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Fluidized Bed Plow Mixers

Plow mixers have revolutionized the solids mixing industry by presenting an intermediate range of mixing technology to the industry.

Before plow mixers, solids mixing was broken into two classifications, low and high intensity. Low intensity mixers gently mix and fold the product, generating very little shear and heat but doing a minimal job of mixing as measured by process time and particle distribution. High intensity mixing, accomplished the mixing in a relatively short time but at the expense of particle degradation and heat input due to mechanical energy buildup. In brief, the application of shear typically increases with the intensity of the mix action, and thus drawback occurs.

The mechanically fluidized plow blender opened a new era by providing means for quick, intense mixing without the application of high shear. This happens by using a method called particle fluidization. Particle fluidization, by definition, is the separation and agitation of solid particles using a rising stream of process gas. Mechanical fluidization is a process of separation and agitation of the particles using the impingement of the product on a rotating element. This is usually done in a cylindrical horizontal vessel that contains a rotating shaft. On this shaft are a series of rotating elements (plows) which are designed to lift and separate the product inside the vessel. The design of the blades, the number and spacing of the elements, and the speed all contribute to fluidization. When done properly, all particles are rotating in a torus, moving in three directions while intermingling in suspension.

The sum of this technology is that given the proper design of the blades the product is lifted in such a gentle manner that very little shear occurs. The advantages of this over a gas fluidization are many. Inside the gas fluidizer the gas becomes the controlling factor, bringing along with it problems dealing with complex fluid mechanics. Furthermore, the suspension of particles using compressible fluids is inefficient both in the propulsion of the particles and the conditioning of the propellant gas. Inside the mechanical fluidizer the fluidization is directly controlled by the rotational speed of the agitator; this becomes a simple mechanical variable to command.

The applications of this technique are many. Because of the gentle yet intense mix action in a hermetically separate environment, a perfect condition exists for a variety of chemical processes to occur.

By its nature, this environment provides the most intense mix action available. This action is excellent for both solid and multi-phase mixes. Mix ratios of up to 1:20,000 are possible. Mixing occurs in a very short time, usually minutes. Mixes of over 600,000 centipoise are possible. The reason for this is twofold: the mix is fluidized and at the same time is being rapidly agitated in three dimensions. Three of the most popular applications; particle granulation, drying, and reactions, account for the majority of installations throughout the industry.

Since the particles are suspended, there is a maximum particle surface area exposed to the process. Small amounts of liquid can be injected to coat the particles in an exact and consistent manner. A binder liquid can be applied to cause the particles to agglomerate. The major advantage of this method of agglomeration is that it generates more shear and particle-to-particle contact; therefore, less binder is used and stronger agglomerates are generated. Another advantage is the ability to process sticky products. High-speed mills quickly disperse the liquid evenly throughout the mix. Typical batch cycles are usually less than 10 minutes. The granulation can then be dried in the same vessel.

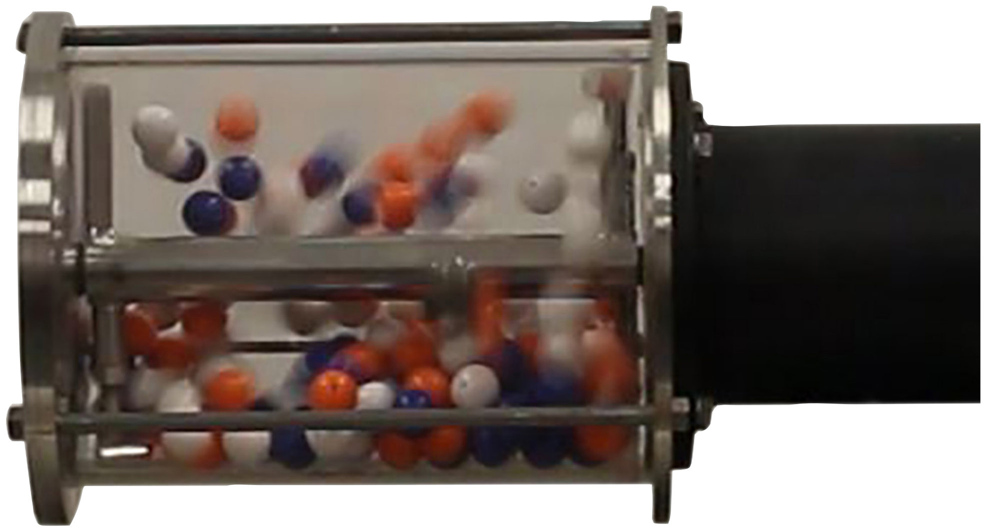
Three variables, heat transfer, surface area, and vapor pressure, affect the removal of moisture from solids. Vacuum drying is the most efficient form of product drying known. By reducing the vapor pressure, moisture can be vaporized at a lower temperature using less heat energy than boiling at atmospheric. Drying in a gas-fluidized bed dryer is difficult because the vapor pressure must be increased to suspend the particles. In a mechanically fluidized bed dryer the movement and suspension of the particles is independent of vapor pressure. Therefore, low vapor pressures (high vacuum) can be achieved by correctly sealing the vessel.

