Dust Suppression with Water Sprays

1st Edition

Content / Navigation

- Background / History
- Classification of Dust Particles
- Nozzles for Dust Suppression
- Contact
Table of Contents

- Background / History 3

- Classification of Dust Particles 4
  - PM10 4
  - PM2.5 4

- Nozzles for Dust Suppression 5
  - Single Fluid Nozzles (low pressure) 5
  - Advantages of low pressure single fluid nozzles 5
  - Targeted moistening of materials 6
  - Nozzle recommendations for dust suppression by targeted moistening of the product 7
  - Single fluid nozzles (high pressure) 8
  - Mist Cannons 8
  - Dust suppression with light material moistening 9
  - Recommendations of single fluid hollow cone nozzles for a light moistening of the material 10
  - Light material moistening and high dust suppression efficiency with twin fluid nozzles 12
  - Recommendations Twin Fluid Nozzles 12

- Contact 13
Background / History

The formation of dust and the associated impact on employees, animals and technology plays a major role in many areas of manufacturing. Dust can occur everywhere where materials are loaded, unloaded or processed.

In general, spraying dust with liquid adds weight to the particulate matter and prevents it from becoming airborne or settles it quickly, if already airborne. A wet particle can become accumulated to another particle or it can adhere to a surrounding object (e.g., a wall or other obstruction).

Depending on the application, several different spray procedures are available for dust suppression:

a) For small, localized dust emission points (e.g., for conveyer belt operation), “static” systems are used, meaning water is sprayed from nozzles which are mounted on fixed pipes within the dust area.

b) For broader defined areas (e.g., halls, dumpsites, varying loading stations, etc.), “dynamic” systems are generally used. In these cases, a spray mist is delivered to the location via a ventilated air flow.

Fig. 1: Dust deposits under a conveyor

Fig. 2: Dust emission during demolition works
Classification of Dust Particles

PM10

Particles larger than 10 μm are filtered out in the upper air passages before they reach the lungs. Particles with a diameter of <10 μm are considered to be respirable (i.e., able to be inhaled into the lungs). Particles which have reached the lungs are deposited there and are removed very slowly over time (respiratory illnesses).

PM2.5

Particles smaller than 2.5 μm (PM2.5) are completely respirable and therefore especially dangerous. They are as large as bacteria and cannot be seen with the naked eye.

Particles larger than 2.5 μm can be precipitated very well with the help of nozzles. Particles smaller than 0.5 μm cannot be precipitated with nozzles any more. Electrostatic precipitators or special filters are needed.

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### Table: Classification of Dust Particles

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10 (thoracic fraction)</td>
<td>&lt;=10 μm</td>
</tr>
<tr>
<td>PM2.5 (respirable fraction)</td>
<td>&lt;=2.5 μm</td>
</tr>
<tr>
<td>PM1</td>
<td>&lt;=1 μm</td>
</tr>
<tr>
<td>Ultrafine (UFP or UP)</td>
<td>&lt;=0.1 μm</td>
</tr>
<tr>
<td>PM10-PM2.5 (coarse fraction)</td>
<td>2.5 μm – 10 μm</td>
</tr>
</tbody>
</table>

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![Fig. 2: Typical distribution of solid particles and their size in ambient air](image-url)

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"Dust Suppression with Water Sprays"
Nozzles for Dust Suppression

Various spray nozzles are used for dust suppression. In general, 3 forms of atomization can be distinguished.

1. Single fluid nozzles (low pressure)
2. Single fluid nozzles (high pressure)
3. Twin fluid nozzles – air and water are mixed by the nozzle

Single Fluid Nozzles (low pressure)

The single fluid system only utilizes water. It is technically simpler in its design and therefore also more cost-effective. The single fluid system is used in cases where the moistening of the product does not cause any problems. In the process, dust is already prevented during its development; i.e., the product is being moistened to such an extent that dust can hardly rise. In this case, the droplet size is not as crucial as in the case of dust suppression in the air. Therefore work can also be performed at a lower pressure. For the most part, hollow cone nozzles or full cone nozzles are used. Figure 3 shows the use of Lechler nozzles in the extraction of brown coal. The nozzles are spraying on specific areas where dust can develop.

