Importance of material testing for the pneumatic conveying of fillers in plastics compounding

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Plastics compounding is an essential and critical step in the production of plastic products and deals with the process of incorporating additives via physical mixing and/or blending into a resin or polymer matrix to compensate for the resin's weaknesses. A wide range of materials is added during the plastic compounding process. Mineral fillers are additives of different shapes that help lower cost and modify the resin's properties without changing its chemical composition.

Particle Interactions and Flow Behavior

During the pneumatic conveying and feeding of fillers to a compounding processing system, particle-particle, particle-equipment and particle-environment interactions influence the filler's flow behavior.

The filler's chemical and physical characteristics such as composition, shape, hardness, particle size & particle size distribution, etc., translate into particle-particle interactions (e.g. van der Waals forces, electrostatic forces, and frictional forces) that affect the behavior of powder flow systems in feeding hoppers and pneumatic conveying systems. Particle-particle interactions are responsible for formation of aggregates or agglomerates.

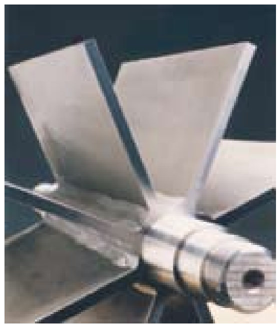
Particle-equipment interactions refer to the interaction of the bulk solid with the walls of the pneumatic conveying system and feeding equipment. The flow of solid particles inside a vessel or a pipe is a function of two important characteristics - wall friction and shear strength. Wall friction relates to how particles slip on a contact surface while shear strength is the resistance that the powder bulk offers to deformation, or how particles slip to each other.

Finally, particle-environment interactions deal with external forces such as temperature, relative humidity, vibration, gravity, pressure, aeration, etc., and how they influence the flow behavior of the bulk solid.

Particle and Bulk Solids Testing

The characterisation of particles at the microscopic or particle level is a necessary and fundamental step to understand the behavior of fillers at the macroscopic (bulk solids) level. Unfortunately, the large number of particle interactions makes it impossible to establish a clear link between filler's properties at the particle-level and its flow behavior as a bulk solid. As a consequence, both microscopic and macroscopic (bulk solid) tests must be conducted for the design, fabrication and selection of pneumatic conveying and feeding systems.

A full understanding of the bulk solid's flow behavior requires a combination of experience, observation



From left: K-Tron Premier Aerolock™ rotary valve in a plastics compounding system; Aerolock™ rotor pockets

and sometimes gut instinct. In many cases, the behavior of solid particles is difficult to quantify. The effect of bouncing plastic pellets within the system, the percentage of particle segregation during transport or the tendency to cling to a metal surface can all have a great impact on the process.

A wide variety of tests can be carried out on a sample of the bulk material to gain insight into its behavior. For instance, determining the bulk density is fundamental in the proper selection of the correct rotary valve used for the pneumatic conveying of mineral fillers. The rotary valve is used to provide the required flow rate (in kg/hr) of material into the conveying stream. A larger rate of filler addition will cause the system to plug as the ratio material/gas (air) gets too high. Conversely, a lower rate of filler addition will cause the system to starve.

Choosing the correct rotary valve depends on the material characteristics, flow rate desired, and system requirements. For each rotary valve model/size, the volume of each pocket (volume between two of the rotor vanes) is known or can be calculated. By using the material's bulk density information, it is then possible to determine how many kilograms of material can be moved in one revolution by the rotary valve.

Conclusion

The exact behavior of fillers in bulk flow is very difficult to predict because of the large number of potential interactions that exist between the different variables affecting such flow. As a consequence, the characterisation of particles at both microscopic (particle) and macroscopic (bulk solids) levels are necessary steps to understand the behavior of fillers in pneumatic conveying and feeding operations.