Vacuum drying in a low intensity blender is slow because the particles are not efficiently exposed to the low vapor pressure or to the heat transfer media. Because tumble dryers, vacuum dryers, ribbon blenders, merely stir the product, only certain areas are exposed to the low vapor pressure at any given time. In a fluidized bed, with all the particles suspended, maximum surface area is exposed to the low vapor pressure. Heat transfer is the final variable. Gas fluidized bed dryers are utilize the propellant gas along with a heated container shell to transfer equation. In low intensity blenders, the product is stirred and eventually will be exposed to the heated vessel walls. Product particles in the mechanically fluidized bed dryer, because of the intense mix action, "visit" the walls of the vessel at a high rate and therefore pick up heat quickly.

A final factor that must be dealt with during drying is the formation of agglomerates during the process. When this occurs, the outside shell of the agglomerates become dry and impervious, shielding the moistures inside from both the low vapor pressure and the available heat. The drying process at this point levels off, with little moisture being removed. The natural mechanical action inside the vessel will eventually break these agglomerates, exposing the inner moistures to the low vapor pressures. Unfortunately, this process comes at the expense of time and energy. Some mechanically fluidized bed manufactures offer high shear mills that are inserted into the mix at right angles to the rotational flow. These mills, with correct blade design, can be used to break these agglomerates as they form, keeping the moisture exposed and therefore lowering the overall drying time.

Within the fluidized bed mixer, with maximum particle intermingling and maximum heat transfer available, a perfect environment for reactions exist. Again, this action is entirely independent of vapor pressure; thus, pressures can be increased either through gas injection or through exothermic reactions. The ability to vary the pressure while maintaining these conditions makes this type of mixer a very efficient chemical reactor. Products can go through various theological stages while inside the mixer with little effect on this mix action. Liquids, solids, and gases can be combined inside the reactor in the most intimate manner under the most optimum and exact temperatures. Given the correct design, the vapor pressure can be lowered enabling the vessel to dry as well as react. In many instances, a product can be completely manufactured from its basic ingredients are noxious or detrimental to the environment.

While the basic action remains the same, a number of design changes are required to utilize the mixer as a granulator, dryer, reactor, etc. For most applications, these involve blade changes, shaft seal changes, vessel structural changes, as well as ancillary attachments such as vacuum filter stacks and solvent recovery systems. For granulating and coating, the mixer must be equipped with non-clogging injectors designed to correctly disperse liquid ingredients into the fluidized bed cloud. Many times high-shear mills are used to help disperse this liquid. To correctly apply the liquid, the correct design and positioning of both the injector and mill are critical.



When using this type of mixer as a dryer, it is very important to seal the vessel as much as possible in order to maintain a high level of vacuum. Vapor pressures of less than .1 atmosphere are typically required for these dryers to be efficient. Therefore, mainshaft mechanical seals and mechanical mill seals are required to prevent excessive air leakage. Access door and discharge valve design also greatly affect the level of vacuum achievable inside the dryer.

The overall success of a mechanically fluidized bed process system is very much dependent on the correct application of the device, as well as the final configuration of the machine designed to do the job. Agitator design, seal design, charge and discharge configurations, horsepower, heat transfer devices, ancillary equipment all contribute to the attainment of a good installation. The final configuration of this type of equipment is very much dependent on the manufacture's counsel. Much of this information can be developed through pilot plant testing. A large part of the brand decision associated with purchasing a mechanically fluidized bed plow mixer comes from a processor's comfort level in working with a certain manufacturer. There is usually much development work and attention to detail required in this type of purchase; the ability to work these details with the manufacturer can greatly affect the success of the project.

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