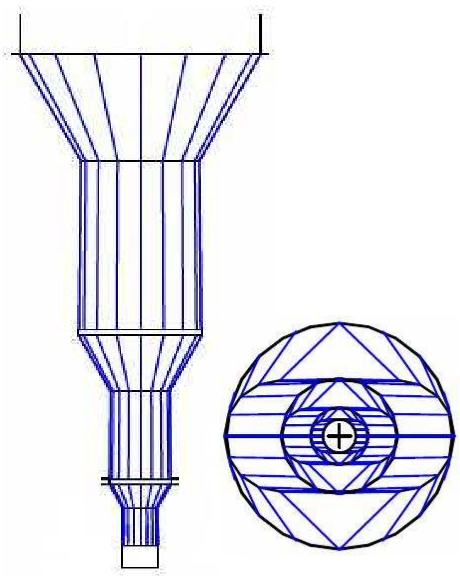
Solving Hang-up Problems in New Process Equipment

Material Flow Solutions, Inc.



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 that you may be experiencing. The most common is the 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, you must measure the unconfined yield strength as a function of stress applied. The basic criteria to prevent hang-up in any process equipment is a limiting condition. Hang-ups will occur in the equipment if the strength of the bulk material exceeds the local stresses acting to break up the stagnant zone. Unconfined yield strength is defined as 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 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, this means that the hopper outlet is wide enough to prevent arching and the hopper slope is steep enough to induce mass flow. It is entirely possible that a given geometry may not have sufficient strength to induce hang-up over the outlet (arch) but have more than enough strength to induce stagnant formation along the container walls (rathole). The method of design for standard materials is to measure standard flow properties and then compute the stress level expected in the design to determine if the material will arch and rathole. If the material is sufficiently cohesive to rathole over the outlet, then consider changing the outlet to a plane flow design. This will significantly decrease arching problems. You will need to make the sloping walls of the hopper steep enough to induce flow at least up to the critical rathole dimension. This is standard design criteria developed by Jenike. At this point, the design should be checked from a flow rate standpoint to assure that material will flow at the required flow rate. Additionally, design criteria will change if segregation is an issue. It should be pointed out that there are dozens of mass flow designs that will work with any given material. Thus, there is rarely just a single solution.

If 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 decision of which particle size to use is based on engineering judgment. In the case where the hang-up is caused by elastic constraint issues, traditional yield strength does not control flowability. In essence, the condition in the process equipment is in a confined state and the 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 design induce flow along the walls to prevent or release the elastic constraining condition. 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. Mass flow designs are 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 find the optimal solution for you new process design.

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