

# Particle engineering by means of agglomeration processes

## Research and development

The engineering of particles is all about the interaction between base material, additives and processing equipment. The challenge is to form particles from this combination, which have the precise properties that contribute toward the successful application of the product by the end user. An important tool in this respect is the agglomeration process.

The role of a machine supplier such as Hosokawa Micron BV in Doetinchem involves much more than simply delivering machines and installations. The client is faced with the task of creating powders or grains that are suitable for the end user's objective. In the majority of cases, that product, whether in the form of powders or grains, must satisfy a series of requirements. The end user will need, for example, to dose, mix and disperse the product. To achieve that, the product should have good flowing properties, and have a specific stability and particle size and must have an excellent wettability. It is absolutely crucial that a client is discussing the desired properties and functionalities of the product with the machine supplier.

## Particle engineering

The knowledge and experience of Hosokawa Micron enable the company the engineering of powdery product or granules in such a way that they possess the desired physical properties (fig. 1). Sometimes, the compatibility of these properties is poor and it is necessary to seek for an optimum balance. This may lead to a situation whereby, for example, a client is suggested to opt for an agglomerate, instead of for a pellet (fig. 2). In other situations, it is suggested that properties relating for example to the drying behaviour, porosity, specific particle surface, bulk density or compressibility be achieved with e.g. layering agglomeration. Only when the relevant required functionalities of the end product have been formulated it is possible to evaluate the various processes that can be applied in order to form the desired particles and achieve the desired properties. This brings us to the stage in which a process is translated into machines and installations, which is yet another step that takes place in close consultation with the client.

## Agglomeration

In many instances, the base materials used to form the product are poor flowing powders. These poor flow properties are often a result of Van der Waals forces, electrostatic charges and irregular particle surfaces. A common process, used specifically to improve the flow properties of such powders, is agglomeration. This process involves the interaction of the base material with the processing equipment and additives. The process often begins with a mixing phase, during which a liquid is fed into the base material. In this phase, liquid bridges are formed between the product particles, and subsequently agglomerates are formed. The stability of the agglomerates is defined by the characteristics of the binding agent. The liquid bridges between the particles in the agglomerates structure are converted into solid bridges by means of drying. These solid bridges consist of the product itself, or of solidified binder.

## Fat-based binders

The choice of binder is extremely dependent on the final application of the end product.

