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A Process for Continuous Production of Spherical Granules with High Density

Reprinted from powder handling & processing March 1993

A Process for Continuous Production of Spherical Granules with High Density

Summary

The following article is an introduction to a unique thermo-mechanical continuous processing technology which transform a liquid or a powder based feed stream into dustfree particulates. The key features of this technology are: a fluidized particle bed, an integrated particle classification system, and a continuous material feed and discharge.

1. Introduction

There are many reasons to dry solutions and suspensions or to make solids from a melt:

- Application Requirements
- Ease of Product Handling
- Ease of Storage
- Enhanced Durability/Shelf Live
- Improved Safety
- Reduced Toxicity

Many of the reasons above coincide with the need to produce dustfree dry powders. For both, drying and granulating, there are various processing alternatives offered by numerous equipment suppliers. Since many different product properties can be obtained using the various technologies available, the selection of the best and most economical technique is very difficult. The state of the raw material, whether liquid or solid, limits the applicability of these processing alternatives.

Spray dryers are broadly used for drying solids suspensions or solutions. This processing technique is simple to set up, flexible in use, and is a cost effective solution in terms of the initial installation costs for pilot plant and semi-industrial sizes. However, there are some serious limitations to this technology. First, the particle size distribution is broad and has a maximum achievable particle size of 400 µm or less. Due to the numerous fines, the resulting end product is dusty. Second, the individual particles are cavity shaped or hollow with low density and a hard outer shell. Finally, due to the typically high processing temperature certain considerations must be given when drying temperature sensitive materials to avoid product degradation.

Several processing techniques have been developed which produce dustfree product using dry powder as the starting material. The difference in these techniques are the methods by which individual particles are permanently formed into one larger granule.

One of these methods utilizes adhesion forces created by compacting the powder under high pressure in a contoured mold. This process is commonly referred to as tableting, roller compaction, or briquetting.

Another method utilizes capillary forces which are created by introducing a liquid binder and forcing particle motion thus building up liquid bridges among particles. One of these processing techniques utilizes a fluidized bed to create product motion and to initiate particle collisions. This technique is appropriately named fluid bed processing.

The desire to create a dustfree and free flowing final product from a liquid based raw material has often resulted in a process of at least two steps which combines, for example, the spray drying and granulation techniques described above. However, even this combination has inherent limitations:

- Limited Granule Size
- Relatively High Attrition/Friability
- Limited Processing Flexibility
- High Investment Costs
- Complex Set-up

The complex set-up leads to difficulties in monitoring the process and in controlling the consistency of the final product.

To overcome the shortcomings of conventional combined spray dryer and granulator, Glatt Ingenieur Technik GmbH, Weimar (Germany) has developed a process which is capable of producing a dustfree end product in a continuous single step processor using either a liquid or a dry powder raw material. This new processor is called the AGT (Anlage zur Granulier Trocknung or Processor for Granulation and Drying) which is described below.

2. Operating Principle

The AGT is a continuous fluid bed granulator-dryer designed with processing flexibility in mind and with the ability to produce product with a narrow particle size distribution. The cylindrical processing tower (please refer to item (1) of Fig. 1) consists of an inlet air plenum (1.1), a processing chamber (1.3), and an expansion chamber (1.4). Air enters the inlet air plenum (a) already filtered and preconditioned to the desired processing parameters. The design of the plenum assures an even distribution of air flow across the bottom of the product chamber where a retention screen is situated (1.2). The retention screen has a greater porosity at its periphery, creating a velocity gradient (b) which initiates an ordered product movement pattern (c) to support the classification of the final product.

As the air flows through the processing chamber (1.3) the contained solids (product hold-up) are suspended in the air stream which is known as fluidization, or a fluidized bed.

