General informative article

Dustiness

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Dustiness and Dustiness Analysis of Powders

INTRODUCTION DUSTINESS

Dust particles that are present in the air – often entitled airborne dust – and can be generated by different sources.

First of all of course there are the natural resources such as volcanos, fire, but also emission from the sea etc. In parallel also mankind is a producer of airborne dust particles via industrial processes.

Particularly in processes that work with powders, granular materials or fibres, dust particles can be released into the air during conveying and transport. Examples are asbestos, cement, fly-ash, pesticides and even dust from tea or coffee. Personal contributions to airborne dust parcles are e.g. emissions by cars and tobacco smoke.

Depending on weather conditions, such airborne dust particles can travel up to 30 kilometres.
Due to more stringent legislation and green manufacturing challenges, producers strive for a lower emission of such particles by implementation of e.g. cyclones and filtration systems. For the design of these types of systems and to optimize their efficiency, it is of great importance to know the particle size prior to and after the filtration device operation.

Powders and particles are very important in many different industrial processes, like chemistry, petro chemistry, pharmacy, food and feed, colorants, building materials and so on. Depending on the discipline, 30-80% of the total product flow consists of powders. The particles contained in the products can vary from millimetres down to submicrometres. Particles that are smaller than approximately 100 micrometres and which are intrinsically present in the product, can be released into the air. In parallel, conveying and handling of the products can also induce attrition and abrasion by which the particle size distribution will contain a larger contribution of smaller particles and therefore an increased dustiness potential.

Higher concentrations of dust in the working environment are undesirable for a different number of reasons. Firstly, dust can be seriously harmful to humans and animals and it will affect the environment. From a business viewpoint, dust is additionally associated with product loss, contamination of other products and/or cleaning costs of process equipment. The latter consequence also leads to additional (maintenance) down time and possible wear of expensive machinery.

Most commonly, small particles access the human body via the lungs, but also the eyes can suffer a lot from small dust particles. To what extent such particles affect our health is related to their size, shape, solubility and toxicity of the particle. Sodium chloride (table salt) that enters the lungs, is not a big problem; it easily dissolves in available moisture and leaves the lungs again. On the contrary, asbestos – although not toxic – has a needle shape geometry, is insoluble and is not biodegradable and is therefore very harmful. Another interesting substance is silicon dioxide (sand), which can be present as an amorphous SiO_2 phase but also as a crystalline phase. In case of the latter this is then often quartz, which is
potentially carcinogenic.

In the first instance, producers/ manufacturers are responsible to control dust emissions; not only from a health, safety and environment viewpoint but also to adhere to more stringent quality requirements by customers. Suppression of dust emissions is more and more regulatory controlled by such organizations as: European Food and Safety Authority (EFSA), Environmental Protection Agency, Office of Pollution Prevention and Toxics (U.S. EPA OPPT), Health and Safety Executive, United Kingdom en the REACH program. REACH is a European legislation for the registration of materials that are being produced and/or sold at quantities exceeding 1000 kilograms per year.

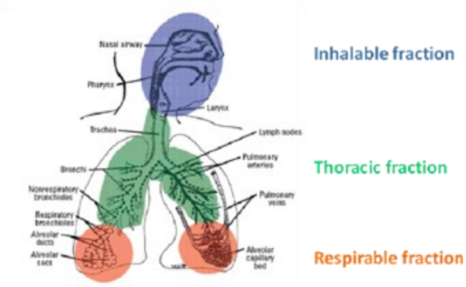

Figure 1. Schematic representation of the respiratory tract emphasizing the different size fractions: inhalable, thoracic, and respirable (according to J. Harkema).

ANALYSIS METHODS FOR QUANTIFICATION OF DUST(INESS) IN BULK MATERIALS

Delft Solids Solutions (DSS) has ample experience in researching the dustiness potential of powders and granulates.

DSS is convinced that such research can help to control and minimize dust exposure in the workplace and to enhance the quality of the (final) product.
Various techniques and methodologies are available that work in accordance with existing international standards and that can quantify the dust content already present in the substance and the dust that is additionally generated by wear (attrition and/or abrasion). The different methodologies are:

HEUBACH

The German standard DIN 55992 comprises Heubach, Stauber-Heubach en Heubach type III. The Heubach methodology is based on the rotating drum principle in which the dust is made available by some mechanical action (bulk solids handling), transported in a controlled air stream and collected on a filter. This dust is quantitatively weighed and is typically entitled as Total Suspended Particulates (TSP) and expressed in mg dust per kg material. The dust collected in this approach is a combination of dust intrinsically present and dust particles generated by some mechanical force. When applicable, additional wear of the investigated material can be introduced via the type III methodology, in which stainless steel balls are used to get in close contact with the particulate matter. This type III approach is frequently used in the detergents industry. The methodology following the Stauber-Heubach approach is generally applicable to (import of) medicines and animal feed.

