Solid Blending Mechanisms and Blend Structures

Author: Jayesh Tekchandaney
Date: 17th July, 2009

The previous article “Introduction to Mixing Technology” defined “mixing” and “blending” operations and discussed the differences between the two. The importance of mixing in the industrial applications was highlighted along with a brief introduction to the different types of mixing and blending equipment.

This article highlights the differences between mixing of liquids and blending of solids and emphasizes the challenges associated with blending of granular and powdered solid materials. The different types of solid blending mechanism and the blend structures are discussed. A good understanding of these concepts is important for selection of suitable blending equipment for solid materials.

Differences between Liquid Mixing and Solid Blending

The mixing of low-viscosity liquids is due to creation of flow currents that transport unmixed material to the mixing zone adjacent to the impeller. Liquid mixing has been a subject of extensive research and is well documented. The improvements in liquid mixing technology have made it possible to produce a well mixed, truly homogenous liquid mix with uniform composition.

Though the blending of solids to some extent resembles the mixing of low-viscosity liquids, there are significant differences between the two processes. A solid material cannot attain the perfect mixing that is possible with liquids. In case of solids, there are no flow currents; the three primary mechanisms of blending are diffusion, convection and shear. These three mechanisms occur to varying extents depending on the type of mixers, blenders and the characteristics of the solids to be blended.

Mechanisms of Solid Blending: Diffusion, Convection and Shear

Diffusion Blending

Diffusion blending is characterized by small scale random motion of solid particles. Blender movements increase the mobility of the individual particles and thus promote diffusive blending. Diffusion blending occurs where the particles are distributed over a freshly developed interface. In the absence of segregating effects, the diffusive blending will in time lead to a high degree of homogeneity.

Tumbler blenders like the double cone blenders, v-blenders function by diffusion mixing.

For rapid blending, in addition to the fine-scale diffusion blending there should be a means by which large quantities of particles can be intermixed. This is accomplished by either convective or shear mechanisms.

Convection Blending

Convection blending is characterized by large scale random motion of solid particles. In convection blending groups of particles are rapidly moved from one position to another due to the action of a rotating agitator or cascading of material within a tumbler blender.

The blending of solids in ribbon blenders, paddle blenders, plow mixers is mainly a result of convection mixing.

Shear Blending

Some texts define shear blending as the development of slip planes or shearing strains within a bed of material. Others define the blending mechanism of shear as high intensity impact or splitting of the bed of material to disintegrate agglomerates or overcome cohesion. For the purpose of this discussion we shall use the latter definition. Shear blending is very effective at producing small-scale uniformity generally on a localized basis.

Blenders with a high speed chopper blades, intensifiers are an examples of shear blending.

Types of Blend Structures

There are two types of blend structures: Structured and Random.

Structured, ordered or interactive blends are observed in most industrial processes. Here, the different blend components interact with one another by physical, chemical, molecular means or a combination of these resulting in agglomeration or coating. e.g. in granulation large particle agglomerates are formed from smaller particles. The large agglomerates thus formed comprise of a uniform blend of smaller building block particles. These agglomerates may either be of uniform size or of different sizes. A blend of agglomerates of uniform size will not segregate after discharge from the blender, however, when the agglomerates are of different sizes, then segregation by size may occur and result in problems like variation in bulk density, reactivity in post-blend processing. In some cases, especially in fine materials the blend components have a tendency to adhere only to themselves, without adhering to the dissimilar components. e.g. carbon black, fumed silica. For blending of these materials, shear blending mechanisms are adopted.

When the different blending components do not adhere or bind to each other within the blender, the result is a random blend structure. In a random blend the individual particles are free to move relative to each other and hence there is no bonding with each other. As a result, dissimilar particles readily segregate from each other under the influence of external forces like gravity, vibration and get collect in zones of similar particles. e.g. a blend of salt and pepper. Completely random blends are rarely encountered in industrial applications.

Blender manufactures need to account for these material behaviors during selection and design of blending equipment.

***About the Author* -** Jayesh R. Tekchandaney is the Technical Director of Unique Mixers & Furnaces Pvt. Ltd (www.uniquemixer.com). He has over 12 years of experience in the selection and design of Industrial Mixing Equipment. His company offers the complete range of Mixing Equipment, besides mixing consultation and testing facilities. Tekchandaney holds a Bachelors Degree in Chemical Engineering from University of Mumbai, and a Master of Science in Industrial Engineering from The Pennsylvania State University, USA. He has earned a Diploma in Business Management from Narsee Monjee Institute of Management Studies, Mumbai.

Phone – (91-22)-2580 1214, 2582 2385
Email: jayesh@uniquemixer.com