Advantages of low pressure single fluid nozzles

- Low pressure single fluid nozzles generate considerably larger droplets which in some situations is a big advantage. Fine droplets are much more sensitive to air flows and are therefore carried along easily. This can pose a problem especially in outside areas. Larger droplets fall to the ground much faster and moisten the product at the spot where it is intended to. Low pressure single fluid nozzles can be the better choice especially on landfills, in quarries or in agricultural areas.

- An additional huge advantage of single fluid nozzles in low pressure areas is the large free cross section of the nozzles. The water quality is not as critical as for high pressure or twin fluid systems, since nozzles with tangential water supply are mainly used (see Figure 3). The application of energy is also relatively low, because no pressurized air is needed.
Targeted moistening of materials

In quarries the formation of dust frequently happens at belt stackers or at hand-over points where the material is very dry. For this application we recommend low pressure single fluid nozzles which moisten the product in a targeted way to prevent the formation of dust.

Lechler recommends full cone nozzles for this application, preferably with a tangential liquid supply. The required amount of liquid should be chosen dependent upon the output. For debris and rock, the following data can be used:

- a) from 30 to 40 t/h \( V = 4 – 7 \) l/min  Spray angle 90°
- b) from 40 to 55 t/h \( V = 5 – 9 \) l/min  Spray angle 90°
- c) from 55 to 70 t/h \( V = 6 – 11 \) l/min  Spray angle 60°
- d) from 70 to 85 t/h \( V = 8 – 14 \) l/min  Spray angle 60°

Depending on the material being transported, it might also be necessary to spray on more water in order to moisten adequately. If the water quality is sufficiently good, nozzles with an axial liquid supply can also be used. These nozzles generate a certain ratio of fine droplets and are therefore able to better suppress floating dust.

Flat spray nozzles and tongue (or deflector) nozzles are also used for dust suppression and material moistening. Figure 6 shows a cold molding cutter.

A nozzle band is located above the molding cutter rotor which sprays water from flat spray nozzles onto the rotor during the cutting process. The removed asphalt is moistened and dust formation is thereby decreased. In addition, the cutting rotor is being cooled by the water.
Nozzle recommendations for dust suppression by targeted moistening of the product

The following table shows a small selection of nozzles which can be considered for general material moistening.

In case already air borne dust is also present, additional hollow cone or cluster multiple hollow cone nozzles can be utilized. These nozzles produce finer droplets and are thus a good choice.

<table>
<thead>
<tr>
<th>Lechler Type Series</th>
<th>Volumetric Flow ([\text{l/min}] \text{ at 2 bar})</th>
<th>Spray angle ([\text{°}])</th>
<th>Narrowest-(\text{Ø}) ([\text{mm}])</th>
<th>Assembly options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full cone nozzles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>422.646.</td>
<td>4,00</td>
<td>90</td>
<td>2,90</td>
<td>Welding nipple / ball and socket joint</td>
</tr>
<tr>
<td>422.726.</td>
<td>6,30</td>
<td>90</td>
<td>3,60</td>
<td>Welding nipple / ball and socket joint</td>
</tr>
<tr>
<td>422.724.</td>
<td>6,30</td>
<td>60</td>
<td>3,60</td>
<td>Welding nipple / ball and socket joint</td>
</tr>
<tr>
<td>460.648.</td>
<td>4,00</td>
<td>120</td>
<td>1,60</td>
<td>Welding nipple / ball and socket joint</td>
</tr>
<tr>
<td>468.646.</td>
<td>4,00</td>
<td>90</td>
<td>1,90</td>
<td>Pipe clamp</td>
</tr>
<tr>
<td>468.724.</td>
<td>6,30</td>
<td>60</td>
<td>2,00</td>
<td>Pipe clamp</td>
</tr>
<tr>
<td><strong>Hollow cone nozzle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>302.686.51.</td>
<td>5,00</td>
<td>90</td>
<td>3,40</td>
<td>Welding nipple / ball and socket joint / Pipe clamp</td>
</tr>
<tr>
<td><strong>Cluster multiple hollow cone nozzle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>502.798.17.</td>
<td>9,50</td>
<td>130</td>
<td>2,00</td>
<td>Welding nipple / ball and socket joint / Pipe clamp</td>
</tr>
<tr>
<td><strong>Flat jet nozzle</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>652.367.</td>
<td>0,63</td>
<td>120</td>
<td>0,50</td>
<td>Pipe clamp with thread and cap nut or bayonet quick cap</td>
</tr>
</tbody>
</table>

