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Innovative Mixing Technology

by Gabriela Mikhaiel

This article discusses fundamental challenges in powder mixing and an innovative mixing technology aimed to improve blending processes.

The mixing of powders is a common and critical element of many solids processing industries. Many challenges have to be overcome not only in terms of safety and hygiene, which are of paramount importance, but also to achieve the best possible homogeneity knowing that a perfect blend of two or more components is very difficult to achieve.

The aim of each mix or blend is to obtain a uniform distribution of all components. The lower the variation of the composition of a sample in comparison to the same amount of powder of the mixture, the better the quality of the mixing.

Statistically, however, perfect homogeneity is unlikely to be achieved. At best, one achieves a random mixture, i.e., a mixture, in which the probability of finding a particle of any component is the same at all locations and equal to the proportion of that component in the mixture as a whole (stochastic homogeneity) - *Figure 1*. This type of mixture generally achieves the best results, provided the different powders have the same physical properties, according to Rhodes.[1]

However, different product properties can lead to segregation. With significant loss in quality when mixing solid materials, the pharmaceutical industry is particularly concerned with the problem of particle segregation. Williams says that one of the most common causes of segregation consists in the motion behavior of particles with different particle size and density, namely segregation by percolation of fine particles.[2]

The Selection of a Mixer

Segregation must be balanced by the mixing principle with respect to an ideal distribution. An ideal blending system achieves statistically the best possible distribution. When selecting a blending system, it is therefore important to choose the type of mixer that is able to compensate for the different properties of the mixed particulate solids.

Mixing Mechanisms by Lacey[3]

1. **Diffusive mixing** – this type of mixing includes blenders, which move the particles by rotation, e.g., drum, double-cone, and V-blenders.
2. **Shear mixing** – the mixing occurs in slip zones between the powder. This category includes rotor mixers.
3. **Convective mixing** – the mixing process takes place by the circulation patterns within the powder, e.g., through rotating paddle systems. One of the most common convective mixers is the ribbon blender.

Although there are more or less suitable mixers for individual product characteristics, most conventional systems tend to have limitations and disadvantages, such as product loss, powder abrasion, and weak containment and are inflexible with respect to the batch sizes. With these issues, industry is seeking solutions that move away from traditional batch process engineering to improve operating and economic efficiency. The future lies in semi-continuous and continuous blending systems.

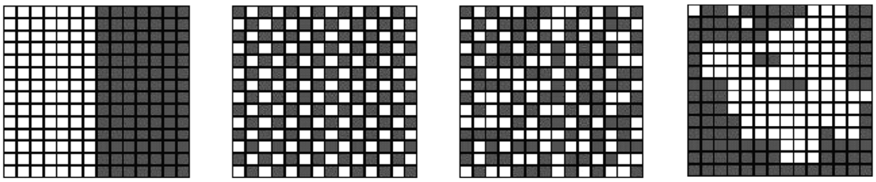

Figure 1. Mixing progressions.

New Developments in Blending Processes

With the aim of improving and/or removing the current blending issues, DEC developed an in-line mixing system to blend active substances without modifying their physical properties and without the risk of contamination for operators and environment. Based on Powder Transfer System (PTS) technology, the system transfers, mixes, and discharges products fully automatically by means of vacuum and pressure under inert conditions. It is especially suited to meet the needs of the pharmaceutical industry and offers the possibility to mix hygroscopic, oxygen sensitive, or explosive powders.

Flexible Scope of Application

With the same unit, different batch sizes can be run, from laboratory scale to large scale production. The mixing system blends powders with large differences in blend ratios (1/10,000) and different properties, ensuring homogeneity and high containment.

This technology is easy to integrate into production lines. Powders can be transferred automatically from drums, sacks, or from process equipment (e.g., a dryer, etc.).

Operating Principle

The system comprises a main mixing vessel with an integrated central deflector, allowing a homogeneous powder distribution. A PTS consisting of a cylindrical chamber with two tangential inlets is installed on top of the tank.

The blender is further equipped with pneumatic valves that are connected to a pneumatic or an electro-pneumatic control cabinet. The PTS chamber is filled and emptied in a cyclic manner by alternating vacuum and pressure. The powders are introduced automatically into the PTS chamber by the opening of one inlet valve, the vacuum valve, which is connected to the vacuum pump and one of the two 3-way-valves. The chamber is emptied by the opening of the outlet valve and the pressure valve for compressed air or nitrogen to dispense the powder over the deflector into the main vessel. Once the powders are all introduced in the main receptacle, the mixing process starts by circulating and conveying the powder again upwards through two mixing pipes into the PTS body where the two jets of product meet, enhancing the efficiency of the mixing process to be emptied back again into the mixing tank.

A flat filtration membrane in the upper part of the PTS prevents fine particles from entering the vacuum system. In order to guarantee its suction capacity through the cycles, this membrane is cleaned with each emptying cycle in a counter current fashion by compressed air or inert gas.

The materials are transferred in dense phase mode and as the speed at which the powders are circulated is limited, particles are not damaged or subject to attrition.

After mixing, the system can be automatically discharged and the mixed powder is conveyed through the bottom towards the next process step by another vacuum source.

