Material in Movement

Storing, Conveying and Metering Bulk Materials

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Despite the wide variety of available bulk materials and their blends, the basic operations of storage, conveying and metering can be governed better than ever. This presupposes knowledge of the particle and bulk properties, selection of the correct equipment, and the use of modern, intelligent metrology and information systems. This has resulted in better product qualities, greater operating reliability and lower production costs. However, even the best plant is of no use if the properties of the bulk material have been incorrectly assessed.

The properties of a bulk material are a complex function of its particle size and particle shape and their distributions, storage conditions, adhesives forces etc. As Fig. 1 shows, with many bulk materials the porosity for particle sizes below 200 µm is increased by the adhesive forces. Thus, under load, they exhibit higher compressibility, cohesive flow behaviour with a tendency to bridging, and many other characteristic features. Bridging may occur in silos or narrow channels, sometimes as a result of wedging, when the diameter of the flow channel is less than ten times the particle diameter.

Since, with small particles, the pore channels in the dense bulk material are small, the flow resistance is greater and loose particles rise. A fluidized bed occurs. If the gas flow is switched off, the particles sink again and the solid bed is restored. However, if the particle sizes lie between 5 and 50 µm, the enclosed air slowly escapes; the bulk material has a fluid flow behaviour and tends to shoot. With coarse particles, high gas flows are required to form the fluidized bed. With compressed tables that are smaller than 5 µm, individual large flow channels form before the powder is fluidized. Moist, sticky, abrasive, fragile and/or in particular non-isometrically shaped particles have other unfavourable properties that necessitate special treatment.

The points discussed above make it clear that a knowledge of the particle diameter range is enough to estimate whether flow disturbances can be expected during storage, conveying and metering as a result of bridging, shooting, dusting, etc. More precise dimensioning, selection and operation of the equipment requires quantitative data for more accurate handling instructions.

Storage

Bulk material silos are characterized by a large length/diameter ratio, since the radial load of the walls approaches a limit value with an e function that is proportional to the diameter. By means of the Jenike theory [2], it is possible to determine the discharge diameter such that no bridging occurs. This also provides information as to whether mass flow or funnel flow is taking place in the silo. For this purpose the material data, comprising porosity, effective angle of friction of the material, angle of friction at the wall, and compressive strength as a function of the consolidation tension and time, must be measured with a shear cell.

In the plastics industry, aluminium silos are often used. For reasons of flow and because the walls are relatively thin, circular silos are often chosen. To reduce the silo footprint for a given volume capacity, Geroldinger GmbH & Co. KG, Sigharting/Austria offers the Multigon silos (Fig. 2). With a capacity of 1020 m^3 and 12 silos, round silos contain 5.8 m^3/m^2 and Multigon silos of the same height 9.7 m^3/m^2.

For most bulk materials, the silo design does not pose any fundamental problems. However, there are many ways of making mistakes. To discharge the bulk material in a metered stream with mass flow, the

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discharge elements must remove the material over the entire cross-section. Various discharge units and auxiliaries with these application criteria are available [3, 4]. The "hopper within a hopper", known as Binsert, allows a funnel-flow silo to be converted to a mass-flow silo.

In batch operation, and even with continuous processes for the production of plastic pellets or powders, slight product fluctuations continually occur. To ensure a constant quality over long periods of time before further processing, relatively large amounts of bulk material must be mixed. Batch homogenization can take place in mixing silos (Fig. 3). In the mixing silo with a central or peripheral screw, a rotating screw stirs up the material. In the Circomix, this takes place centrally, and in the fluidized-bed mixer, segment by segment, with air. In addition, interior baffles (Combiflow system from Waeschle GmbH, Weingarten/Germany) or intake openings in the central pipe (Centroblend system from Zeppelin GmbH, Friedrichshafen/Germany) causes transposition processes. The multi-pipe systems have several intake openings. To reduce the forces, the pipes are also laid against the wall or on the outside.

To determine the level in the silo, weighing cells, immersed bodies, gamma emitters etc. are used. If we consider the high technical sophistication of modern systems, innovations at the component level could be found at Achema 2000.

