Selection of an Agglomeration Method

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1. ABSTRACT

Agglomeration is the process of transforming fine particles into larger particles by the introduction of external forces, and is a value-added step in many processes involving powdered materials. There are many different reasons to agglomerate, including increased flowability and improved product shape and appearance.

With the multitude of options available to achieve an agglomerated product, it can be difficult to narrow down the best method for your application. The main factor in selecting the right kind of equipment is to specify the type of end-product required. The particle size distribution, shape, hardness, solubility and dispersability, and binder addition requirements will point to a certain type of agglomeration equipment.

I will outline the most common options, and clarify the product characteristics of each. This review should be helpful for the novice, and is a good reminder of other options for those already proficient.

2. INTRODUCTION

Agglomeration is the process of transforming fine particles into larger particles by the introduction of external forces, and is a value-added step in many processes involving finely divided solid materials.

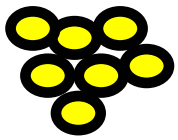
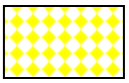
There are many different reasons to agglomerate. Agglomeration will minimize or eliminate dusting, which will improve storage and handling characteristics as well as making the environment safer for people working with the material. It will improve flowability, which improves metering and dosing characteristics. Segregation within bulk blends is eliminated through coagglomeration of materials. It can also be used to increase or control bulk density, or to produce a defined shape, size, or weight product. Some methods of agglomeration will also allow control of solubility and dispersibility. The end result is a product offering more valuable to you or your customer.

With the multitude of options available to produce an agglomerated product, it can be difficult to narrow down the best method. I will outline the most common options, and clarify the product characteristics of each. This review should be helpful for the novice, and is a good reminder of other options for those already proficient.

3. SELECTION OF A PROCESS

Most materials could be agglomerated using any of the methods listed below. The main factor in selecting the right kind of equipment is to specify the type of end-product required. The particle size distribution, shape, hardness, solubility and dispersibility, and binder addition requirements will point to a certain type of agglomeration equipment. Having a well-defined product specification early on will streamline the selection process. Common characteristics for various product types are detailed in Table 1 below.

Table 1. Product Comparison.

Product Form /Product Properties	**Onion Skin**	**Agglomerate (Mixing)**	**Extrudate**	**Hollow Sphere**	**Granule**	**Briquette**
Flowing Properties	**4**	**4**	**3**	**1**	**4**	**3**
Bulk Density	**4**	**3**	**3**	**1**	**4**	**2**
Dispersability	**1**	**4**	**2-3**	**3**	**1**	**1**
Instant Characteristics	**1**	**4**	**2-3**	**3**	**1**	**1**
Particle Size	**1-5 mm**	**0.2-1.2 mm**	**0.3-5 mm**	**< 200μm**	**0.1-5 mm**	**5 mm+**
						

4 – Very good / excellent
3 – good
2 – moderate
1 - poor

The initial state of the feed material to your process will point toward certain methods, as will any requirement on purity. If the feed is a paste, extrusion should be considered, as an example. If your material is very sensitive to binder addition, dry agglomeration may be the only viable option.

The combined capital and operating costs for any agglomeration system are typically quite similar. If the system does not include curing or post drying, this would be an exception. Therefore, it is best to narrow down the equipment choices first through product and feed specifications, before concentrating on the costs for the system.

4. TYPES OF AGGLOMERATION

There are four main categories of agglomeration. The first is pressure agglomeration, which includes briquetting, compaction granulation, tabletting, and others. The second is tumbling agglomeration, which includes drum, disc, cone, pin mixer, and others. The third is

extrusion, which includes low pressure screw, gear pelletizer, pellet mill, and others. The last is thermal, which includes flaking, pastillating, prilling, sintering, and others. These methods are outlined in more detail below.

4.1 PRESSURE AGGLOMERATION

In pressure agglomeration, material masses are subjected to high forces. The application of high pressure causes partial crushing and realignment of the individual particles. The pressure can be high, in excess of 30,000 psi. This results in the particles being forced into close proximity, where interparticle forces result in binding.

Pressure agglomeration can be accomplished using a variety of units, including roll compactors, tablet presses, and piston presses. This is a dry method of agglomeration, which generally requires little or no binder addition, instead relying on interparticle forces for agglomeration. High density products are produced at a high capacity with relatively low energy input. Products will be of uniform size and shape, and can be relatively large compared to other methods. Because of the high density of these products, their dispersability is generally limited.

One of the most common examples of high capacity pressure agglomeration is roll compaction. A double roll compactor is pictured in Figure 1. In this unit, material is force fed in the top by a feed screw. It is then drawn between the counter rotating rolls where it is partially crushed, and formed to the shape on the surface of the rolls. Individual briquettes can be formed in a variety of shapes. For granulation, a sheet of material is produced. This is then crushed and screened to size.

