



Aspects of granulation in the chemical industry

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ARTICLE INFO

Available online 20 April 2008

Keywords:

Process comparison
Bulk density
Dissolution kinetics

ABSTRACT

In general, the intention of granulation processes in chemical industry is to achieve certain product properties. The requirements are specific for each product and cover application properties, process and handling properties, safety characteristics and marketing features. However, selection of an agglomeration process and equipment to be used for production is usually influenced by other factors than product properties: Options are often limited, because equipment which was used for another product is available, or the granulation process has to fit in the total production process.

In granulation, only few information about scientifically based differentiation between alternative granulation processes such as mixer agglomeration, compaction or fluidized bed granulation and classification of different apparatus can be found in literature.

Therefore, one focus of industrial investigations in granulation is on comparison of different processes and assessment of different types of apparatus. Here, an example for a comparison of different granulation processes with respect to product properties will be shown.

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1. Characteristics of formulation and process design in the chemical industry

Products in the chemical industry play a major role as process chemicals, intermediates, additives, and as end products or parts of them in our daily life. An overview of BASF's products (Table 1) gives an impression of the wide range of materials that are dealt with on a daily basis in the chemical industry. Solids account for roughly 1/3 of the total number of products in the chemical industry, showing the importance of particle formulation technology.

In this text the term granulation will be used to describe the process of preparing grainy particles of the same or at least a preferably uniform size, according to Rumpf [1]. This rather broad definition is appropriate here as it focuses on the advantageous properties of a granulated product (compared to a fine powder) rather than on the granulation process itself. This corresponds with the aim of granulation processes in the chemical industry: to improve product properties. The term agglomeration is used, when granulation involves a sticking together of small primary particles.

The requirements on product properties are specific for each product and range from application, process and handling properties, to safety and marketing considerations. However, the selection of agglomeration processes and equipment to be used in production is usually also influenced by factors other than product properties. Handling aspects such as the need for inert conditions, caking problems or

special requirements for material of the apparatus, availability of equipment and, of course, production costs have to be taken into account. Economic constraints of a product play a major role in the selection of an appropriate granulation process, as in highly competitive markets even a better quality product is only accepted when offered at the same prize. Moreover, process design has to consider options for contract-manufacturing and/or modification of existing plants, as new products typically do not justify the investment in a separate production facility.

Table 1
BASF's products (2007)

Segment	Products (examples)
Chemicals	Inorganic basic chemicals and specialties, electronic chemicals, glues, resins, petrochemical feedstocks, catalysts, plasticizers, amines, diols, polyalcohols, acids, specialty intermediates
Plastics	Styrene, styrene-based polymers and copolymers, caprolactam and nylon, engineering plastics, polyurethane basic materials and polyurethane systems, specialty elastomers
Performance products	Performance chemicals for coatings, plastics, detergents, textile and leather chemicals, fuel and lubricant additives, automotive OEM and refinish coatings, industrial coatings, acrylic monomers, superabsorbents, paper chemicals, raw materials for adhesives and construction chemicals, admixtures, flooring, protective coatings, facades, building systems
Agricultural products and nutrition	Herbicides, fungicides, insecticides and seed treatments, vitamins, carotenoids, enzymes and organic acids, aroma chemicals, pharmaceutical active ingredients and excipients, pharma custom synthesis, polymers and UV filters
Oil and gas	Crude oil and natural gas (exploration, production as well as transmission, storage and trading)

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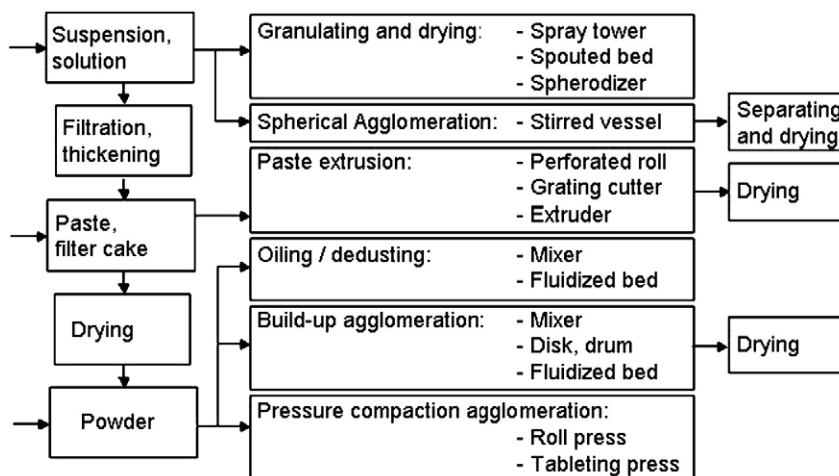


Fig. 1. Production methods for granulated particles [2].