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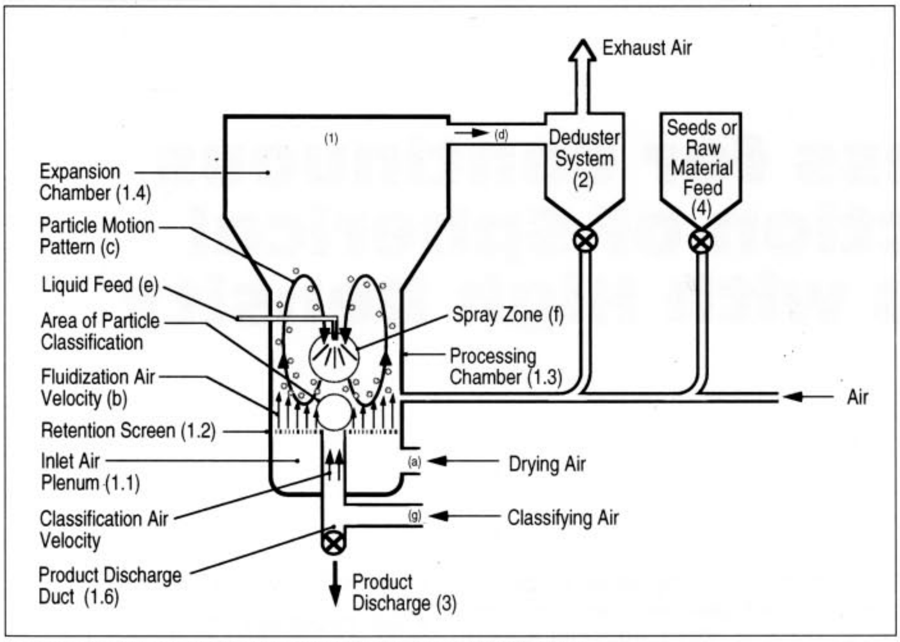

Fig. 1: Continuous fluid bed spray dryer and granulator (AGT-processor)

The air velocity is reduced in the expansion chamber (1.4) due to the increased diameter of the chamber thus reducing the level of particle carry-over. The air leaves the processing tower through the outlet port (d) which is located in the upper portion of the cylindrical section of the expansion chamber.

If particles are carried over into the exhaust by the fluidizing air stream, or the process requires a recirculation of fines, a suitable deduster system (2) collects the fines and returns them into the processing chamber by either a pneumatic or a gravity conveying system.

Due to the nature of particle motion within the fluidized bed the product is efficiently mixed.

This mixing leads to uniform heating of the particles and both, homogeneous and rapid evaporation of the applied liquid. More importantly, this mixing is the basis of a uniform particle growth rate in the processing chamber and the elimination of all hot spots.

3. Processing

3.1 Spray Drying Processing

The following description of this processing method is based on a system which has reached equilibrium after the start-up phase.

The liquid feed, a solution, a suspension, or a hot melt (e) is sprayed continuously onto the exposed surface of the fluidized particles. The carrier liquid, usually water is evaporated by the drying air and is carried out of the system by the airstream.

In the fluid bed process there can be a natural generation of fines either by attrition of the fluidized product or spray-dried droplets of the liquid feed. Those fines recirculate in the processing chamber where they once again pass the spray zone (f) to create a tacky outer surface area. In this state collisions with other particles create an agglomerate by the building of liquid bridges which become permanent as excess moisture is evaporated. Due to the liquid's binding characteristics, as well as a layering effect, the particles grow continuously in the processing chamber.

The processing parameters, specifically the liquid spray rate and the drying capacity of the fluidizing air, and the chemical properties of the components dictate which one of the two distinct particle growth patterns will dominate: layering or agglomeration. The difference in particle growth patterns is shown in Fig. 2.

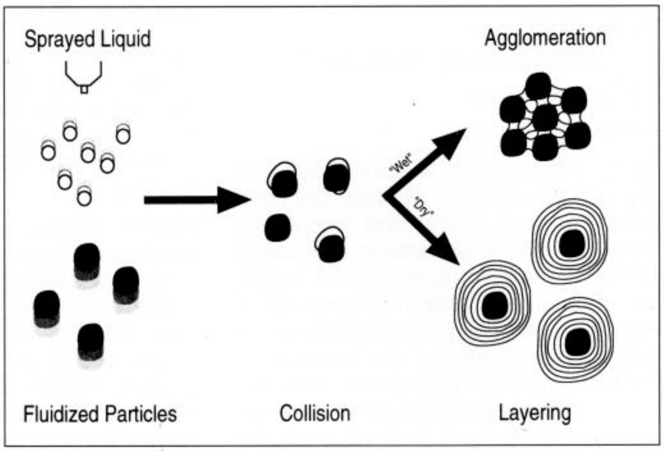

Fig. 2: Fluid bed particle growth pattern

When the product is not tacky and the process is run at "dry" conditions the building of liquid bridges among the particles is inhibited. In this case the particles grow only by layering. Under wet processing conditions building of liquid bridges is more likely and particles grow by agglomeration.

