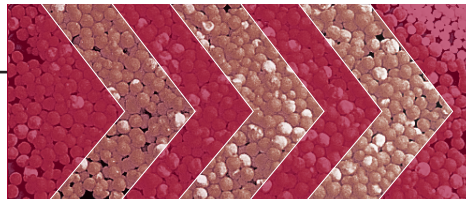
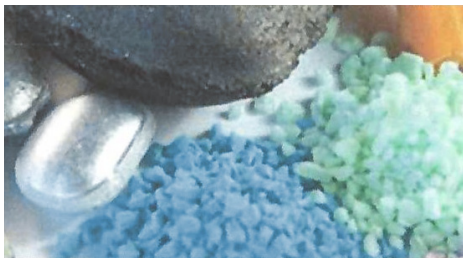




Agglomeration: Enlarging and controlling particle size

In the solids processing industry, agglomeration—or particle enlargement and control—is a critical step in improving the safety, flowability and performance of many different bulk materials. While the mechanical process of increasing particle size can be relatively straight-forward, each material is unique in the way it responds. This, in turn, affects the way a bulk product performs in its ultimate role. Getting the agglomeration process right often requires consultation with a trusted equipment supplier who can help refine the process for consistent results.

It is difficult to overestimate the importance of agglomeration in the chemical, food and mineral processing industries. Agglomeration is a widely used process that plays a key role in de-dusting, controlling particle size and shape, controlling density and the overall performance of bulk solid products. From porous granules and charcoal briquettes to masonry bricks, agglomeration or particle size enlargement transforms powdery bulk solids into materials of larger sizes with either random or controlled shapes and performance characteristics.

A common example includes using agglomeration to create round granules of dry garden fertilizer from its powdery, dusty components of mechanically mixed compounds. Not only does granulation of the bulk material prevent separation of its initial components during transportation, storage and use in the field, the size and density of the particles can be tailored to control the rate at which the particles disperse and dissolve.

An example from the food industry involves particle size control of drink mixes to enhance solubility and mixing. If the drink mix particles are too small, they will tend to float on the surface and clump up. If the particles are too large or hard, they will tend to sink and not dissolve readily. The key is to create a particle size that is neither too small nor too large and hard in order to facilitate rapid dissolving.

REASONS TO CONSIDER AGGLOMERATION

As the previous examples demonstrate, there are multiple reasons to consider adding agglomeration to your bulk processing or manufacturing. Some of these reasons are:

- To eliminate dust that can lead to loss of product during handling or can be an explosion hazard
- To prevent poor flowability during discharge from hoppers or cause difficulty in metering and dosing
- To prevent segregation of individual components in the material
- To improve solubility, dispersibility and permeability
- To control the final form as a defined shape, size or dosage
- To increase product value or lower processing costs

It's important to determine the properties that are desired in the final product. Once these requirements are confirmed, a path toward an agglomeration solution becomes clearer. Depending on the end product's intended use, the proper agglomeration process can yield materials with widely differing characteristics which demonstrates the flexibility of the process. End product characteristics that can be controlled include:

Size and size distribution – Particle size and size distribution of bulk materials is critical in many applications. Enlarging particles helps eliminate dust problems and separation of

components during shipping and handling. By controlling the range of particle sizes, the performance of the final material can be kept within specifications.

Shape – The shape of the final product may be important for its function or for its appeal. For example, an almond-shaped water softener salt briquette not only aids in handling, it helps control the rate at which the salt dissolves. On the other hand, roll-pressed or extruded cat food pellets in the shape of little fishes enhances its consumer appeal.

Strength – The strength of the end product can be controlled by the addition of a wide range of binder materials or the amount of compression used in forming a briquette. A charcoal briquette, for example, has to be hard enough to endure shipping and handling, yet porous enough to support controlled combustion.

Other end product characteristics that can be controlled through agglomeration include dissolution rate, flowability, compressibility and density.

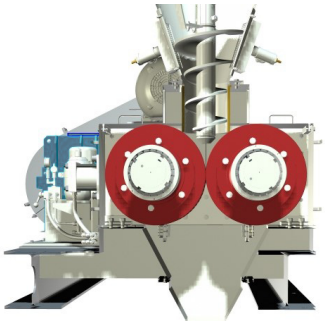
AGGLOMERATING METHODS

In almost every case, an industrial bulk solids processing system contains a key particle forming device that is usually a single component of a more complex system. By becoming familiar with the various types of agglomerating methods, the time required to go from concept to final product can be greatly reduced.

