

Ask Joe! Column

Dealing With “Flooding” Powders

Guest article by Lyn Bates, Ajax Equipment Ltd

When fine powders are pneumatically conveyed, dumped quickly into a storage vessel or agitated, the separated particles trap air in the bulk. It can then take some time for the material to settle to a non-fluid condition. This loose condition gives rise to ‘flushing’ or ‘flooding’ problem in hoppers, where the contents run wildly from the outlet without control.

There is no stopping it!

A belt or screw feeder cannot stop the escape of this flood of product. Many other difficulties are caused by the variations of density and lack of control of aerated powders. Powder in this condition will not pass up inclined belt conveyors and gives rise to problems at transfer points. Volumetric feeders offer poor accuracy, packing machines give variable weights and sometimes the required contents will not fit in the pack. Sacks are unstable and present sealing and stitching problems. Big Bags ‘wobble’ about and the slightest opening leaks profusely. Readers can no doubt extend this list.

These characteristics result from the presence of excess air in the voids of the powder. The weight of the material is partially sustained by the void gas pressure developed as the bulk builds up in a hopper or silo. This pressure inhibits the growth of particle-to-particle contact forces that introduces shear strength to the mass. Air is slow to escape from a large mass because of the long, tortuous path that the gas must travel between the fine particles. The gas can only reach the atmosphere at an unconfined surface so, in a deep bed, the escaping air from the lower layers tends to replace that leaving the layers above. Consequently, the surface layers tend to remain in a fluid condition for an extended period. It is usually necessary to allow such materials to stand for a period before discharging, to allow the lower regions to stabilize to a condition in which it may be handled. Similarly, for a storage hopper in continuous use, it is common practice to retain a ‘heel’ material so that fresh product cannot immediately pass to the hopper outlet.

In a non-mass flowing hopper or “conical-flow” hopper, a narrow flow channel develops during discharge allows loose powder to be drawn from the surface with little time for the material to settle to a stable condition. The limitations of a short residence period are exacerbated by the high flow stream velocity that opposes the back flow of escaping gas. Non-mass flow hoppers are therefore prone to flushing or flooding when loaded with highly aerated material.

Mass flow can help

A simple approach is to widen the flow stream by use of a mass flow design. This, in theory, maximizes the residence time, minimizes the flow velocity, and provides the most favorable circumstances for the powder to settle to a stable and relatively consistent condition. Unfortunately, two features impede achieving the predicted benefits. First, the converging section of any flow channel has a velocity gradient such that material moves quicker in the center than at the outer regions. This shortens the shortest residence time well below the average. The second feature is that product in a fluid state exerts hydrostatic pressure. This means that the horizontal pressure applied by the fluid material greatly exceeds that of the surrounding non-fluid material in the discharging flow stream. As a result of these effects the faster moving region draws down the more fluid material, which then further resists the inflow of the less dilute surrounding powder until the fluid product eventually penetrates the bed of material to the hopper outlet.

Delaying discharge until the powder has settled or using a larger bin to give a longer residence time may not be satisfactory options. De-aeration can be accelerated by use of submerged vent devices covered with filter cloth. These tend to have limited value because they clog easily as de-aerated powder presses against the filter surface, leading to an impervious mass resisting further gas passage. A more durable technique is to mount inclined plates from the container wall. These act as reverse sedimentation surfaces for the gas. Air rising from within the bed meets the underside of these plates and accumulates, to flow up the surface with little resistance. The gravitational shadows of these plates shelter their under-surfaces from high contact pressure on the stored powder, allowing the velocity of the air to carry along local fines and enlarge the cross section of the gas channel.

Get the air out - solutions you can use

A more sophisticated method is to mount an array of vertical rods from a frame. Even as a static structure, these intrusions to the powder bed constrain the packing characteristics of the particles against the surface of the rods. The local increase in voidage between the particles produces a statistically empty space around the rods. The ring of 'space' around each rod allows air to pass more easily to the surface, thus providing a multiplicity of vent channels acting deep into the powder bed. The velocity of rising air reinforces the gas escape channel and small, volcano-like eruptions of gas and fines emerge around the rods at the powder surface.

This technique is enhanced by the application of a rotary vibrator running at the natural frequency of the extended rods. As they resonate in a circular path in a fundamental or higher mode of vibration, they press impress a hole into through powder bed. This provides effective, multiple escape routes for the gas under the pressure differential between the deeply submerged voids and ambient.

The combination of inserts, mass flow design and de-aeration devices, requires a degree of experience to secure optimum effects. In fact some duties require the simultaneous injection of controlled volume air, to prevent the material flow condition becoming too de-aerated and causing other flow problems. The technology however, offers a solution for many intractable installations that suffer from the effects of excessively aerated bulk materials.

About the Author

Many thanks to Lyn Bates who has been a major contributor to the Ask Joe! column. As managing director of **Ajax Equipment Ltd.** in Bolton, UK (www.ajax.co.uk), he finds time to serve on the Bulk Material Handling Committee of the Institution of Mechanical Engineers and be a UK representative to the Working Party for Mechanics of Particular Solids of the European Federation of Chemical Engineers.

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Welcome to Ask Joe!, a monthly column by our resident materials handling guru, Joe Marinelli of Solids Handling Technologies. Joe addresses the issues that bug you the most. And Joe knows!! Formerly with Jenike & Johanson, Solids Flow and Peabody TecTank, Joe is an expert on materials handling.

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Guest articles for the **Ask Joe!** Column are always welcome, for more information please contact Joe Marinelli directly at his email address: joe@solidshandlingtech.com.