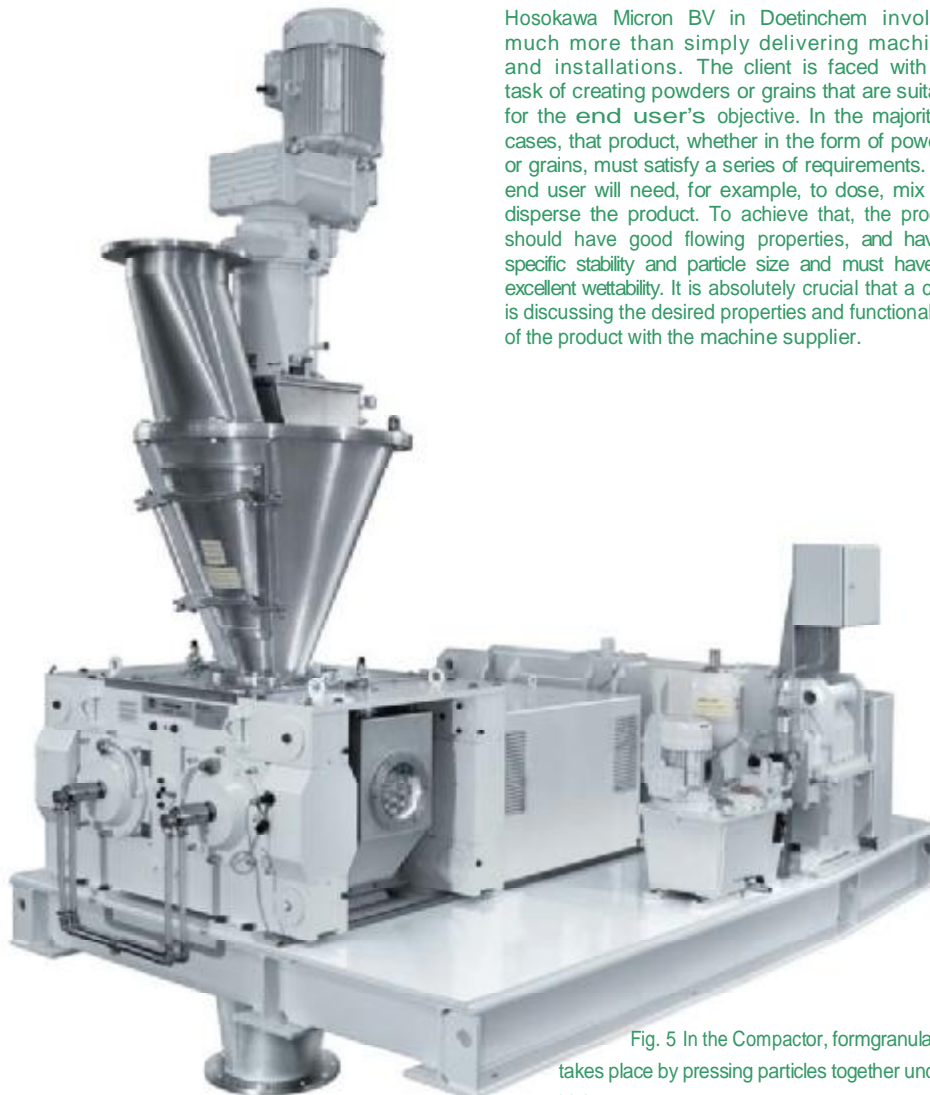
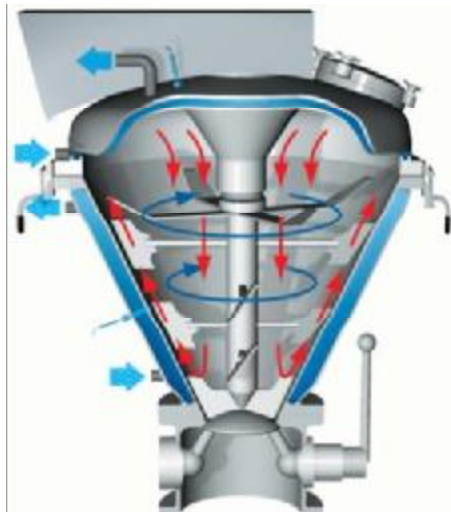


Fig. 5 In the Compactor, formgranulation takes place by pressing particles together under high pressure

Some binders are edible, whilst others are not. The strength of agglomerates is influenced by the kind of binder and its interaction with the base material. In the case of some binders, it is possible to easily crush or smear the agglomerates between the thumb and forefinger, whilst other binders on the contrary produce an extremely strong agglomerate. In the case of fat-based binders (fig. 3), the melting point or -phase is highly important, both for use in food and non-food products. It may for instance be a requirement that the granules fall apart or disintegrate at a temperature of 80°C, for reason that the product is being extruded at this temperature. Examples of fat-based binders include palm oil, cocoa butter, polyethylene glycol (PEG) and paraffin.

### Water-soluble binders

In addition to oil-based binders, water-soluble binders are also applied. Examples of edible, water-soluble binders include sugar, CMC (CarboxyMethyl Cellulose) and modified starch. Sugar as binding agent is giving a strong and stable agglomerate. Agglomerates based on CMC and modified starch as a binder are weaker and more soft. Starch can be added to the base material both in powdery form and as a solution. An example of a non-edible, water-soluble binder is sodium silicate.



This binder is applied within the chemical and minerals industry. The use of sodium silicate is resulting in stable and brittle agglomerates that dissolve relatively slowly in water. Somewhat more expensive water-soluble binders include PVP and PVA (polyvinyl pyrrolidone and polyvinyl acetate), which are used for the formation of strong agglomerates.

