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Spray Drying Plants for Manufacture of Dustless Powders—A Technical Note

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The paper describes the methods and the equipment for production of free flowing and dustless powders, which are often required for thermal spraying applications. The powders are made from a suspension including finely dispersed material to be agglomerated as a powder, the binder, and some other components (plasticizers, wetting agents, *etc.*). The binders added in the suspension play a particularly important role with regards to improving the particle size and stability. The paper also describes the alternative drying applications that can be realized using the different types of plants. The systems are described on the basis of two different types of feed product: (1) a liquid and (2) a powder.

Keywords feedstock, free flowing powder, agglomeration, atomization

1. Introduction

There are strong demands for free flowing and dustless powders for the following reasons:

- greater security at handling, because the risk of a dust explosion is substantially smaller when the product consists of coarse particles;
- better working hygiene at handling of the product;
- easier dosing and conveying of the product due to improved flowability; and
- more uniform thermal spray application, which is possible with better deposition adherence.

Granulation and agglomeration are widely used methods for the production of dustless powders.

The purpose of the process is to form a particle composed of a certain size, made of primary particles, and to separate fines from the finished product.

2. Plant Types Used When the Feed Product is a Liquid

2.1 High Body and Wide Body Spray Dryers

The fountain atomizer in a high body dryer is used for production of spherical monogranulates with a mean particle size of 150 to 300 μm, whereas a centrifugal atomizer in a wide body dryer is used to manufacture particles of 30 to 100 μm. The air enters the drying chamber tangentially in countercurrent flow in the case of fountain atomization, while it is cocurrent in the case of a centrifugal atomizer. One or several pressure nozzles are used to atomize the liquid feed for fountain atomization, depending on the plant capacity.

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The drying chamber has a smaller diameter but larger cylinder height for a fountain atomization (Fig. 1a) compared with a chamber designed for centrifugal atomization (Fig. 1b). The dryers are used mostly for drying of ceramics and other inorganic products due to the high heat impact on the products. The particle size can be adjusted by means of pressure, when using a fountain nozzle, and by means of a rotation speed when using a centrifugal atomizer.

Powders for thermal spraying are often very abrasive, and special wheels with wear resistance inserts for centrifugal atomizers, therefore, are required (Fig. 2).

2.2 Uniflow Dryer (Nozzle Tower)

The uniflow dryer is used for production of large spherical particles with a mean particle size of 150 to 300 μm.

The drying air enters into the drying chamber through an air distributor made of several perforated sheets. The aim is to create a laminar airflow without any eddies and to avoid product deposits within the chamber. As the laminar flow reduces the drying efficiency of the plant, it must be compensated by an increase in the chamber height, so that the particle residence time in the dryer in extended (Fig. 3a).

The usual design of the drying chamber, with an outlet duct placed in the center of the chamber, results in carryover of, not only fine particles, but also the larger ones. To avoid this, the chamber can be made with a bustle outlet (Fig. 3b). This reduces the outlet air velocity and also the amount of powder carried into a powder collector. It is not unusual to reduce the carryover of powder to the powder collector from 30% in a standard uniflow dryer to 5 to 10% while using a bustle outlet. Further improvement can be achieved by using a fluidized bed. The improvement is used to render the powder dustless (Fig. 3c). This type of dryer is used for producing heat sensitive products such as dyestuffs, proteins, and similar products.

2.3 Spray Bed Dryer

The spray bed dryer (SBD) consists of a drying chamber with an integrated fluid bed built into its cone. The hot drying air is introduced to the dryer through a specially designed air distrib-