Blending Effectiveness

Mixing trials, conducted by the University of Applied Sciences Institutes of Life Technologies and Systems Engineering in Switzerland, reporting the validation of the mixing performances and efficiency for a mixture of two cohesive powders, lactose monohydrate as excipient, and salicylic acid as tracer have proven to obtain promising results. The tests were carried out with a 100 l system with a theoretical mixing capacity varying between 5 l and 90 l, controlled by computer software regulating filling, mixing, emptying and cleaning steps. They studied the effect of the fill levels (25%, 50%, and 90%) and tracer concentrations of 0.01% to 10% (w/w) achieved without pre-blending on the blend homogeneity (relative standard deviation, RSD) and the mixing

Figure 2. PTS Batchmixer, fully contained, self-filling powder blender.

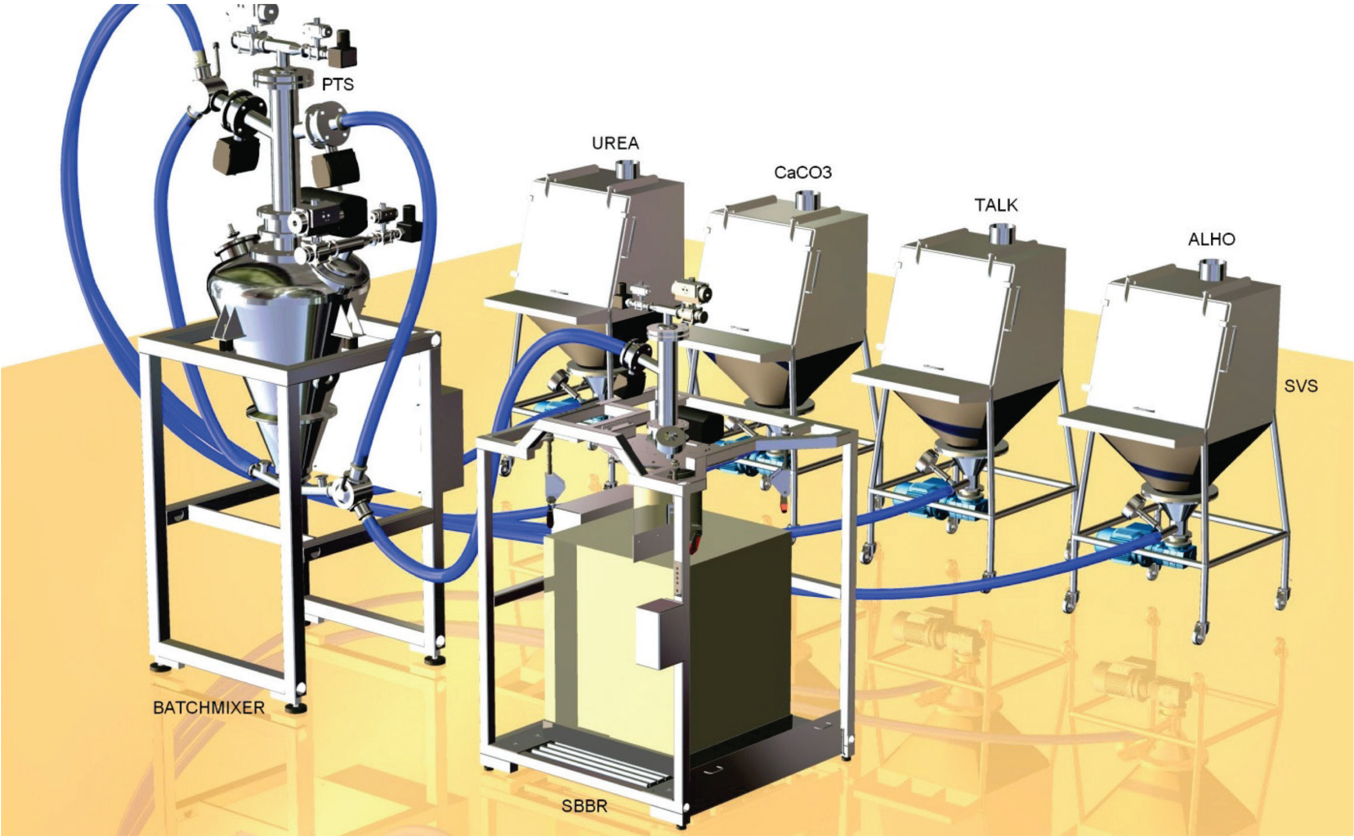

Figure 3. Multiple ingredients powder blending.

time. They also investigated the effect of the sampling size (30 g vs 1 g) on the stochastic homogeneity of salicylic acid blends with an automatic sampling device.

The crucial operation of the sampling, which results should be representative for the whole mixture, was done by two in-line sampling devices taking samples during the mixing process; the MPTS sampling device for 30 g samples and the MicroPTS system for 1 g samples. Both systems work with vacuum and pressure in dense phase mode.

The system has achieved very good results. It obtained highly diluted blends up to 0.01% w/w without premixing stages within 6 min. and without segregation after the mixing process of about an hour. Concerning the repeatability, the target concentrations are reached with RSD values between 1.5% and 7% as far as the 30 g in-line sampler is concerned, depending on the concentrations studied. The 1 g in-line sampler allows the investigation of the homogeneity of high-dilution blends within the limits of +/- 10% of the target value, without any disturbance of the actual mixing state. See reference for complete test results and discussion.[4]

Conclusion

The mixing system discussed is available in different sizes from 5 to 3000 l and is a closed self-filling blending system ensuring satisfactory product homogeneity, a high level of containment, and significantly reduced mixing times in comparison to traditional systems. It has no moving or rotating mechanical parts, therefore requires little maintenance and is easy to clean (CIP/SIP).

References

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About the Author

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