Retrofitting Processes to Solve Material Hang-up Problems

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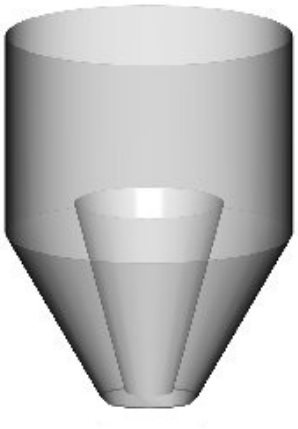

When bulk material hangs up (arches or ratholes) in existing processes, and it is not feasible to redesign the material to run smoothly, retrofitting the current system is often the best answer. Material hang-up problems are generally caused by one of four things: cohesive forces between powder particles or granules, inter-particle locking, external forces, or elastic confinement issues. It is critical to understand the type of hang-up occurring. Most common is generation of cohesive blockages due to adhesive forces between particles. This causes the bulk material to support shear and normal forces allowing the material to remain stagnant under normal gravity feed situations. In this case bulk unconfined yield strength must be measured as a function of stress applied. The basic criteria to prevent hang-up in any process equipment is a limiting condition. Hang-ups occur in the equipment if the bulk material strength exceeds the local stresses acting to break up the stagnant zone. Unconfined yield strength is the major principle stress required to induce material to yield or fail in shear. All bulk materials have weight and some processes operate in such a way as to induce external stresses in the material. If the combination of the process geometry, material weight, and external forces can induce stresses greater than the yield strength in all portions of the equipment, then the material will flow. In simple geometries, the hopper outlet is wide enough to prevent arching and the hopper slope is steep enough to induce mass flow. In more complex geometries, material may not have sufficient strength to induce a hang-up over the outlet (arch) but have more than enough strength to induce stagnant formation along the container walls (rathole). The first step is to measure standard flow properties of the bulk and compute the stress level experienced in the design to determine why the material hang-up is occurring. Often existing designs are non-plane flow and the arching problems can be helped if the lower portion of the existing design is converted to a plane flow design – this is called retrofitting, and will significantly decrease the arching problems. The sloping walls of the hopper must be steep enough to induce flow at least up to the critical rathole dimension – standard design criteria developed by Jenike. Check the design from a flow rate standpoint to assure material will flow at the required flow rate. Note that design criteria can change if material segregation is an issue. Overall, there may be multiple mass flow design options that will work with any given material. However, in retrofit conditions the biggest issue is usually lack of headroom. Proper retrofitting of the system often requires engineering judgment.

If the hang-up is due to particle interlocking then the outlet size must be at least 6 times the particle size. For conditions where the particle size distribution is wide or multi-modal the question of which particle size to use is a question of engineering judgment. Where hang-up is caused by elastic constraint issues, traditional yield strength does not control the flowability. Essentially, the condition in the process equipment is in a confined state and yield strength is defined for an unconfined state. This results in a pseudo-strength that is due to the extra confining pressure. In this case, it is critical that the retrofit design induce flow along the walls to prevent or release the elastic constraining condition. Again, traditional mass flow design principles do not apply. Finally, external forces, gas pressures, vibrations, etc., can induce additional compaction stress or reduce major principle stress required to knock down hang-ups. Retrofitting to achieve mass flow designs is possible in these conditions, but the external body force terms must be included in the design to assure reliable flow without hang-ups. At Material Flow Solutions, we can help you optimize a retrofit solution for your process.

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