

Fugitive dust emission abatement

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1. Introduction

The relative importance of sources of atmospheric dust changed over the last years. While dust emissions from fugitive dust sources have been increasing still, the total dust emission is decreasing (Bernicke and Cohors-Fresenborg 2009). This is due the fact that conducted source (non-fugitive) emissions were reduced as a consequence of highly efficient separation devices which were successfully installed. For fugitive dust sources the installation of suitable abatement methods is still a quite challenging task and therefore significant reductions were not achieved yet. One aspect is that the emission concentration of a fugitive dust source is not easily detectable, which should be the first step for designing an efficient abatement method. Therefore considerable scientific efforts to develop technologies for dust reduction in Austria focussed on fugitive emissions and to the developing of suitable abatement methods.

2. Sources of fugitive dust emissions

Fugitive dust emissions can be emitted from the following sources (see also the detailed assessment in this compendium, pp. 4 ff):

- Resuspension of dust from paved and unpaved roads (car traffic)
- Building site and roadworks: demolishing of buildings
- Wind erosion: farmland, bulky solids material heaps
- Agricultural processes
- Handling of bulky solid material

Theoretical studies were carried out to better explain the emission situation in the area of fugitive dust emissions. Scientific investigations described here concentrated on the sources of bulky solids handling and resuspension from roads. For this purpose, the typical procedures of bulky solids handling were analyzed as actually occurring in Austrian industry. The influence of these processes on dust emissions was evaluated (Trenker and Höflinger 2001b). Furthermore, the resuspension of dust from paved road due to the car traffic were analysed over more than one year for the city of Vienna (Koschutnig et al. 2003, Höflinger and Koschutnig 2003). Rheina-Wolbeck and Höflinger (2003) use all model approaches to assess the dust reduction potential for the main dust sources of the city of Vienna.

3. Dust generating mechanism during falling of bulk solids

Dumping dry solids, using gravitational forces for material transfer, is the most important handling procedure of bulky solids associated with dust release. Therefore the physical mechanism during such dumping processes of bulky solids were investigated in detail and the reasons responsible for dust generation were worked out (Trenker and Höflinger 2002, Ehrenberg and Höflinger 2002, Rheina-Wolbeck and Höflinger 2005, 2006a-d, Rheina-Wolbeck 2006). Rheina-Wolbeck and Höflinger (2006d) also developed recommendations to optimally design dust capture devices for such bulk solids handling procedures. Designing of an encased system, these authors recommend to adjust the suction flow of the capture devices such that the back pressure area in the encased volume is minimized (see Figure 1).

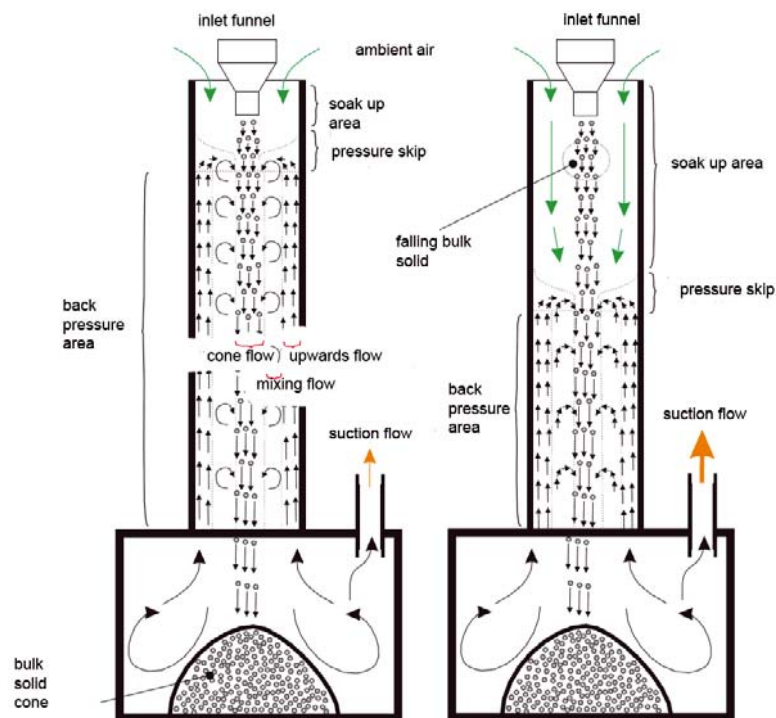


Figure 1: Dust generation of falling bulk solids in encased systems.