The integration of the granulation step in the production plant is particularly important, and often determines the granulation method. Chemical production processes of solids often start from a reactor, where the material is synthesized in solution, and continue with a crystallization, filtration or other thickening operation and a drying step. In Fig. 1, granulation processes are classified according to the form of the feed material [2].

Two important characteristics of granulation in the chemical industry are the great variety of products and the wide range of processes and equipment used. Granulated products comprise all different classes of solids including organic and inorganic materials, small molecules and polymers, crystalline and amorphous materials, harmless or reactive and toxic substances. The products are often more complex than model substances, and one has to deal with e.g. wide particle size distributions, several components, changes in the raw material quality, changes in formulation or a limited choice of auxiliary agents such as binders. Moreover, products from the chemical industry include high value products as well as commodities.

The huge variety of equipment mainly results from the very different requirements for the various products. Production processes of different products vary largely in capacity and can be operated batchwise or continuously. The capacity range of different granulation processes according to [2] is shown in Fig. 2. Moreover, the chemical industry comprises traditional product segments, such as fertilizers or pigments, which develop their own typical equipment.

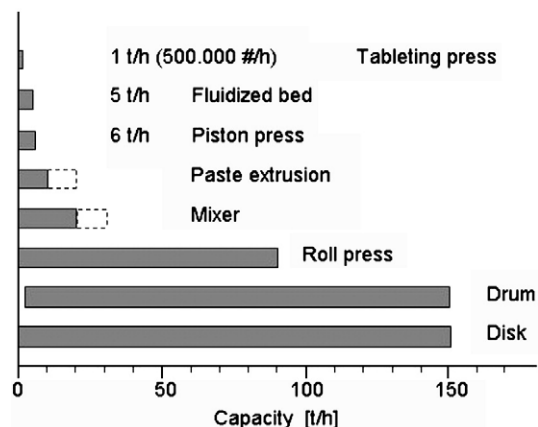


Fig. 2. Capacity range of granulation processes [2].

2. Requirements for process development

Faster process development is a key objective to contribute to economic success in the chemical industry. As particle technology is still a very empiric subject in process engineering, the demand for faster process development is a challenging task. For granular products, it can be achieved by short-cut methods for early evaluation of product behavior, small scale feasibility studies for preparation of product samples and a basis for pre-selection of the process, improvement of scale-up and modeling methods as well as expertise in assessment of alternative processes. To give an example, short-cut methods that are used already include the assessment of compression behavior during roll press granulation by a preliminary tableting test or the analysis of paste rheology as a basis for selection of a suitable paste granulation apparatus [3]. Granulation in a batchwise laboratory scale mixer can serve as a small scale study for batch or continuous granulation.

Research in granulation aims at understanding and being able to describe the physical processes involved. This is essential as a basis for improved technologies in industrial process development. Another important aspect of industrial investigations in granulation is the comparison of different processes and assessment of different types of apparatus. This is somewhat different from the focus of research in universities, where projects on granulation are typically based on a given piece of equipment and do not take characteristics of the apparatus into account. To give an example, build-up agglomeration in mixers is a widely applied technology with a big variety of mixers suitable for granulation, but there is very little information about scientifically

Pressure compaction agglomeration:
Roll press (B)

Build-up agglomeration:
Mixer (A)
Fluidized bed (C)

Spray granulation:
Fluidized bed (D)

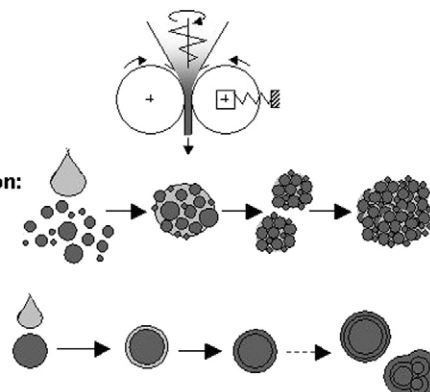


Fig. 3. Granulation methods considered for comparison.

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