There are many reasons for better nozzle technology

Droplet Size Analysis of Sprays

SO THAT THERE'S NO
WE WORK WITH STAT

The technological development of nozzles benefits spray applications through the nozzle performance itself, improved work processes, optimized product quality, and reduced production costs.

Lechler is one of the world's leading companies in the spray technology field. During more than 130 years since the company was founded, we have gained unsurpassed know-how to give you tangible advantages as a user.

Let Lechler be your partner in developing quality and economical spray applications.

To aid us in maintaining this leading position, our experts are constantly researching new technical solutions along with developing and producing nozzles and spray systems for practically all sectors of industry, environmental technology, and agriculture.

We achieve this through state-of-the-art development and production processes and on the very best in high technology. Here we will introduce a field of work from this subject area and illustrate possibilities as to how you can use the results for your own work.

If you have any further questions, we are at your service to provide technical assistance.

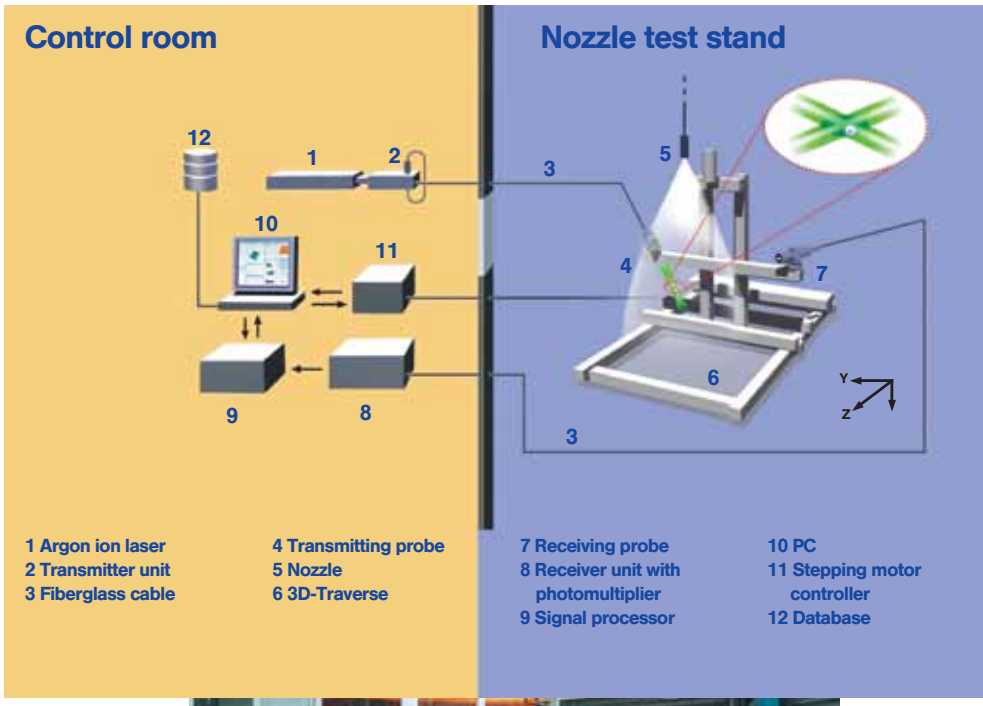
Data and facts that you can rely on.

There are many reasons for our products' success. One very important reason is that we can make accurate statements about the spray characteristics of a nozzle based on precise measurements.

This ability provides reliable data for development and makes evaluation easier for you with regard to fulfilling the specific spray requirements of your particular application even before the nozzles have been integrated into your system. This saves time, reduces costs, and provides planning security.

Droplet size information is very important for certain applications. Obtaining it requires a lot of know-how and refined technology. The Phase Doppler Anemometer (PDA) is one of the most modern optical measurement systems in this field.

It performs non-intrusive and simultaneous measurement of the velocity and diameter of spherical droplets. Using the PDA as an example, we would like to illustrate for you our technical expertise and the associated advantages offered for you.



1 Argon ion laser
2 Transmitter unit
3 Fiberglass cable
4 Transmitting probe
5 Nozzle
6 3D-Traverse
7 Receiving probe
8 Receiver unit with photomultiplier
9 Signal processor
10 PC
11 Stepping motor controller
12 Database

The measuring laboratory with the Phase Doppler Anemometer provides valuable data for practical use of our nozzles.

RISK TO YOU,
E-OF-THE ART TECHNOLOGY.

The optics and the argon ion laser form the core of the measuring system.