3.2 Continuous Mixing and Agglomeration Processing

In some cases a seed material may be added to the system in a continuous mode while agglomerating and drying at the same time. This results in a granule of several components in a fixed matrix formation.

4. Product Discharge

An integrated product discharge (1.6) port located in the center of the retention screen is designed to act as a gravity classification system also known as an air sifter. An additional air stream g) enters the bottom of the processing chamber through the discharge duct. As the particles reach their target weight, which is function of their size, they overcome the classifying air velocity and drop through the discharge duct into a fluid bed cooler, product hopper, or conveying system (3). The discharged particle size is a direct function of the classifying air velocity. By varying this velocity the particle size can be varied from 0.1 - 10 mm and even larger.

The fluidization pattern (c directly impacts the efficiency of the air classification system and thus the particle size distribution of the final product. The more quickly particles recirculate in the processing chamber the greater is the probability that the particles will be removed from the system as soon as they have reached a given size. Thus excessive granule growth is avoided, eliminating the need for additional sieving down stream of the dryer.

Since there is a continuous discharge of final product, the number of particles, i.e. the material mass, in the processing chamber must be kept in equilibrium by continuously balancing the feed-rate of dry material into the processor (4). These

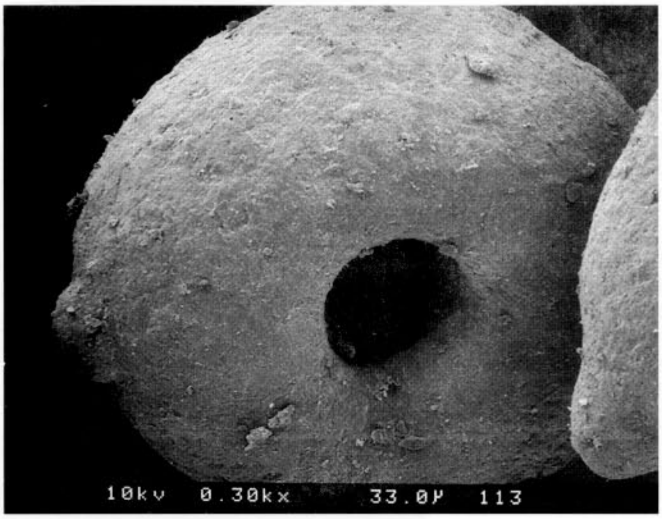

Fig. 3 a) Spray dryer: Sperical and hollow product (diameter approx. 0.2 mm)

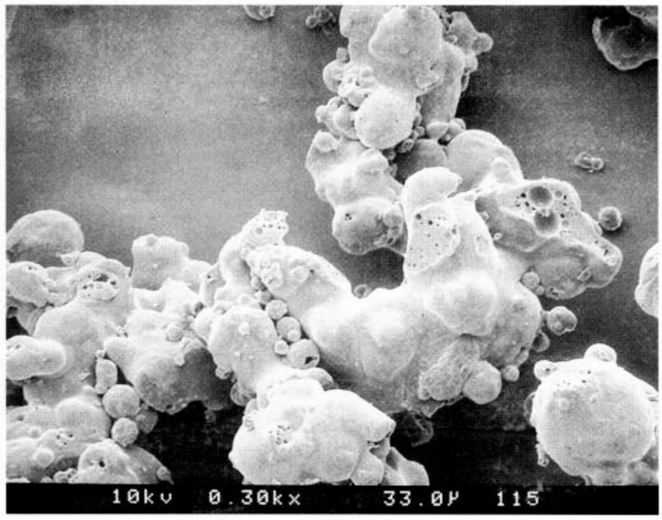

Fig. 3 b) Spray dryer/fluid bed granulator: Instantized product (approx. 0.2 – 0.3 mm dia.) showing high amount of fines