Further a testing method was worked out by which the dust generation ability of different bulk solids can be classified and compared. For this purpose a so called falling apparatus was developed, by which the generated dust can be related to the mass of falling bulk solids (Trenker and Höflinger 2001c). By this method it can be also found out which minimum moisture content a bulk solids needs, in order to stop dust generation (Trenker and Höflinger 2001a).

4. Minimisation of the dust generation from bulk solids by water spraying

Generally, there are 3 ways to reduce dust generation in bulk solids handling. The first method is to optimise the operation parameter of the handling process or to change the product properties (compacting of powders to pellets by way of moistening) with the goal of less dust emission. The second method is to enclose the dust generation area and to suck off and filter the generated dust over a bag filter. The third method is to spray water into the dusty air in order to precipitate the dust particles. For this purpose special nozzle types are used which can produce very fine droplets to ensure high specific area for dust capturing with low water consumption. Mathematical models simulate the water consumption in relation to the efficiency of the spraying nozzle on dust minimisation (Höflinger et al. 2008a-b, Zhang et al. 2008, Faschingleitner et al. 2009a-b). Due to the low water consumption and the very fine droplet generation, water evaporation is becoming significant, especially for low air humidity, which was also considered during model development (Grundnig et al. 2006, Höflinger et al. 2009).

Looking at the third method of water spraying used for moving bulk solids (e.g. dedusting of conveyor belts), a more detailed analysis had the goal to identify the relevant separation mechanism, when the area around moving bulk solids will be sprayed with water. The results show that the moistening effect of the bulk solids has by far the dominant effect on dust minimisation compared to the capturing mechanism of the dust particles by the droplets (Faschingleitner et al. 2010a-b, Faschingleitner and Höflinger 2010, 2011b).

Because of these findings the scientific focus was laid to optimize water distribution on the bulk solids, for best dust reduction while keeping water consumption low. Spraying nozzles do not homogeneously distribute the water over the area of bulk solids, generating water puddles next to dry areas where unwetted material remains as source of dust emission. A mathematical model calculation was developed, by which the moisture input distribution (defined as moistening velocity $v(x)$ representing the water volume applied per area and time) over the radial distance x at the bulk solids area can be quantified for different kinds of spraying nozzles, different operation parameters, like the water volume flow dV/dt of the nozzle and the nozzle distance from the bulk solids h (Figure 2).

Furthermore a numeric calculation method was worked out by which the spraying device of a conveyor belt transfer station can be optimally designed for minimum dust generation and lowest water consumption. For this calculation the results from a bulk solids falling apparatus are needed, which quantifies the necessary minimum moisture content of the regarded bulk solids for less dust generation (Figure 3).

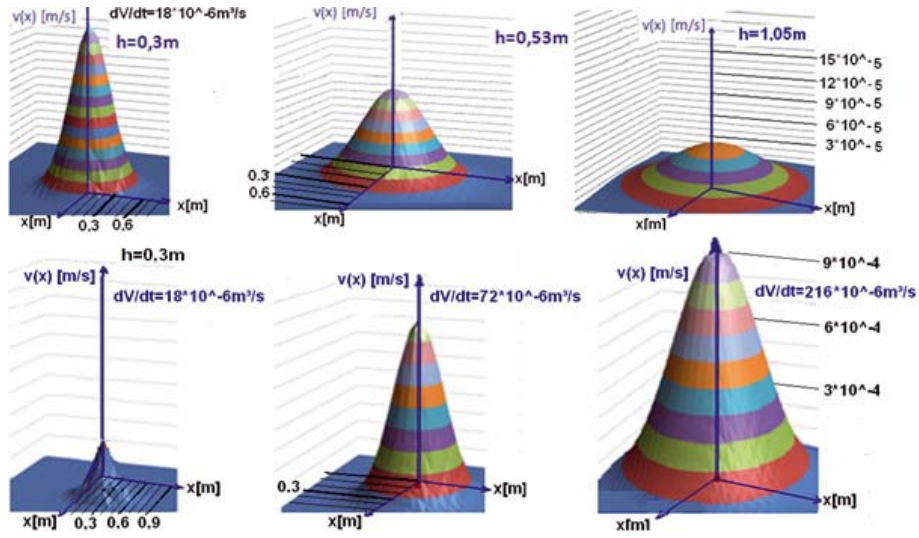


Figure 2: Moistening velocity $v(x)$ as input distribution profile over the radial distance x at the bulk solids area for a spraying nozzle for different nozzle volume flows dV/dt and different distances h to the bulk solids area (Faschingleitner and Höflinger 2010).