Assembly accessories for nozzles tips can be found in our main catalogue, which is available in the online shop from the category marketing literature.
Single fluid nozzles (high pressure)

High pressure single fluid nozzles are used for the bonding of mist from the air. The product is still being moistened, but not as much as for low pressure single fluid nozzles. By utilizing pressures up to 100 bar, water is being atomized to very fine droplets. Due to physical limitations, very small cross sections are necessary in the nozzle to produce such small droplets. These nozzles are mostly used in closed areas.

Since the throwing range of such nozzles is very low due to the air resistance (approx. 1 to 3 meters), ventilators are used (similar to snow machines) in order to increase the throwing range (fig. 7). In addition, the droplets are not diverted as strongly by outside influences.

The following things have to be considered when working with high pressure single fluid nozzles:

1. Fine droplets are quickly braked by the resistance of air. This decreases the efficiency as the relative velocity of droplet and dust particle is lower. The degree of precipitation reaches zero when no more relative velocity is present. In many cases ventilators are needed (fig. 7).

2. Very good water quality is needed, so that the nozzles do not clog. For the smallest nozzles frequently even osmosis water is used.

Mist Cannons

In outside areas, ventilators are used to systematically accelerate the fine droplets within the water mist. Due to the high speed of the droplets, they cannot be easily diverted.

In fig. 7, the mist cannon shown consists of a ventilator, a diffuser, and a circular ramp with nozzles from type series 212.333.11.33.

The nozzles spray directly into the air flow and therefore the droplets are carried along immediately to the point where the cannon is targeted at.

Such cannons are used in areas, in which dust is repeatedly generated at varying locations, for example at landfills or at demolitions.

Fig. 7: High pressure smoke screen with a water mist cannon from the company “Hennlich Industrietechnik” and Lechler nozzles of type series 212.333.11.33.
Dust suppression with light material moistening

Oftentimes a strong moistening of the material or product is not desired. In this case the dust has to be bonded in the air. As already introduced in the chapter “Mechanism of dust suppression”, it is necessary for this purpose to atomize water very finely in order to produce a collision between the dust particle and water droplets. The product is thereby only moistened slightly.

Hollow cone single fluid nozzles are available for this application which either work in a low pressure or high pressure area. The volumetric flow of these nozzles is very low and, depending on the type series and pressure range (see table on page 13), lies between 0.025 l/min and 3.6 l/min.

The fine water mist generated from hollow cone single fluid nozzles falls to the floor very slowly. In this way, air streams can carry away the droplets and thereby prevent the dust suppression. Therefore the use of high pressure single fluid nozzles is most efficient, especially in closed areas.

Typical areas of application are:

- Conveyor belts / hand-over points
- Breaker mills
- Riddles
- Bulk basins
- Indoor riding-halls – moistening of the ground
- Setting and removal of dust raising materials
Lechler offers various nozzles which produce very small volumetric flows and therefore generate a very fine mist.

<table>
<thead>
<tr>
<th>Lechler Type Series</th>
<th>Volumetric Flow [l/min] at 2 bar</th>
<th>Spray angle [°]</th>
<th>Narrowest-Ø [mm]</th>
<th>Assembly options</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.217.xx.00.</td>
<td>0,025 (at 60 bar)</td>
<td>50</td>
<td>–</td>
<td>N 10 - 24 UNC</td>
</tr>
<tr>
<td>200.217.xx.01.</td>
<td>0,055 (at 60 bar)</td>
<td>70</td>
<td>–</td>
<td>N 10 - 24 UNC</td>
</tr>
<tr>
<td>200.140.16.xx</td>
<td>0,1 to 3,6 (at 100 bar)</td>
<td>20, 40, 80</td>
<td>0,33 to 0,65</td>
<td>M5, M6</td>
</tr>
<tr>
<td>212.333.11.33.</td>
<td>1,23 (at 15 bar)</td>
<td>50</td>
<td>0,6</td>
<td>G 1/4 A ISO 228</td>
</tr>
<tr>
<td>222.xx4.16.24.</td>
<td>0,036 to 1,06 (at 1,5 bar)</td>
<td>60</td>
<td>–</td>
<td>Pipe clamp with cap nut</td>
</tr>
<tr>
<td>2TR.xx5.</td>
<td>0,16 to 1,57 (at 2 bar)</td>
<td>80</td>
<td>0,55 to 1,30</td>
<td>Pipe clamp with cap nut</td>
</tr>
<tr>
<td>214.xxx.</td>
<td>0,08 – 0,32</td>
<td>60, 80</td>
<td>0,50</td>
<td>G 1/8 i ISO 228</td>
</tr>
<tr>
<td>216.xxx.</td>
<td>0,40 – 10,40</td>
<td>60, 90</td>
<td>1,00 to 2,00</td>
<td>G 3/8 i ISO 228</td>
</tr>
</tbody>
</table>
Twin Fluid Nozzles

