Retrofitting Your Equipment to Overcome Process Flow Issues

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Often the most cost effective solution to process flow problems is to modify or retrofit the current process to work with the current material(s). One significant advantage to this approach is that existing structure and capital equipment can be used. Another advantage of the retrofit design is that the plant always has ample product for flow property testing. The down side of the retrofit solution is that headroom and space may be limited. As a result, sometimes a retrofit will require a limit in capacity of process equipment. Realistically, this limit can be considered a lessor problem since flow behavior in current equipment has likely effectively reduced the active volume. Therefore, any change in the process will be better than the current poor operation.

The first step in retrofitting a process is to quantify the behavior in the current plant operation without pre-assigning a cause. The process will have a set of observable behaviors that occur consistently, periodically or chaotically. Some of these behaviors may arise more frequently at certain times of the year (i.e., more pronounced during hot summer months, or conversely during cold winter weather). Some behaviors may be tied to a particular material or operation condition (i.e., always observed at high or low level in the bin, etc.). Sometimes it is possible to directly observe zones that remain stagnant in the process. Other behaviors are detected by monitoring the flow rates at key locations. It is important not to jump to a particular cause too early in the retrofit design process. Several observations can be attributed to multiple causes. The more information gathered during observation, the better these observations will aid in selection of a testing protocol to discover the root cause(s) of the issues occurring in existing equipment. Sometimes it is also advantageous to have well trained engineers visit the plant site to observe these behaviors first hand. Attempting to determine the cause for adverse process behavior without a full set of data upon which to base design can be a large (and costly) waste of time.

Therefore, the second step in retrofit design is to consider and rank the behaviors from those which are critical and must be eliminated from the current design, to those which it would be nice to eliminate, if possible, and finally to those which do not negatively impact the process. In other words, the next step is to determine the constraints which must be imposed on the process retrofit design scope.

Plastic powder

Plastic flakes

Plastic resin pellets

Figure 1. Multiple plastic materials that may be handled in the same process

Just as in new process design, the retrofit design must be undertaken with basic solid's flow principals in mind, particularly when the retrofitted process will handle one or many products (Figure 1). The flow properties of these materials, along with the current equipment geometry, will dictate the expected behavior in the process. Thus, the third step of successful retrofit process design is to determine a testing protocol that will cover the diversity of the products handled in the current process. This set of flow properties can provide the basis of a successful process design. Often the lack of testing and material characterization is the reason the process does not work as originally designed. Successful retrofit process design must be achieved with knowledge of the key flow properties.

It will be critical to assure that the testing protocol is planned in such a way as to simulate the process conditions as close as possible to the expected worst-case operational conditions in the plant. The operator would never purposely run the process past established operation conditions. Doing so could easily induce flow stoppages that would impact production and the bottom line. Thus, process observation can only get the design engineer so far down the road to understanding the critical operations that can cause flow problems. However, it is possible to impose more stringent conditions in the lab and determine the behavior of material at worst-case process conditions, allowing for more accurate determination of the envelope of process conditions that would cause poor process situations. Thus, a robust testing protocol can indicate the critical operation conditions to avoid, and rank the risk associated with certain operations and retrofit configurations.

The current process may be experiencing one or more typical system of poor operation. The process may be subject to rathole or arching effects (Figure 2). Likewise, segregation of product during the handling process may be a problem that requires a retrofit design (Figure 3). Finally, erratic flow rates may cause uncontrolled or unregulated flow from process equipment.

Figure 2. Material hang-up (rathole and arching) of material in a system causes process down-time

Figure 3. Segregation patterns formed during pile formation in a process

If the retrofit process must avoid hang-ups, then the cohesive flow properties of a representative number of materials should be quantified. If the retrofitted process must minimize segregation, then segregation testing of a representative number of mixtures should be conducted. If the retrofit must supply a controlled flow to a downstream process, then measurement of bulk density, permeability and perhaps segregation due to particle size may be required. In most cases, the flow properties depend on the stress levels in the process equipment. Since the flow properties determine the process behavior, flow behavior is often a function of the stress level in the process. It is not generally necessary to measure every mixture and/or product going thru the process, but a representative set of material flow properties will be critical to successful retrofit design.