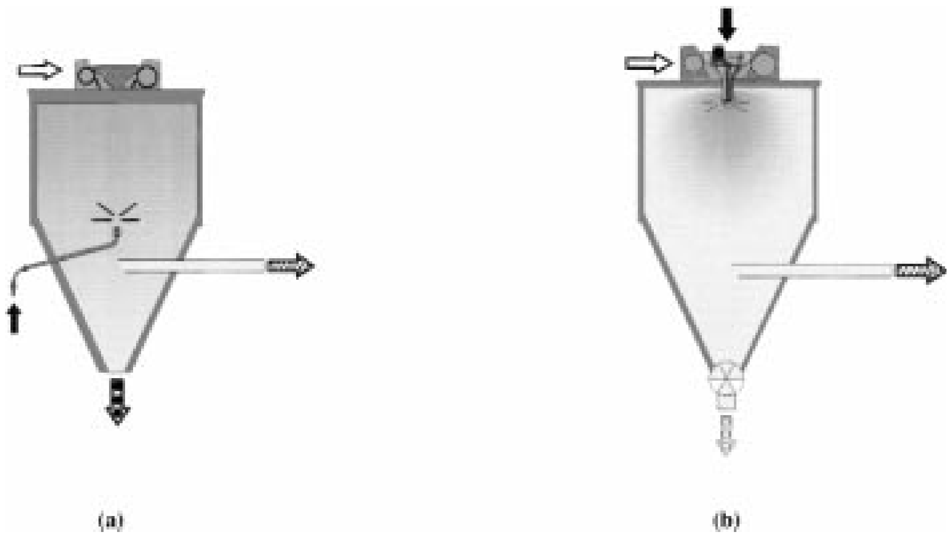
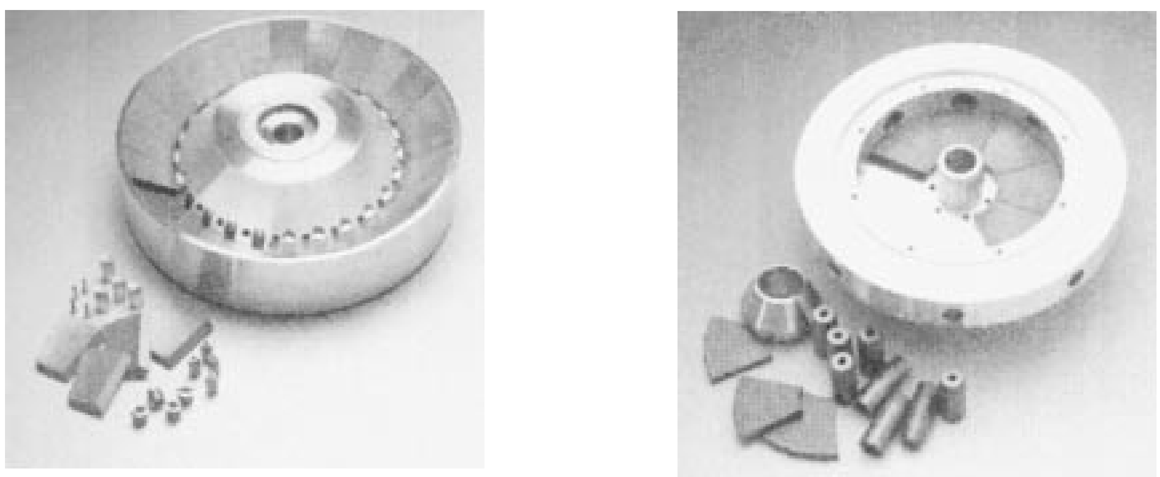


Fig. 1 Spray drying plants: (**a**) fountain atomization and (**b**) centrifugal atomization