For these nozzles, water and air are being mixed, either inside or outside of the nozzle. Air, which flows with a higher speed, is thereby the energy supply. In contrast, the flow speed of the water is rather low. Due to the air flow, twin fluid nozzles have a greater throwing range than high pressure single fluid nozzles. However, due to the fine droplets they create, twin fluid nozzles are also more likely used in closed areas. Because of their use of compressed air, twin fluid nozzles have considerably higher energy absorption than single fluid nozzles.

Twin fluid nozzles generate even finer droplets than the high pressure single fluid atomization. The droplet sizes vary depending on the type series as well as the set ratio between air and water. The droplets become smaller and smaller with an increasing air/water ratio.

Recommendations of Lechler twin fluid nozzle are available on the following page.

Fig. 9: Generation of mist with a Lechler twin fluid nozzle type series 136.2
Light material moistening and high dust suppression efficiency with twin fluid nozzles

Twin fluid nozzles can generate very fine droplets and have especially high dust suppression efficiency as long as the nozzles are aiming directly at the point where the dust is generated and as long as the distance between that point and the nozzle is not too large. The max distance should be less than 4 meters.

One advantage of twin fluid compared to single fluid nozzles is the higher droplet velocity of the liquid stream. Especially in situations with a high air/water ratio (i.e., a high air pressure and a lower water pressure), the differential speed between the dust particles and water droplets is higher over a larger area than for single fluid nozzles. Without the air flow, the droplets would quickly lose speed due to their size. High differential speeds between water droplets and dust particles boost the degree of precipitation.

Another advantage is the high control ratio of twin fluid nozzles, since the droplet size has a crucial influence on the degree of precipitation. If the droplets are too large, the dust particles won’t collide with the droplets due to their mass inertia. If the droplets are too small, they evaporate before they collide with the dust particles. With twin fluid nozzles it is possible to affect the droplet size by adjusting the air/water ratio. For instance, a high air/water ratio results in smaller droplets. The droplets become larger as the air/water ratio decreases.

Recommendations Twin Fluid Nozzles

<table>
<thead>
<tr>
<th>Lechler Type Series</th>
<th>Droplet Size* SMD [μm]</th>
<th>Spray angle [*]</th>
<th>Narrowest-Ø [mm]</th>
<th>Mixing principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>136.20x.</td>
<td>~ 30 – 80</td>
<td>60</td>
<td>0,50 – 1,50</td>
<td>mixing inside</td>
</tr>
<tr>
<td>136.3xx.</td>
<td>~ 20 – 30</td>
<td>20</td>
<td>0,40 – 2,50</td>
<td>mixing inside</td>
</tr>
</tbody>
</table>

* The droplet sizes stated are approximate values which are achievable at a high air/water ratio.

Water Quality

A high water quality is necessary for the high pressure single fluid as well as the twin fluid system. That means that only particles are allowed in the water which are not larger than a third of the narrowest free nozzle cross section. Larger particles can partly or completely clog the nozzles and therefore lead to a failure of the dust suppression process. Therefore adequate filters are required. Another possibility is a treatment of the water utilizing a reverse osmosis system.

Low pressure single fluid nozzles with tangential water supply are less prone to clogging and do no need special water treatment in many cases.
Contact

In case you need further assistance when selecting nozzles for your application, contact us directly.

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