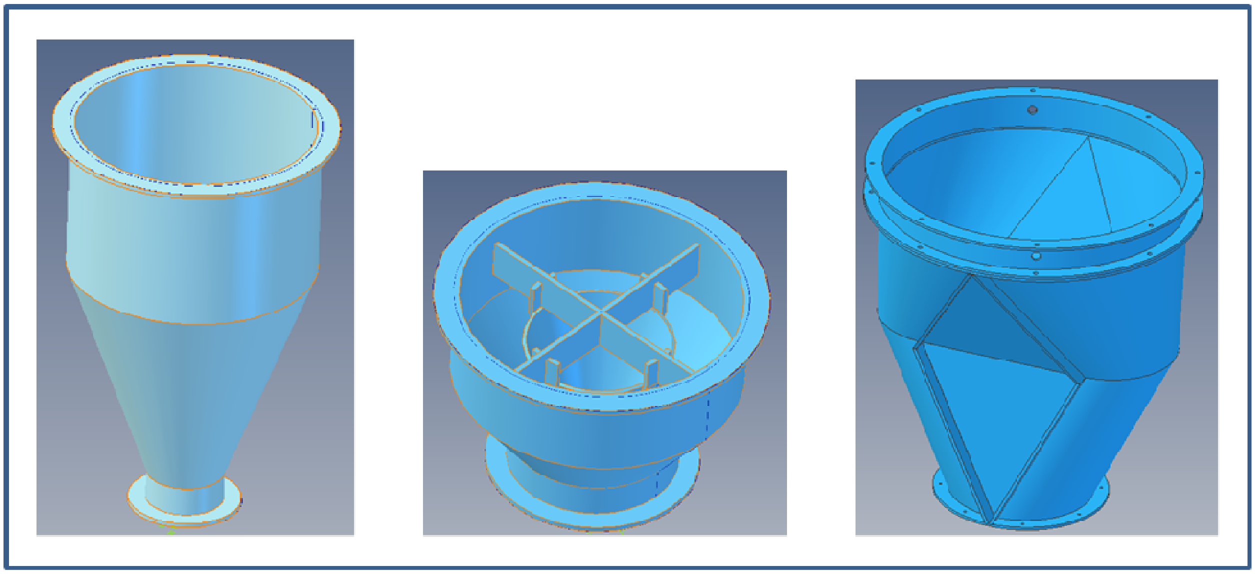
However, key flow properties should be measured at conditions that mimic process behavior (temperature, relative humidity, temperature cycle, time at rest, static charge, etc). In some cases materials may undergo changes (crystallization, aging, particle breakage, or chemical reactions) that alter one or more of the key flow properties during handling. Therefore, a test regimen must be selected that isolates conditions to include these changes. Where possible, the key flow properties should be measured prior to the change, during the change (to act as base-case information), and again after the change (for comparison, reducing the number of process variables which affect material performance). In some cases, the material may demonstrate viscous behavior that causes key flow properties to be a function of strain rate. The testing protocol should include these effects as well. Fibrous material may require special testing protocols.

Sometimes a key requirement of the retrofit is to prevent the unwanted breakage of particles in the process. This will require the test protocol to relate the breakage to the stress/strain and impact velocities in the process (Figure 4).

FCC catalyst *Recycled glass* *Pretzel squares*

Figure 4. Examples of particle breakage

Typically, any one (or some combination) of several retrofit recommendations will work to solve the flow issues in the process (Figure 5) by achieving mass flow. However, often the goal is to find the one that fits best in the allowable headroom and space constraints. Because many retrofit options will require excess headroom, the result of the retrofit process may be a reduction in the size of the process equipment. As a result, surge capacities may have to be sacrificed to achieve reliable operation in the retrofitted processes. A ranking of acceptable losses should be developed prior to the start of the retrofit design. This may automatically limit (or eliminate) some of the potential retrofit configurations, making them impossible to satisfy the allowable process constraints. It is possible to keep the same outlet diameter and modify the process equipment shape to avoid hang-ups.



Conical hopper *Cone-in-cone hopper* *Diamondback® hopper*

Figure 5. Some examples of mass flow hopper configurations

Finally, during the review of the process and the retrofit design it may be concluded that certain operation conditions must be avoided at all costs. These can be identified as part of the retrofit process and operation procedures recommended to prevent recurrence of the poor process conditions. Be aware that sometimes the amount of gas entrained in the bulk material or the process pressure gradient can change the flow behavior of the material and it will be necessary to control these gas pressure gradients during the handling process to avoid poor process operation. This analysis should also be part of the retrofit system design.

The amount of gas entrained with the bulk material may change the key flow properties and, therefore, the expected flow behavior. It may increase or decrease the hang-up potential depending on the situation. It could modify the segregation potential as well. If these operational conditions are known at the time of retrofit design, then the effect of these conditions can be incorporated in the process design, including a set of operation parameters to assure reliable operation. At Material Flow Solutions, we can help you find the optimal solution for your retrofit process design to use as much of the existing system as possible while allowing reliable flow.