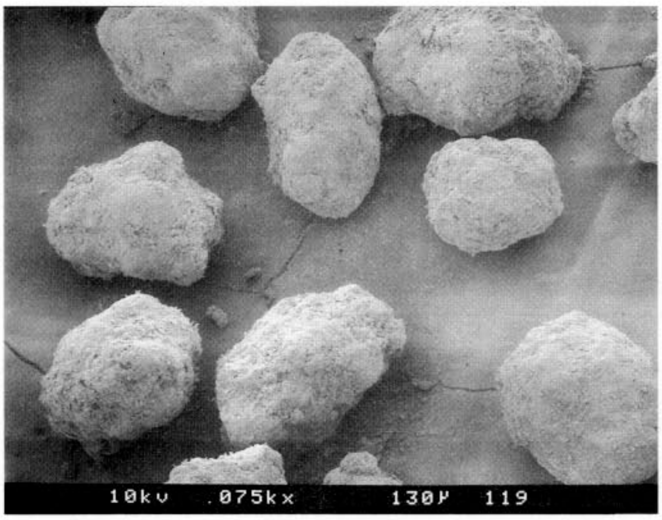

Fig. 3 c) AGT-processor: "Dry" processing of the same product as shown in Fig. 3 a) (layering, dia. approx. 0.3 – 1.2 mm)

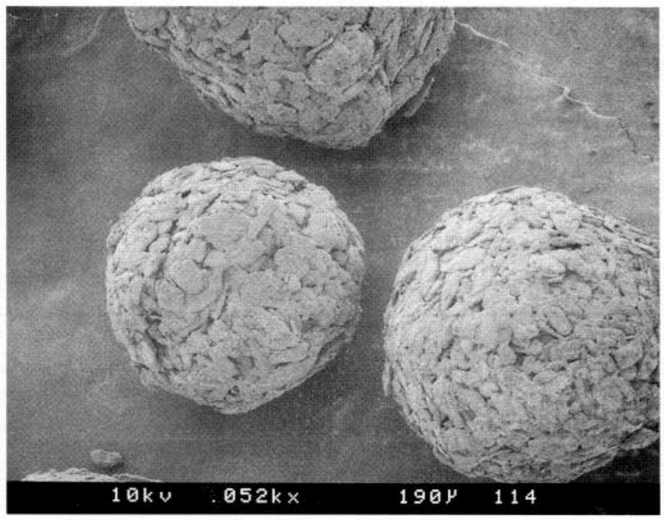

Fig. 3 d) AGT-processor: "Wet" processing (agglomeration of dry powder feed, dia. approx. 1 – 2 mm)

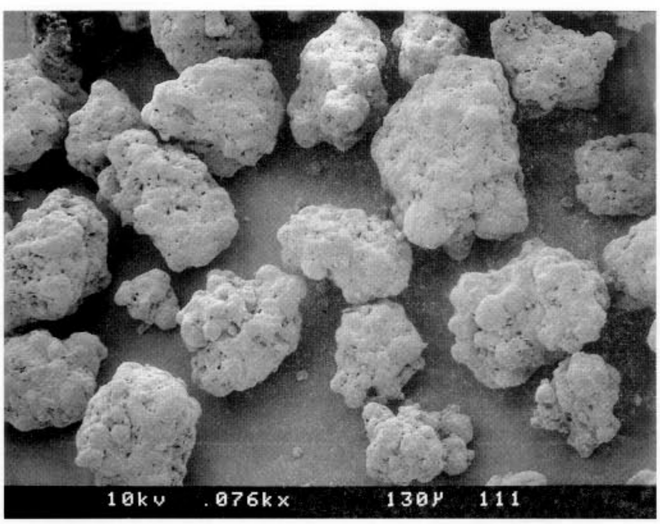

Fig. 3 e) AGT-processor: Combined layering and agglomeration (dia. approx. 0.2 – 0.5 mm)

