Theoretical Basics

1. Droplet size - Definition

Size and contribution of droplets are determining factors for spray quality (degree of atomization and efficiency). It is especially important to have the proper understanding of droplet size specifications when it comes to critical applications such as gas cooling, treatment of hazardous chemicals, gas washing, spray-drying, combustion, and dust suppression.

Droplet size is given in microns 1µm = 0.001 mm.

Sauter Mean Diameter (D 3.2) - Its ratio of volume to the surface area is equal to that of the entire jet. It is a very accurate tool when it comes to determining ratios of evaporation, reaction, or combustion processes.

Volume Median Diameter (D 3.0) - Its volume, multiplied with the number of droplets, equals the volume of the entire jet.

Mass Median Diameter (D 0.5) - It divides the jet into two equally sized parts.

Droplet size in µm (Sauter Ø D 3.2) for unary nozzles

	Liquid pressure p					
	1 bar		2 bar		5 bar	
Unary nozzles	V̇ (l/min.)	D 3.2 µm	V̇ (l./min)	D 3.2 µm	V̇ (l/min.)	D 3.2 µm
Axial-flow			0.1	140	0.17	100
Hollow cone			1	240	1.6	180
Eccentric			1	320	1.6	240
Hollow cone	1.8	700	25	640	40	490
Full cone	0.7	540	1	400	1.6	300
	18	1,300	25	1,100	40	750
Bundle nozzle	0.9	200	1.25	175	2	150
	20	400	28	265	44	190
Flat fan	0.7	400	1	360	1.6	300
	18	1,200	25	1,000	4.0	690

Illu. 1

Droplet size in µm (Sauter Ø D 3.2) for binary nozzles

Binary nozzles or air atomizer	Air/water ratio (m³/h:l/min)					
	5		10		20	
	V̇ (l/min)	D 3.2 µm	V̇ (l/min)	D 3.2 µm	V̇ (l/min)	D 3.2 µm
Others	varies	90	varies	55	varies	40

Illu. 2

Atomization of 1l of water results in

for droplets of	a surface of
110 µm	5 .45 m²
30 µm	20.30 m²
12 µm	50.20 m²

Illu. 3

2. Nozzle wear

Spray volume and quality decrease
according to the nozzle orifice geometry's wear.
For flat fan nozzles the spray angle decreases.
For hollow cone nozzles
the uniformity of atomization decreases.

How to create small droplets:

- Increase spray pressure
- Decrease flow rate, i.e. several small nozzles instead of one large one
- Use the same nozzles with maximum spray angle
- Use a spray medium with lower specific gravity

Formation of droplets (non-varying conditions):

Hollow cone nozzles - fine droplets
Flat fan nozzles - mid-size droplets
Full cone nozzles - coarse droplets

Classification of droplet size ranges:

Atomization	Droplet diameter (µm)		
Finest fog		to	20
Finest fog	20	to	100
Fine mist	100	to	250
Light rain	250	to	1,000
Heavy rain	1,000	to	6,000

Illu. 4

Comparing droplet sizes:

• 500 µm, • 1,200 µm, ● 5,500 µm

Illu. 5

If a droplet is cut in half, the following ratios occur:

	Volume	Surface
D	is 1 droplet	1-fold
1/2" D	are 8 droplets	4-fold

Illu. 6

Approximated wear behaviour of typical nozzle materials	
Aluminum	1
Brass	1
Steel	1.5-2
Monel	2-3
Stainless steel	4-6
Hastelloy	4-6
Stainl. steel, galv.	10-15
Ceramic	90-200

Illu. 7