(a) **(b)**

Fig. 2 Atomizer wheel with the inserts and the wear plates

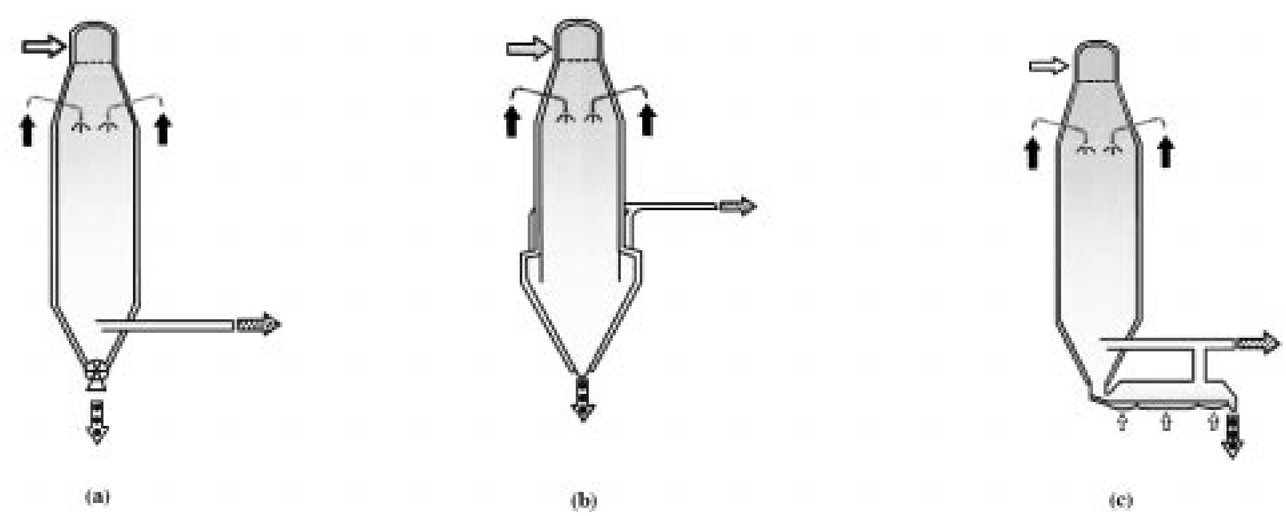


Fig. 3 Types of uniflow dryers: (**a**) laminar flow, (**b**) bustle outlet, and (**c**) fluidized bed