Some examples of products made with pressure agglomeration are charcoal briquettes, salt pellets for water softeners, pills, and fertilizers. Common characteristics of all these products are a high density, uniform shape, and slow dispersibility.

As a general rule, one would consider this type of agglomeration if:

1. Binder addition is not allowed
2. High density or resistance to attrition is desired
3. Large particles (greater than 1”) or particles of controlled size are required.

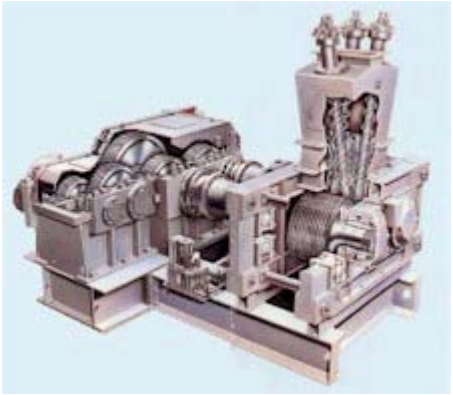


Figure 1. Double Roll Compactor

4.2 TUMBLING AGGLOMERATION

In tumbling agglomeration, material masses are combined with a binder and subjected to rolling or tumbling forces to form loose agglomerate structures. Agitation can be high or low shear, depending on the equipment. The feed to this type of system is typically a fine powder. Binding is generally accomplished by liquid bridges or chemical reaction.

Tumbling agglomeration can be accomplished on a variety of units, including drum or cone mixers, pan or disc agglomerators, and pin mixers. This is a wet method of agglomeration, meaning a binder or moisture must be added to accomplish the particle enlargement. This is a good method for dedusting materials, or prior to waste disposal. Tumbling agglomeration systems typically have high capacities, and offer a low capital cost if post drying or curing is not necessary.

A pin or paddle mixer is a good example of a unit used to dedust materials. Figure 3 below shows an example of a paddle mixer. This unit is fed dry powder through the large inlet at one end, and liquid through the couplings slightly downstream. In this unit the paddles are adjustable to allow one to tailor the degree of mixing to a certain application.

Another of this type of agglomerators is the Schugi Flexomix that is often used in instantizing. This agglomerator is shown in Figure 2. The Flexomix combines the powder and liquid in a high shear environment. The granules are relatively porous, and easily dispersed. The agglomerates will require drying, typically in a fluid bed dryer. The high speed contact of the mixer yields smaller more uniform particles in a short residence time.

Some examples of products made using tumbling agglomeration are detergents, instant drink mixes, fly ash dedusting, and agricultural chemicals. Common characteristics of these products are medium to low density, good flowability, easy dispersion, and a rounded or raspberry shape.

As a general rule, one would consider this type of agglomeration if:

1. Binder addition is allowed and anticipated
2. An economical means of wetting a powder for dedusting
3. Easy dispersion is required

Figure 2. Schugi Flexomix, Instant Mixer

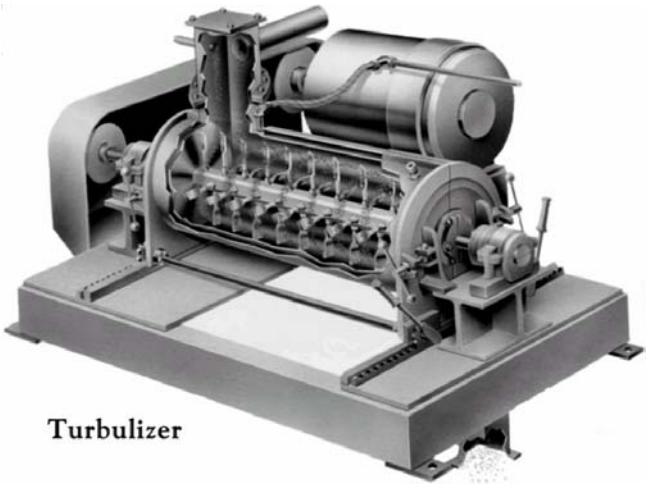


Figure 3. Turbulizer, Paddle Mixer

4.3 EXTRUSION AGGLOMERATION

In extrusion agglomeration, material masses are subjected to forces pressing them through a die plate to form pellets. Pressure ranges from low to high depending on the type of extruder chosen. Feed to an extruder must be formable by the die, meaning it must be a wetcake, paste, or dough, or form one through the mixing process in the extruder.

Extrusion agglomeration can be accomplished on a variety of units, including single screw extruders, gear pelletizers, basket type extruders, and pellet mills. Often curing or post drying is required. The material is forced through some type of die to form the granules, which makes the particle size of the product very uniform. An extruder will typically produce a medium density product that is good for time release applications. It will have the capacity to handle sticky and high viscosity products.