The multiline laser beam is manipulated by a beam splitter and color separator which creates two pairs of monochromatic coherent laser beams. Those beams are sent to a transmitting probe via mono-mode glass fibers. All four beams converge on the probe's focal point and thereby form the measurement volume. When a droplet passes the measuring volume, it sends scattered light into the entire room. This scattered light is captured by the receiver probe. The device only counts particles that really have passed the measurement volume.

The optical signals are transmitted to the receiver unit via fiberglass lines. There they are transformed to electric signals by photomultipliers and sent to the processor for further processing. In the signal processor, the information is converted into velocity and diameter values and is then plotted as a measurement result in realtime on the PC. This produces a representative spray analysis from a large number of measurement results. Individual positions in the spray are scanned successively in a three-dimensional traverse movement. With the use of a fully-automated controller, the measurement processes can be optimally reproduced because the pattern can be repeated at all times under the same conditions. The measurement results are saved in a database.

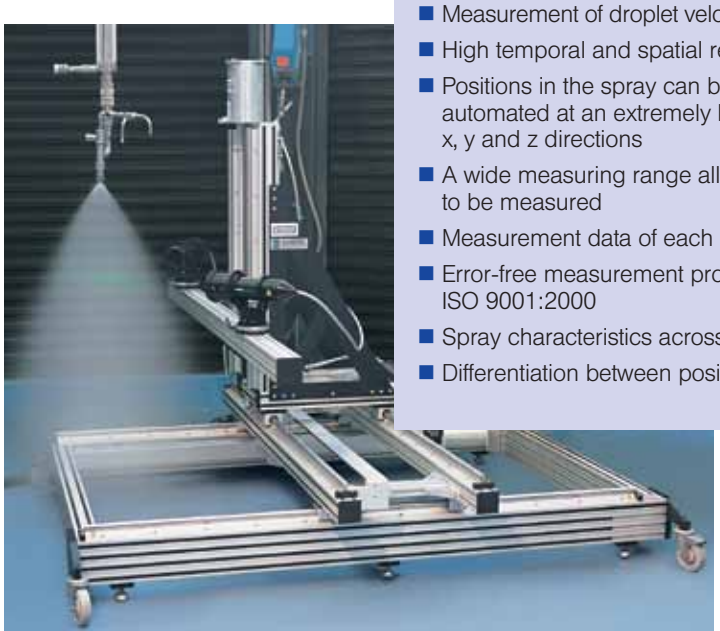
The advantages of this measurement method:

Various measuring processes are known for droplet analysis; for example, laser diffraction spectroscopy or particle image velocimetry (IPI, shadowgraphy).

One advantage of the PDA is that it can simultaneously determine droplet size and velocity over a wide measuring range even with a high spraying density. A second advantage is the fact that the measuring process is absolute; in other words, it does not have to be calibrated. The signal is evaluated independently of the light intensity. Measuring errors resulting from beam attenuation or beam deflection do not occur with this method. Thanks to the extremely wide measuring range, sprays with broad droplet size and velocity spectra can also be measured reliably.

The PDA advantages at a glance

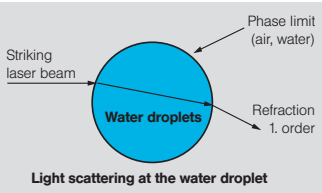
- Precise and reproducible measurement of the droplet size and velocity in sprays
- Measurement of the entire spray, or local positions within the spray
- Documentation of the spectrums for both particle size distribution and velocity
- Determining the Sauter mean diameter as well as many other process-related variables
- Measurement of even very dense sprays is possible thanks to state-of-the-art laser technology
- Measurement of even very small droplets in the µm range is possible—as is recording very large droplets of up to 8 mm
- Measurement of droplet velocities up to 200 m/s
- High temporal and spatial resolution
- Positions in the spray can be positioned and measured fully automated at an extremely high accuracy—in 3D and in the x, y and z directions
- A wide measuring range allows even broad particle spectrums to be measured
- Measurement data of each individual droplet is recorded
- Error-free measurement process in accordance with ISO 9001:2000
- Spray characteristics across range recorded three-dimensionally
- Differentiation between positive and negative velocity components



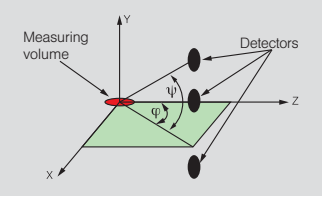
Within the spray, individual positions are scanned by the three-dimensional traverse movement.