Conveying

In plant for production, compounding and processing of powder and granular bulk materials, a wide range of conveying functions must be performed. After production in a chemical factory, the finished products are often conveyed over several hundred metres, protected, in pneumatic pipelines to large silo batteries comprising 50 units. The product, in silo vehicles or bagged, is then dispatched to the consumer and is pneumatically transported into large silos or deposited in storage halls. It may be further transported pneumatically in-house by suction or pressure. Tried and tested solutions as well as innovations in pneumatic conveying can be found in [4].

Competitors include work conveyors or the flexible spiral conveyor, which are also enclosed to prevent dusting (Fig. 4A). TransiTec Anlagenbau GmbH, Willich/Germany, also prevented wall cleaning spirals at Achema.

Fig. 5 shows a big-bag filler with automatic switchover after filling with spiral conveyors.

For piece goods such as injection moulded parts, conveyor belts are used, and for transferring loads up to 300 kg, Schmalz Förder- und Handhabungstechnik GmbH, Glatten/Germany, supplies the vacuum tube lifting system (Fig. 6). This area is seeing a variety of new fields of application.

Many individual improvements to components as regards ease of operation, cleaning and extended lifetimes were to be seen. Gericke AG of Regensdorf/Switzerland and Jaudt Dosiertechnik Maschinenfabrik GmbH, Augsburg/Germany, presented at Achema, for example, quick cleaning hatches for pneumatic conveying, in which a precise guide rail allows quick and easy dismantling.

Metering

The precise metering of bulk and liquid components is a prerequisite of many of the process operations in the manufacture of high-quality products. By metering is meant the quantitative apportioning, conveying, usually with supplied energy, and controlling of the setpoint value of an amount of substance or stream of substance. Volumetric metering can only be as good as the constancy of the filling level and the porosity. To achieve this, various processes are used [5]. They are also used for gravimetric metering, since they make it less necessary to make adjustments.

Thanks to low-cost of electronic parts, even small metering units are now available with intelligent systems. At Achema 2000, the trend in metering equipment is towards field-bus systems, "learning" metering units, more compact arrangements of entire metering stations, the use of modular systems throughout, easier cleaning while keeping to pharmaceutical and food standards, as well as specific improvements in detail.

Gericke presented a novelty, the Easydos EL-1 control system for differential metering balances. It is claimed to be more accurate and is not based on the hitherto customary gravimetric measurement of mass-stream changes. The compact control unit is installed directly on the balance. A centralized switch cabinet is not necessary.

The focus of the presentation by Brabender Technologie KG, Duisburg/Germany, was the enhanced model of the already established FlexWall metering unit. The novel trapezoidal design, in combination with the moving, flexible polyurethane trough, improves the mass flow in the feed tank.

New container geometries and a circular arrangement of different metering units, as shown in Fig. 7, reduce the space demand at the dispensing point. These solutions are presented by various exhibitors.

K-Tron International, Pitman/USA, complemented existing belt weighers with an integrated tare balance. The tare signal provides important information for the continuous dosing process about the state of the belt (deposits, abrasion etc.) without the bulk material.

For large quantities of bulk material, several manufacturers offered modified flowmeters, in which the material is guided through a specially formed measurement chute with force transducer. The advantages of this system are that they do not require drives or moving parts, they avoid impact crushing, and the associate dust, and are easy to clean. The flow continues even when the unit is switched off.

Fig. 1. Porosity as a function of particle size [1] Porosität = Porosity, Partikeldurchmesser = Particle diameter

Fig. 2. Arrangement (left) and interior view (right) of a Multigon silo (photos: Geroldinger)

Fig. 3. Mixing silo designs Schneckenmischsilo = Screw mixing silo, Fließbett-Mischsilo = Fluidized bed mixing silo, externe Führung = external guidance

Fig. 4. Screw conveyors, A: rigid single-shaft screw, B: flexible screw conveyors

Fig. 5. Big-bag filling with screw conveyors

Fig. 6. Vacuum tube lift system for large piece goods (photo: Schmalz)

Fig. 7. Compact metering station with modular metering elements (photo: Brabender)