This method of agglomeration requires the material to be formable by the die. This means the material must either have a melting component, or a binder or moisture must be added to it. Some extruders have the capability to mix the feed materials prior to extrusion; however, it is more common to feed a premixed material. Figure 4 shows an extruder capable of mixing internally. Figures 5 and 6 show a gear pelletizer, which must be fed premixed material.

Some examples of products made using extrusion agglomeration are animal feeds, wood products, and polymers. Products from extrusion equipment will be cylindrical in shape. Typically, the diameter will be between 1 and 10 mm, and length will be fairly uniform. The particles will have a constant cross section due to the die forming process. Products typically have a density between that of tumbling agglomerates and pressure agglomerates, and a medium dispersibility as well.

Extrusion can be followed by spheronization, to round the edges of the cylindrical product and form spheres. This is accomplished on a spheronizer, a flat bottomed bowl shaped unit, with a spinning disc on the bottom surface. The pellets are spheronized while still green to allow reagglomeration of fines created during the process.

As a general rule, one would consider this type of agglomeration if:

1. Feed is a wetcake or paste
2. Pellet or Spherical shape is required
3. Small uniform particles are required

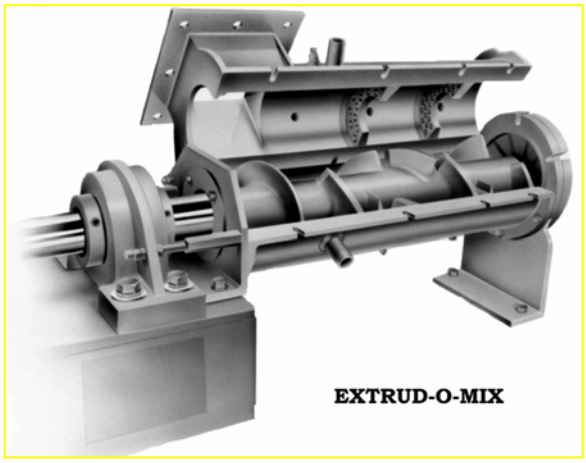


Figure 4. Extrudomix, Mixing Screw Extruder

Figure 5. Gear Pelletizer

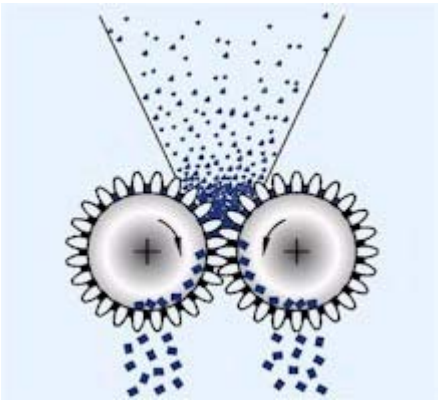


Figure 6. Gear Pelletizer, Material Flow Diagram

4.4 THERMAL AGGLOMERATION

Thermal agglomeration is a wide category focusing on agglomeration using heat transfer processes. These processes involve sintering through heat application, solidification through cooling, or coagulation through melting. Examples of equipment in this category include drum flakers, rotary kiln nodulizers, prilling towers, etc. Since the category is so varied, it is difficult to generalize the characteristics of products produced.

One common example of this type of equipment is a prilling tower. A prilling tower requires a hot melt feed material. The feed is formed into droplets by various methods, and the droplets fall through the tower through a countercurrent of air. This allows the material to harden, and form roughly spherical products. Typical particle size is 300 micron for this method, larger products would require more falling distance to sufficiently harden. This process can be followed by a fluid bed dryer to fully dry the newly formed agglomerates.

Some examples of products produced using thermal agglomeration are stearic acid prills, fatty acids, and gelatin.

5. BATCH VS CONTINUOUS PROCESSING

Most of the equipment described above operates continuously. Another factor to consider when choosing equipment is whether batch or continuous processing is best for your operation.

Batch processing is mainly used when the production rate is very low, or product is only required intermittently, or when material tracing is required. It can also be a good option when producing a wide range of different products, making frequent cleanout necessary. Batch processing has the advantage that off spec material can easily be identified and separated from the final product stream.

Continuous processing is typical for a plant with high production rates and few different product specifications. Continuous processing will be more economical for these large rates due to decreased labor demand, and more uniform end products.

6. CONCLUSIONS

Agglomeration equipment is the key part of a total agglomeration system, which can include mixing, size reduction, drying, and particle size classification and recycle.[1] As noted above, there are many options available for agglomeration. Defining the desired characteristics of the end product is the most important step in choosing the correct agglomeration equipment for your process. Most materials can be agglomerated on many types of equipment listed, but products from each of the machines will have different characteristics. However, once product characteristics are defined, the choices of agglomeration equipment can be narrowed down, and then testing can be done to verify the machine that will produce an end-product that meets specifications.

7. REFERENCES

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