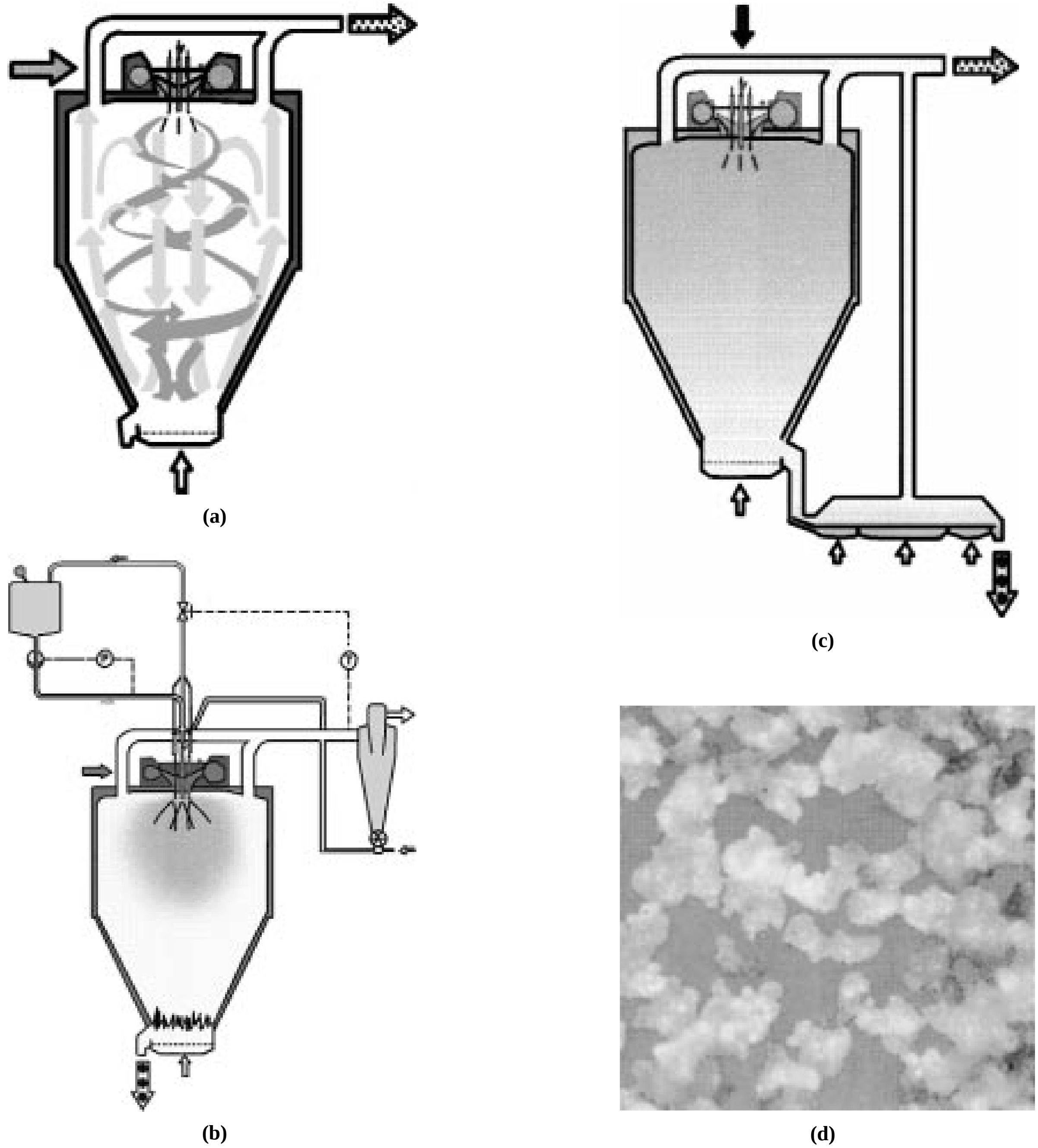
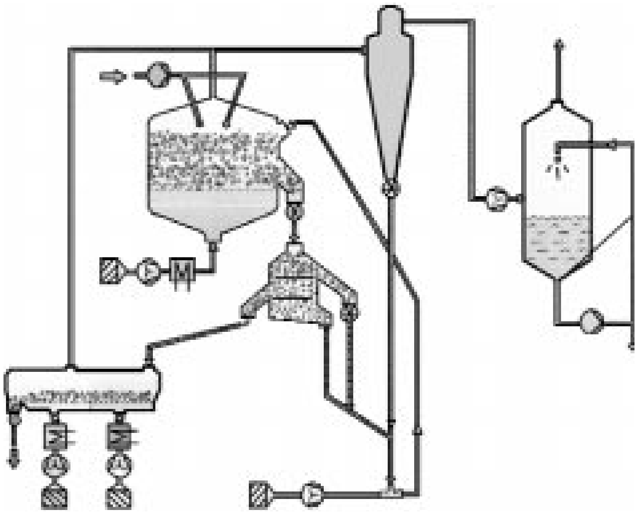


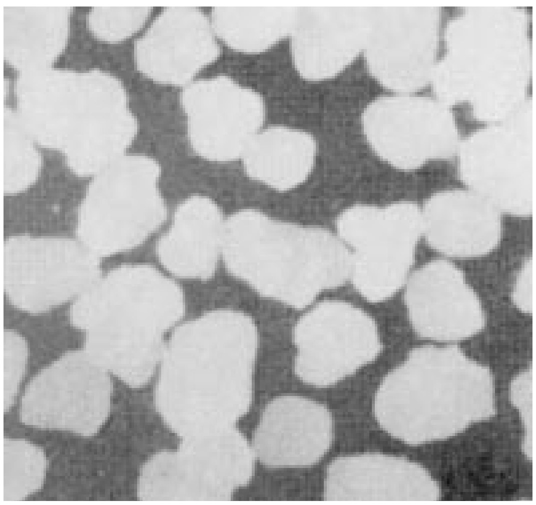
Fig. 4 The SBDs: (**a**) general outlay, (**b**) with fine powder separator, (**c**) with the third stage of drying and cooling, and (**d**) powders produced with it

utor. Liquid is atomized either by means of a nozzle atomizer or centrifugal atomizer (Fig. 4a).