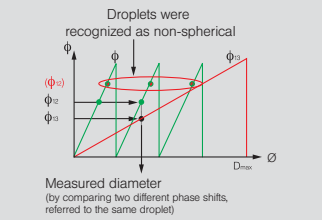
Precision right from the start

Only with much experience, understanding, and wide-ranging knowledge can the measurement results be correctly interpreted and evaluated. But when they are, they form an excellent basis for creating valuable results.



Light scattering at the water droplet





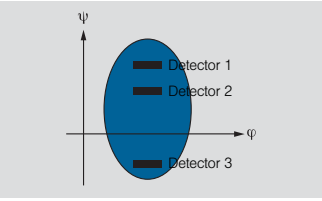
Droplet size measurement

When a droplet passes the measuring volume, light of first, second, third and higher orders is scattered. To determine the droplet size and its velocity, a configuration is selected in which the scattered light in first order refraction is dominant. The light refracted on the droplet falls into the receiving probe and is registered by three photo-detectors.

Due to the arrangement of the photo-detectors in the receiving probe, the beam path of the scattered light is not identical, with the result that a phase shift can be observed on the basis of each wavelength. This phase shift is closely related to the diameter of the droplet.

$$\Phi = \frac{-2\pi d_p}{\lambda} \frac{n_{rel} \sin\theta \sin\psi}{\sqrt{2(1+\cos\theta\cos\varphi\cos\psi)(1+n_{rel}^2 - n_{rel}\sqrt{2(1+\cos\theta\cos\varphi\cos\psi)})}}$$

d_p = droplet diameter
n_{rel} = refraction index
l = wavelength of the laser beams



The optimized arrangement of the photo-detectors allows the measurement of a very wide droplet size spectrum and ensures that the measurement results are unambiguous.

Profit from our competence in this specialist field and from the technical possibilities we offer. Simply outline your task for us and we'll find the optimum solution for you.

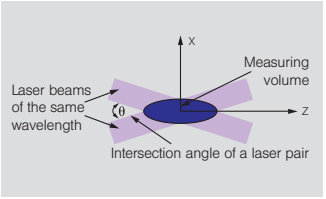
Droplet velocity measurement

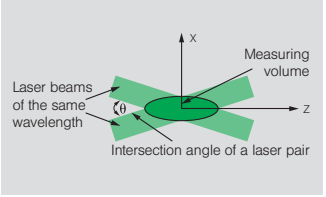
Determining the droplet velocity is based on the Doppler effect. This occurs when the receiver and transmitter move relative to each other.

Since the droplets are in motion, the detectors receive a light wave that is shifted by a certain frequency of the original light of a laser beam pair. The frequency shift thus determined is proportional to the velocity vector and can therefore be determined directly.

$$f_D = \frac{2U_x}{\lambda} \sin\theta/2$$

Two pairs of laser beams with the wavelengths 514.5 nm (green) and 488.0 nm (blue) arranged orthogonally with respect to each other guarantee maximum accuracy and recording of the vectorial velocity in the respective measurement plane.





Measurement results

A measurement result is obtained from a large number of individual droplets, the sizes and velocity values of which are determined for each droplet. A spray is categorized by evaluating and depicting droplets in spectrums. Characteristic values are formed from this which can be used for further process-related calculations:

d_{32} a.k.a. Sauter mean diameter: The Sauter mean diameter is of great interest, particularly in process engineering and generally with regard to absorption or cooling processes because it provides information about the available substance transfer interface between two phases.

$$d_{32} = \frac{\sum ni \bullet Di^3}{\sum ni \bullet Di^2}$$

ni = number of droplets
Di = droplet diameter

DV_{50}: 50 % of the atomized water volume consists of droplets smaller than or equal to the value of DV_{50}.

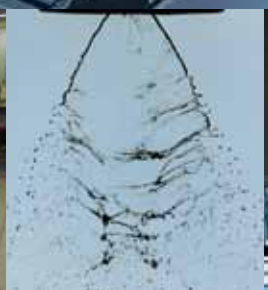
DV_{98}: 98 % of the atomized water volume consists of droplets smaller than or equal to the value of DV_{98}. This characteristic variable is relevant when the maximum droplet size occurring in the spectrum is crucial for process engineering.

Data analysis can provide many possible outcomes. For instance, droplet sizes and diameters can be combined in diagrams, thereby providing valuable information.

With state-of-the-art technology, we cover the whole range of measurement tasks:

- Liquid flow rate
- Spray angle
- Spray pattern
- Air flow rate measurement
- Droplet size measurement
- Droplet velocity measurement
- 3D-Spray impact measurement
- Liquid distribution
- Spray videos
- Sound level measurement

Complex technologies and detailed documentation provide reliable data for construction, production, and practical use. You can count on Lechler for this.



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