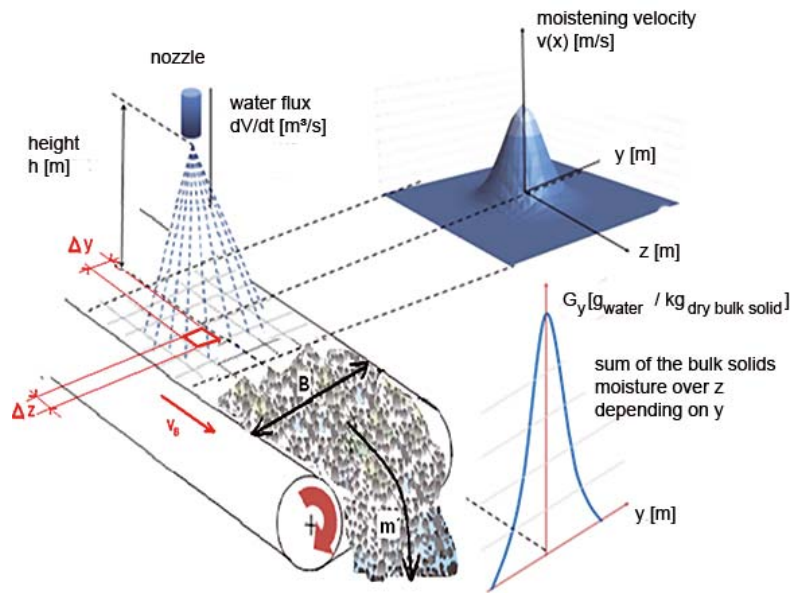


Figure 3: Application of the moisture distribution profile for minimisation fugitive dust emission at a conveyor belt transfer station (Faschingleitner and Höflinger 2011a).

5. Resuspension of dust from roads (car traffic) in the city of Vienna

According to equations developed by the U.S. EPA, resuspension of dust from roads depends on the dust mass, deposited on the road and on the weight of the vehicle travelling over the road. In an experimental study, the so-called silt content, which is the mass of deposited dust mass per road area below $75 \mu\text{m}$ was detected in Vienna for 44 randomly chosen street points over a period for 17 month (see Figure 4). It can be seen that in autumn the dust deposit on the roads starts to increase due to the falling leaves from the trees and increases then dramatically in winter when road sanding starts. Then silt content steadily decreases until summer. Using the car statistics of Austria and including meteorological data, average PM10 emissions per month over the year can be calculated with the help of the above mentioned EPA equations (Höflinger and Koschutnig 2003, 2004). Results demonstrated that road sanding has a long lasting impact over the year on dust emission and in consequence a list of roads was prepared, describing which roads have the largest dust loads and should be preferably cleaned.

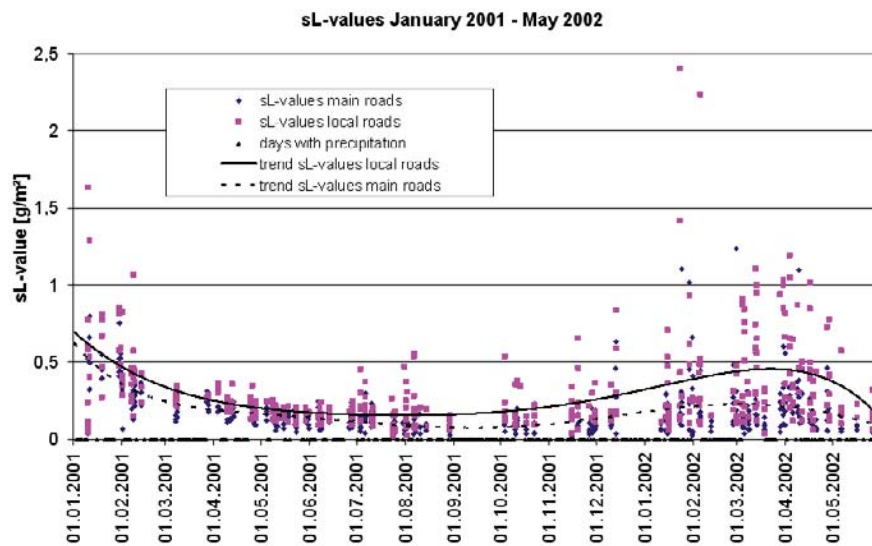


Figure 4: Silt load (sL-) values for 44 roads in the city of Vienna over a period of 17 months (Höflinger and Koschutnig 2003).

Also the effect of road cleaning (washing) was investigated (Koschutnig et al. 2003). Here the silt content was determined before and after passage of the road washing car on different roads, as well as in the days following the

cleaning event up to 2 weeks. It turned out that the cleaning effect depends on the level of the silt content before. At silt contents of about 0.2 g/m² the cleaning effect will be eliminated within a period of approximately 2 weeks.

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