The powder enters into the integrated fluid bed with a relatively high moisture content. Then, the powder is dried to the desired moisture content. The fluid bed air separates fine powder particles from the rough powder particles and carries them to the air outlet ducts situated in the ceiling of the drying chamber. The fine particles pass through the wet atomization zone where agglomeration takes place. Any nonagglomerated powder leaves the drying chamber with the drying air and is separated in a powder collector. The separated fine powder particles are led back to the atomization zone for agglomeration (Fig. 4b). The plant is additionally equipped with a control flow nozzle, where pressure and flow rate to the nozzle can be adjusted separately. Any SBD plant can be more effective by introducing a fluid bed as the third stage for additional drying/cooling and dedusting of the powder (Fig. 4c). This SBD plant produces an agglomerated powder easy to disperse with a good mechanical stability. Particle sizes vary from 150 to 400 μm. The dust amount in the finished product is very low due to the dust reduction properties of the fluid bed. It may be as low as 0% particles below 100 μm (Fig. 4d).



(a)



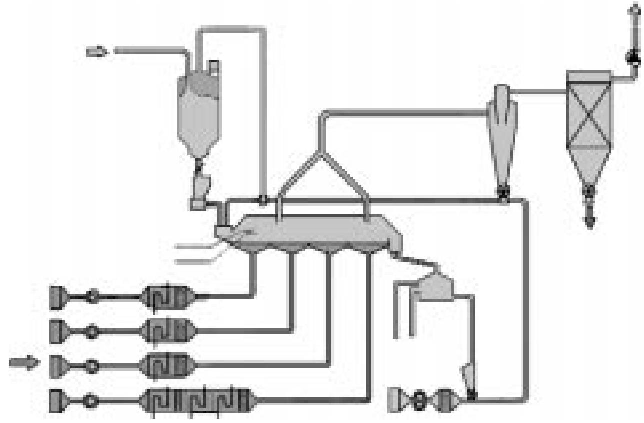
(b)

Fig. 5 The spray granulize: (**a**) outlay and (**b**) powder produced with it

2.4 Spray Granulize

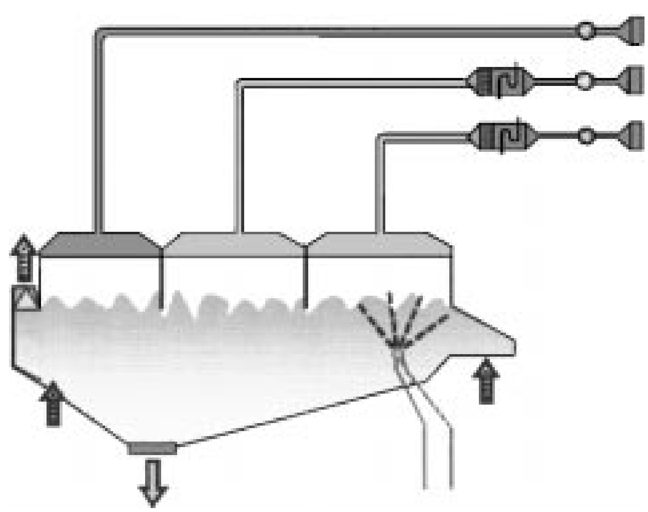
The spray granulizer process is a fluid bed process, but, contrary to other agglomeration/granulation processes, which convert an incoming flow of powdered material into agglomerates or granules, the spray granulizer continuously develops granules directly from the liquid feed (Fig. 5).

