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Invited review paper

Dry dispersion of fine particles in gaseous phase

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ABSTRACT

Dry dispersion of fine particles is discussed as a simultaneous process of dispersion and agglomeration. Various problems on the dry dispersion are summarized based mainly on our works and key terms such as partial dispersion efficiency and powder characteristic value are reviewed to analyze the dispersion mechanism and to evaluate easiness of dispersion for any kind of powder. Improvement of disperser unit is also suggested based on the analysis of dispersion process.

Electrostatic charging, especially contact electrification between particle and its surface layer, seems to give further improvements on the dry dispersion of fine powder containing sub-micron particles.

Contents

1. Introduction

Dry dispersion of fine particles becomes more important as the particles interested in this field become smaller and smaller. Advanced powder-handling system needs fine particle operations such as particle classification, separation and collection, transportation, feeding, and so on. Dry powder handling is expected to achieve high quality powder processes without any contamination of product powders. In the evaluation of dry powder processes, usually small amount of powder is sampled from the process and particle size measurements are carried out after dispersing it in liquid medium to get the size distribution of fully dispersed particles. However, dispersion in air is more preferable to avoid any characteristic change of the sampled powder. In the case that the particle-properties are changed in the dispersant liquid medium

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through swelling, dissolving, and so on, dry dispersion is the only way to take.

Aerosols, suspended fine particles in gaseous phase, are unstable in nature, and therefore, it seems almost impossible to get fully dispersed gaseous suspension of fine particles. However the limit of dry dispersion in this sense is not yet clear. Here the dry dispersion of fine particles is discussed as the simultaneous process of particle agglomeration and dispersion of agglomerated particles. Various problems on the dry dispersion are summarized and key terms such as partial dispersion efficiency are reviewed.

2. Technological subjects relating to dry dispersion

Fig. 1 shows the main subjects relating to the dry dispersion. First subject is continuous feeding of powder into dispersion unit. Second one is particle adhesion and agglomeration in a transport line or the dispersion unit. Third one is particle deposition and re-entrainment. Further, it should be noted that particle electrification through powder handling is inevitable in the dry system.

Powder feeding for the dispersion unit should be done under suppressing the fluctuation in the powder flow as small as possible so as to maintain the constant concentration of particles in the dispersion unit. For this purpose, further development is needed on the field of evaluation and modification of powder flowability [1–3] or on the precise feeding mechanism especially for fine particles [4,5].

Adhesion and agglomeration of fine particles make the dry-dispersion difficult. The phenomena arise mainly through attractive force between particles such as liquid bridge force, van der Waals force and electrostatic force. As discussed later, particle deposition and re-entrainment are also found in the dispersion system. These phenomena cause re-agglomeration of the dispersed particles.

Primary particles in the powder to be dispersed may have different surface components even in a single particle. In such a case, electrostatic agglomeration also arises. On the other hand, if all particles are electrically charged in the same polarity, positive or negative, they have electrostatic repulsion resulting in easier dispersion but increased particle deposition in the dispersion system. Although the electrostatic effect is sometimes called as electrostatic diffusion, which may have a role to prevent agglomeration, the name electrostatic diffusion is a little confusing. It is not diffusion in such a sense of Brownian diffusion, but it is electrostatic motion induced between anyone of the charged particles and the space charge produced by other charged particles. Therefore, all the particles in the space are contributing to the phenomenon, which makes the numerical simulation difficult.

3. Dispersion methods, process and partial dispersion efficiency

Here the several methods to disperse fine particles are briefly introduced. Then the dispersion process is discussed through introducing partial dispersion efficiency to evaluate both the dispersion mechanisms and achievements of the operation. A new factor named powder characteristic value is also introduced in order to evaluate easiness of dispersion for any kinds of powder. Improvement of a dispersion unit will also be discussed based on the analysis of dispersion process.

3.1. Various methods for fine particle dispersion

Powders stored in a vessel are usually agglomerated. Particles suspended and transported in air are also more or less agglomerated. In the theory of aerosol agglomeration [6], it is postulated that every contact between particles makes them agglomerated. However this is not always true even in gaseous state and some particles do not agglomerate after the contact, as in the case of liquid suspension. Anyway strong dispersion force can bring about sometimes both agglomeration and disruption of particles.

Fig. 2 shows various methods of dispersion [7]; (a) ejector, (b) ventury, (c) orifice, (d) fluidized bed, (e) mixer (high speed rotating blade) type disperser. Both ejector and ventury disperser utilize the suction pressure at their throat to introduce powder into the line. Then the powder is mixed with air and the resulting suspension is accelerated to disperse agglomerated particles. Other dispersers in Fig. 2 need powder feeders. Fluidized-bed disperser utilizes dispersion medium such as coarse glass beads or heavy particles which are fluidized by air. Powder to be dispersed is continuously fed through a side line using an appropriate feeder.

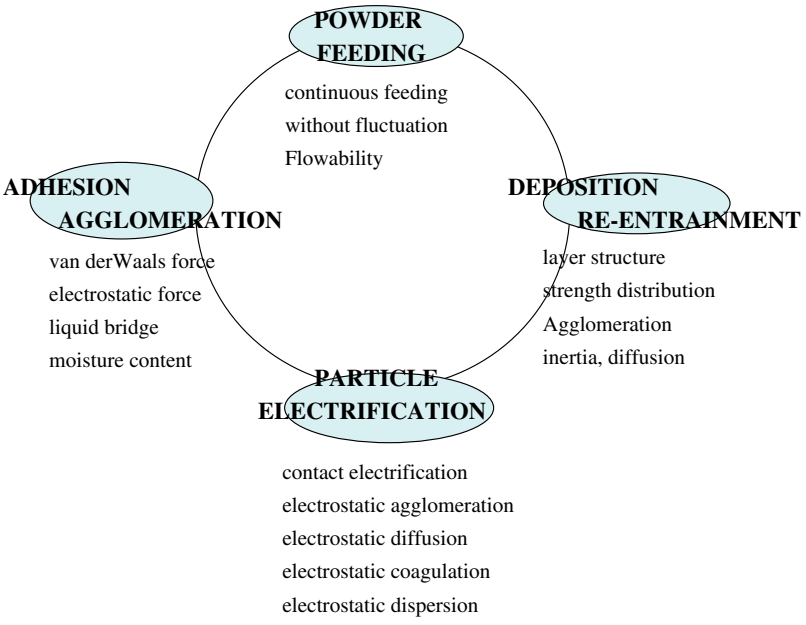

Fig. 1. Main subjects relating to powder dispersion.