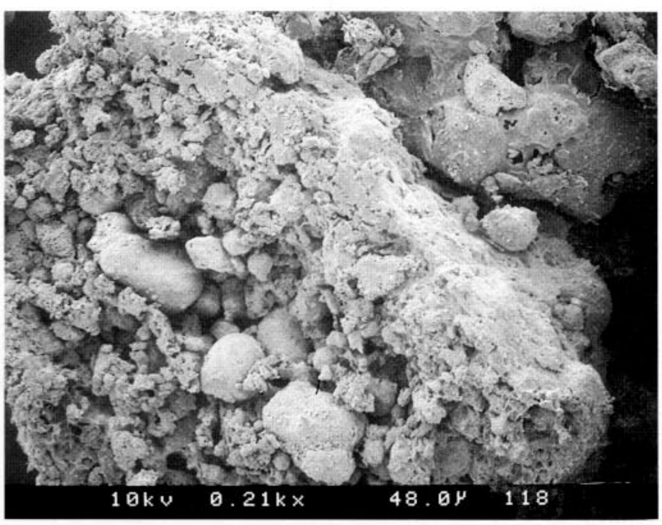

Fig. 3 f) AGT-processor: Cross-section of particles shown in Fig. 3 e). The spraydried droplets are agglomerated to a larger granule injected particles can be either new seeds or milled final granulate. The addition of seeds is not required for products which generate a sufficient amount of nuclei through product attrition or through spray drying of the liquid state feed stream.

5. Product Properties

The final product properties are a result of a mixture of:

- Fluid Bed Principle
- Processing Parameters
- Material Properties

In addition, the final product properties can be influenced by certain additives and by the way in which the various materials are introduced into the system.

Typical particle surface and cross section textures of different processing techniques are shown in Figures 3 a - f) (previous page).

The different particle shapes of AGT spray dried and granulated product compared to conventional processing is obvious resulting in unique product properties. In Table 1 some typical properties as well as their potential application advantage are listed.

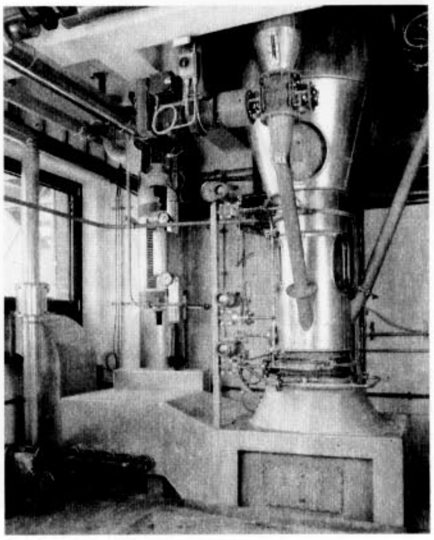

Fig. 4: AGT pilot size unit

Table 1: Product properties and application advantage of AGT processed products

Final product property	Application advantage
Dustfree	Dust is very often an inconvenience or even a serious health hazard to exposed personnel. The design of the equipment ensures an absolutely dustfree final product. Sieving or additional agglomeration is unnecessary
Narrow particle size distribution	Allows very precise dosage using automated product dispensing systems and ensures no segregation during conveying, shipping, or storage
Controllable and variable particle size	The ability to meet stringent and changing product size specifications
Low product temperature processing	Heat sensitive products can be processed without degradation
High particle strength attainable	Very little product attrition of the granule occurs during pneumatic conveying, transportation or other product handling
Consistently high and reproducible product density attainable	Easy storage for hygroscopic/moisture sensitive products. Reduced packing volume. Reliable application properties.
Consistent solids/residue content	By changing the relevant parameters, the solids content can be kept at any specified level
Consistent product quality even at inconsistent feed compositions	If the upstream installed equipment is not producing constant quality (i.e. feed concentration), the AGT can handle it and still guarantees the final product specification. Constant and reliable final product quality means higher yields and reduced down time.
Sealed surface structure	The very tight surface texture of every granule provides a barrier against internal mycological and bacteriological growth
Ability to mix continuously various components	By adding new seeds or solids during feed spraying, the final product will consist of a mixture of different components free from segregation