Through a nozzle atomizer, the liquid feed is sprayed down into the bed of fluidized granules. The feed droplets adhere to the granules and dry out, and new droplets can adhere and dry. In order to control the final size of the granules, a continuous flow of granules from the granulation chamber is separated into three fractions in a sifter. The oversize fraction can be milled down and the undersize fraction is recycled into a granulator. Thus, new seeds for new granules are continuously being provided for the production process. The middle fraction, which is the final



(a)

(b)



(c)

Fig. 6 The rewet agglomeration: (**a**) outlay, (**b**) powder produced with it, and (**c**) the fluid mix plant of APV Anhydro product, can be post-treated, such as drying and cooling, or can be bagged off directly. As the mesh sizes in the sifter determine the ultimate size of the granules, an equilibrium operation can be established, in principle, for any required fraction of the granules, *e.g.,* between 500 and 700 μm (Fig. 5b). Any liquid, which can form stable, growing granules in a fluid bed, can be transformed to a dustless product in this process. The product produced in the spray granulizer is free flowing, easily dispersible, and easily soluble due to the fine-crystalline single particles in the granules. The product remains stable and free-flowing while exposed to a moist air. A small drawback of this process, while using the liquid feed, is a need of some initial powder to seed the process.

3. Plant Types Used When the Feed Product is a Powder

3.1 Rewet Agglomeration

When the feed material is already in the form of a powder; *e.g.,* from a spray plant with centrifugal or two fluid nozzle atomizer, it is possible to make a dustless product by using the rewet agglomeration process. In this process, the dried powder is initially moistened on the surface with water or other suitable liquid. This enables the particles to stick together and form agglomerates. The product is dried and cooled after agglomeration. The process takes place in a fluid bed divided into sections. Usually, there is an agglomeration section, a drying section, and a cooling section (Fig. 6).

In the agglomeration section, an atomized liquid is sprayed onto the product by means of two-fluid nozzles. The proportion of liquid depends on the product and varies from 10 to 30 vol.%. The agglomerated powder contains particles of a size between 200 and 600 μm. The particle size depends on the powder properties and the quantity of applied liquid. The powder is easy to disperse and dissolve. The bulk density is often reduced in comparison to the density of the powder feed (Fig. 6b).

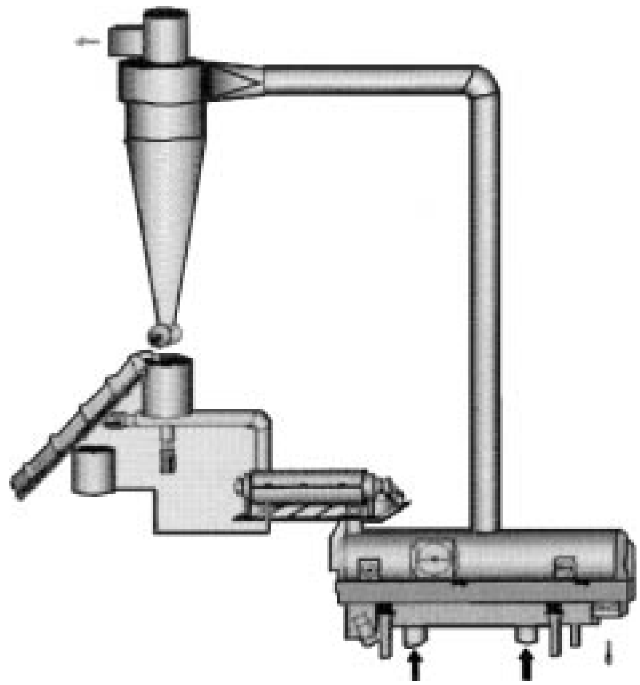
The Fluid Mix plant is an example of this type of process (Fig. 6c). The plant is designed for a continuous production of powder detergents and uses a large amount of raw powder. Mixing and agglomeration of the components takes place in a vibrating fluidized bed. Liquid components such as surface active components and disilicate are atomized into the fluidized powder mixture.

The powder particles are bound together to form stable agglomerates. The fine particles are carried with the outlet air to the powder collector. These particles are discharged and continuously recycled to the fluid bed for further agglomeration. In this way, the process results in a practically dust free product.