EN 15051

The European standard 15051 is based on the rotating drum principle or on the continuous drop methodology.

In this approach, the dustiness is not calculated as a single TSP value but the airborne dust particles are physically fractionated into different "size" fractions thereby simulating the human respiratory tract.

This provides information on the inhalable, the thoracic and the respirable fraction. The inhalable fraction concerns all particles than can be inhaled by the human respiratory tract. The thoracic fraction are particles typically smaller than an aerodynamic diameter of 10 µm and which can penetrate the lower part of the lungs.
The respirable fraction are typically all particles smaller than an aerodynamic diameter of 4.25 µm, which can even penetrate the alveoli and which often are most harmful.
The EN15051 also makes use of the rotating drum principle, similar to what has been described for the Heubach methodology. A second methodology described in this standard is the so-called continuous drop approach.

This approach simulates the emptying of a bin, hopper or big bag and does not include any attrition or abrasion component. The powder is continuously dosed into a dedicated measuring tube placed in a vacuum system and suitable inhalable and respirable (cyclone) samplers are used to collect the appropriate size fraction, which in turn is gravimetrically quantified resulting in fractions expressed in mg dust per kg material.

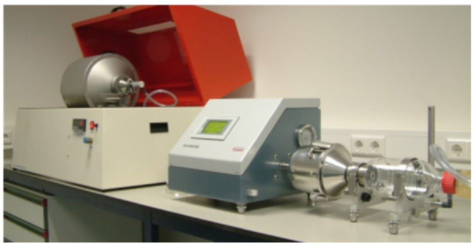

Figure 2. Two different set-ups devoted to dustiness potential analysis by means of the rotating drum principle; left: EN 15051 set-up right: Heubach set-up.

SUBSEQUENT ANALYSIS OF DUST FRACTION OR PARTICLES

The dust fractions collected during the afore-mentioned experiments can be further analyzed for additional (bio-) chemical or physical information. Different particle size analyzers are available for more detailed particle size information. Neutron activation analysis can be used to fully quantitatively analyze the total dust fraction for its elemental composition. In case a minimal amount of sample is generated in the dustiness potential experiments, electron microscopy coupled to energy dispersive x-rays (SEM-EDX) can be applied to quantitatively determine the elemental composition of the particles including morphological information.

Active pharmaceutical ingredients (API's) and specific additives as used e.g. in animal feed are typically characterized by the supplier employing dedicated analysis methods. In such cases, the respective dust fraction can be returned to the supplier for further processing.

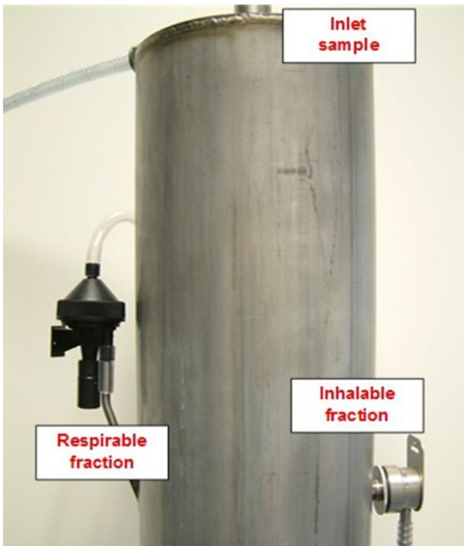

Figure 3. Close-up of the so-called "Continuous drop" set-up in accordance with EN 15051. Highlighted are the introduction of the sample into the tubular tester and the two samplers for the inhalalble and respirable fraction.

Besides the above-described measurement techniques, Delft Solids Solutions (www.solids-solutions.com) offers a wide variety of niche characterization techniques focussed on mostly physical properties of particles and powders.

One can quantify the specific surface area, porosity and pore size distribution of materials; determine the strength and degree of attrition and abrasion of particles; segregation of powders; particle size and particle shape of powders and dispersions/emulsions; flow ability of powders, etc.