Agglomeration methods include:

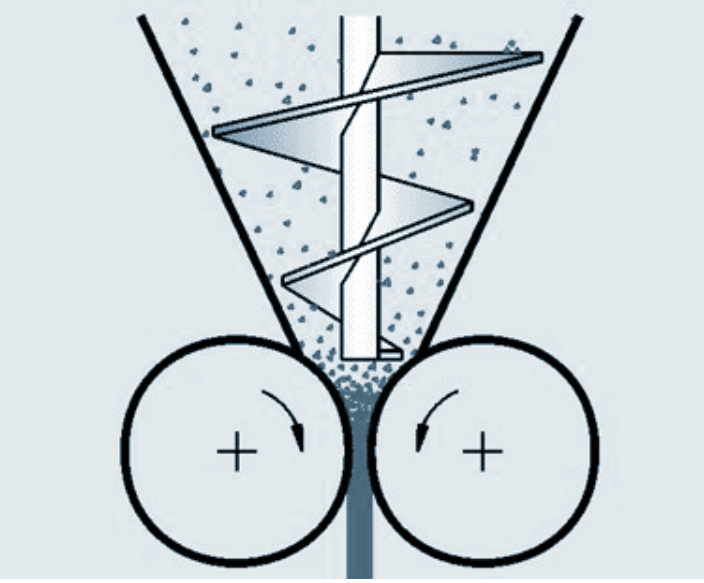
- Pressure or compression
- Mixing or tumbling
- Thermal heat treatment

Each agglomeration method has its strengths and weaknesses and will produce end products with different characteristics.



ROLL COMPACTOR

Figure 1: Roll compaction



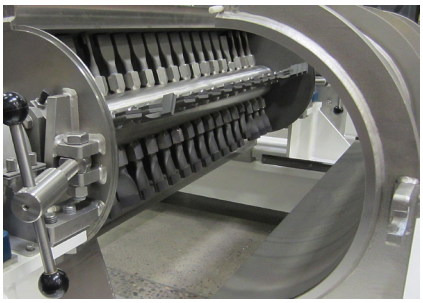
Pressure agglomeration – In pressure agglomeration, enlarged entities are formed by applying external forces to usually dry bulk solid particulates using dies to form the appropriate final shape of the product. In other applications, a roll-pressure device is used to form a compacted sheet of material that can later be crushed and screened to yield uniform granular products. The level of force applied can be low, moderate or high, depending on the characteristics of the material or the desired density of the final product.

A highly flexible method, pressure agglomeration can be used in the manufacture of a wide variety of end products, from granules as small as 150 microns to briquettes up to 150mm or beyond. The advantages of this agglomeration method are 1) A wide range of final product sizes; 2) Uniform shape and size; 3) High density and strength; 4) High resistance to product breakdown; 5) Limited dispersibility. Another advantage of pressure agglomeration is that it tends to lower processing costs by eliminating binders and waste in the form of fines.

Applications for pressure agglomeration are wide-ranging and inlude:

- Briquetting press
  - MgO Refractory material
  - Charcoal
  - Calcium oxide
  - Salt pellets

- Granulating press
  - Fertilizers
  - Feed additives
  - Bromines/Chlorines
  - Sweeteners
- Tablet press
  - Pharmaceuticals
  - Water treatment tablets
  - Nutraceuticals
- Piston press
  - Machine shop scrap
  - Wood pucks

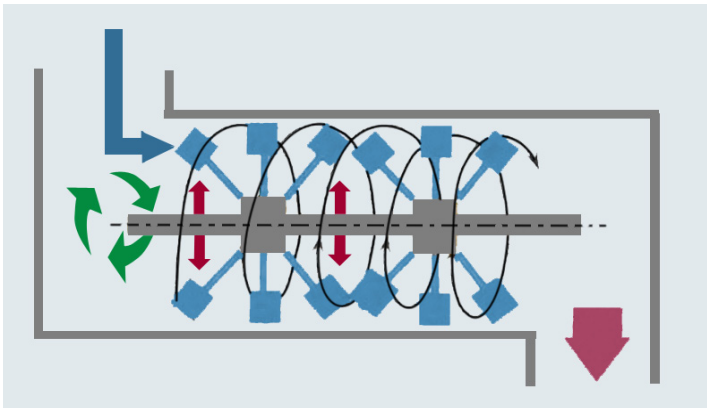


PADDLE MIXER

Tumbling agglomeration – In tumbling agglomeration, a bulk material is subjected to either paddle mixing or drum tumbling with or without the addition of water to help small particles adhere and form larger particles. In paddle mixers, the bulk material is mixed with a liquid (usually water, or another binding agent) to achieve the appropriate particle enlargement required. Typical paddle mixers offer: 1) Low capital costs; 2) Formation of rounded particles; 3) Granules with good dispersion; 4) Uniform particle size and shape; 5) Products with acceptable density and strength.