### Principles

For the formation of agglomerates, various process concepts can be applied that correspond to different kinds of installations.

**Agglomaster:** In the case so-called build-up agglomeration, the Agglomaster may be applied. With his equipment, agglomerates are formed by the formation of liquid bridges, allowing e.g. nanopowders to be converted into micron-sized agglomerates. Generally speaking, the agglomerates are porous and highly dispersible. The Agglomaster also facilitates the coating of individual particles or to modify the structure of the agglomerates.

**Cyclomix:** In the case of shear agglomeration, the particles are rubbed against each other, resulting in high shear forces. A machine that is operating according to this principle is the Cyclomix (fig. 4). The agglomerates are dense and stable.

**Compactor:** An agglomeration technology that is based on applying pressure onto the product is the Bepex Compactor (fig. 5). In this equipment, the particles are pressed together under very high pressure. Related to this form granulation technology is extrusion. Equipment used for extrusion is the Bextruder. The extruded or compacted product has a specific shape and is typically dense.

**Flexomix:** Another impact mixing technology is using the effect of interparticle collisions in an aerated powdery environment. In the Flexomix a fluid is atomized in and evenly distributed over a vertical, intensively agitated and fast moving powder stream. The agglomerates are generally porous and are comparable to the results achieved with the Agglomaster.

Processing equipment  
Base material, Binder, Particle engineering

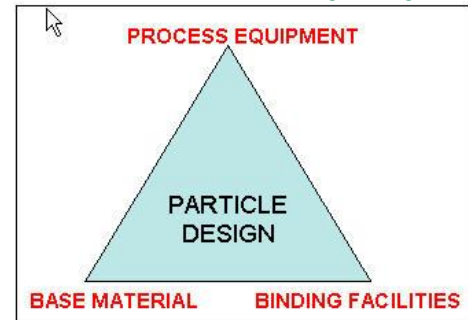


Fig. 1 The engineering of particles involves the combination of base material, processing equipment and binding facilities.

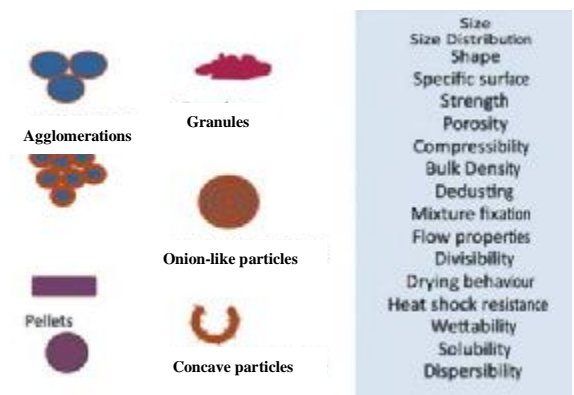


Fig. 2 Examples of particle forms and properties

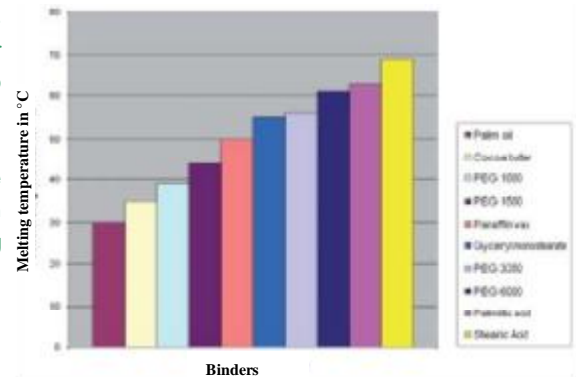


Fig. 3 Fat based binders and their melting temperatures

### Drying and cooling

The final stage of the agglomeration process may incorporate a drying stage (for water-soluble binders) or a cooling stage (for fat-based binders). The drying- or cooling rate, the final moisture and final product temperature all dictate the quality of the agglomerates and must therefore be determined with a view to the final application of the product. **BULK**

B. Mak, Team Manager Chemicals, Minerals and Metals; Hosokawa Micron BV, Doetinchem