type Q, incl. Calibration unit and Mounting unit	9081X0121
Software	DynamicStudio base Package	9080S0571
	Dynamic Studio ShadowSizer Add-on	9080S0481
Electronics	Timing Hub 8 Outputs, 2 Inputs USB	9080N0481
	Performance Imaging PC for a 1-Cam imaging system	9081N0021

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