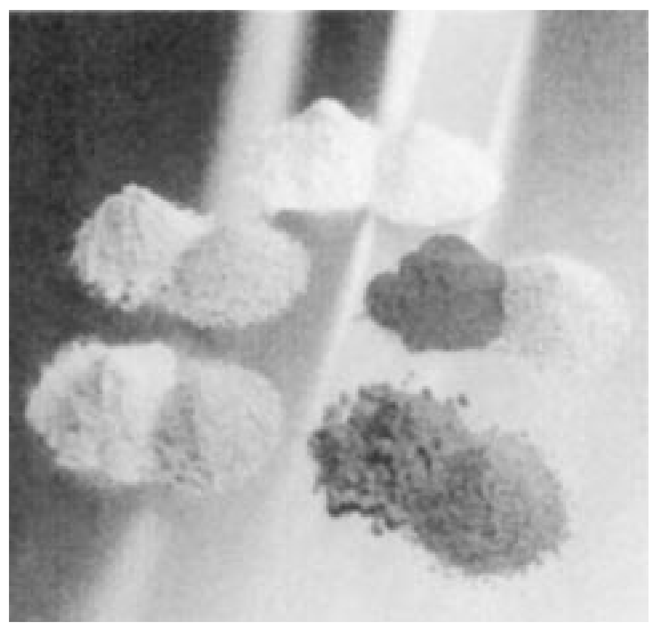
3.2 Mechanical Granulation

Dry powders can be transformed by means of a mechanical granulation followed by fluid bed drying/cooling into the dustless and free flowing granulates with high mechanical stability and high bulk density (Fig. 7a).

In the granulator, the powder is mechanically mixed and, simultaneously, a granulation liquid is applied to the powder, making the particles stick together and form granulates. The granulation liquid may be water, product solution, or other granulating agents to an amount of 10 to 20 vol.% based on the powder rate. After the mixing process, the wet granulates are led into the fluid bed for drying/cooling and dedusting. The fine particles are removed by the drying air and carried to the powder collector. These particles are separated from the air and returned to the granulation process. The mean particle size of the granulates is typically 600 to 1000 μm and the amount of particles below 200 μm is in the range of 0 to 5 wt.% (Fig. 7b).



(a)



(b)

Fig. 7 The mechanical granulation plant: (**a**) outlay and (**b**) powder produced with it

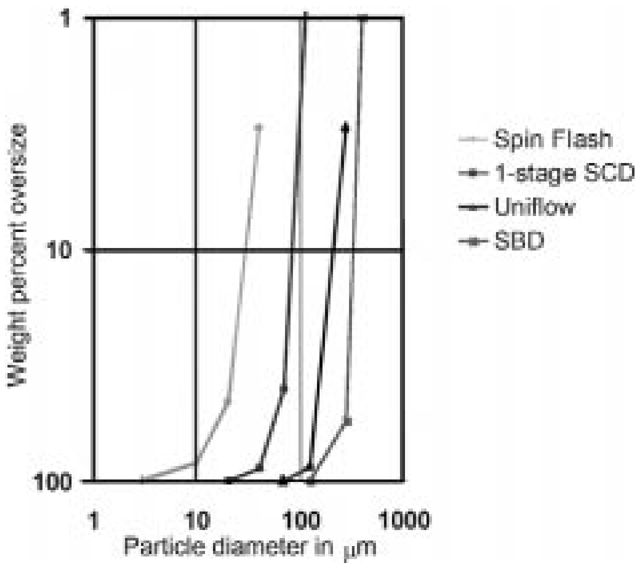


Fig. 8 Percentage of oversized particles obtained using different methods of spray drying

Contrary to a fluid bed agglomeration, the particle size of the feed powder is not a significant parameter, and it is possible to agglomerate even very small particles of 1 to 10 μm.

4. Conclusions

As appears from the above discussion, there are several possibilities to fulfill the growing demand for dustless products. It is not always necessary to invest in a new plant. Existing plants can be modified either by rebuilding them using a spray bed process or by installation of an agglomerating unit, and, in that way, to meet the growing demands from the end users of the products (Fig. 8).

The spray drying processes offer a unique opportunity to manufacture, in a cheap and efficient way, the powders for thermal spraying. The plants shown in this paper can be adapted to produce the powders of specified chemistry and size.

Acknowledgment

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