One disadvantage of tumbling agglomeration is that when a binder is used to enhance particle enlargement, the process usually must involve a drying step which can increase operating costs. Another disadvantage is that since the tumbling process works best with fine powders as a starting material, that pre-milling of the feed material may be required.

Figure 2: Tumbling agglomeration



Applications for both paddle mixing and tumbling agglomeration cover a wide range of materials and cross many industries:

- Disc or drum pelletizer
  - Ores
  - Fertilizers
  - Soil conditioners
  - Metal wastes
- Pin or paddle mixer
  - Clays
  - Fertilizers
  - Ag chemicals
  - Pigments/Dyes
- Instant mixing
  - Instant drinks
  - Sugars and sweeteners
  - Instant soups/sauces
  - Protein supplements

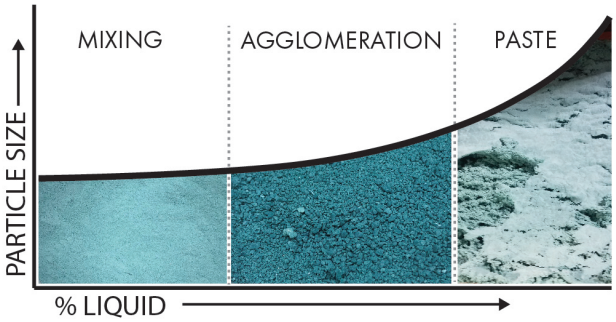
Extrusion agglomeration – Extrusion agglomeration involves forcing bulk materials through dies to form larger particles. The process is used to form pellets that have a cross section defined by the die shape and a length that can be controlled by a cutting device. In low-pressure extrusion, the final product has a typical diameter from 1 mm to 10 mm and a medium density for controlled dispersibility. Binders may be required, depending on the feed material. The resulting pellets can be further processed by spheronization to yield a round bead which vastly improves the product's flow characteristics.

Low pressure extrusion agglomeration is especially useful when the desired end product is large in size and the feed material is in a wetted or paste condition. It is also conducive to creating uniform spheres and improved drying efficiency. Low pressure extrusion is less successful when the feed material is abrasive or dry and brittle. The addition of water or binders is common but post drying increases operating costs. High pressure agglomeration uses screws or pistons to apply high pressure to a feed material and to extrude it into discrete shapes such as masonry bricks, wood pucks or logs.

Applications for extrusion agglomeration are concentrated in a few key industries and applications:

- Low pressure screw
  - Granules for ag chemicals
  - Pharmaceuticals
  - Rubber additives
- Pellet mills
  - Animal feeds
  - Biomass pellets
  - Aquaculture pellets
- High pressure screw
  - Bricks
  - Tiles
  - Byproduct recovery
- High pressure piston
  - Biomass logs
  - Plastic scrap

Particle size and performance depend on fine-tuning proportions of water and material.



Developing a process

It has often been said that developing an efficient process for agglomeration is as much an art as it is a science. This is true, in part, because every feed material behaves differently and often defies scientific rules and assumptions. For example, every feed material will react differently to the addition of water during tumble mixing. As the amount of water sprayed on to the material is increased, the material will go from a dry powder to larger particles. However, if the amount of water goes beyond a certain limit, the mixture will form a paste or even a slurry. Finding that proper operating "window" is the key to fine tuning the process to yield the particle of the right size and performance. Depending on the feed material, some windows are rather wide and some windows are extremely narrow.

To make sure an agglomeration process is economical, efficient and yields a consistent product, it is important to consult with an experienced agglomeration equipment supplier with broad industry experience. Working with an agglomeration expert will shorten the time between concept and production and reduce overall costs while optimizing product performance.

About Bepex International

Bepex International, with roots dating back to 1897, serves the global food, chemical, and polymer markets by providing process development services and custom-designed industrial scale process systems and equipment. With a wide array of proprietary platform technologies, including thermal, size reduction, compaction/agglomeration, mixing and blending, and mechanical dewatering, Bepex custom-designs each piece of process equipment to the exacting requirements of each process and customer, reducing time-to-market and increasing processing efficiency.

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