The guiding role of fluidized and spouted bed technologies in particle building processes

Content of the whitepaper

The guiding role of fluidized and spouted bed technologies in the particle building process — page 3

Spray granulation – Drying and granulating in one step — page 8

Spray agglomeration for perfect wetting and dispersing properties — page 11

Spray coating – Functional product properties by surface modification — page 15

Microencapsulation – customized properties in abundance — page 18

Checklist for plant engineering — page 22

About Glatt Ingenieurtechnik — page 23
Introduction

Owing to their unique flow characteristic and thermodynamic properties, fluidized bed and spouted bed technologies have become established as important formulation processes to optimize powder properties, as well as the particle-forming procedure, when drying solid-containing liquid solutions. Thanks to the great variety of process parameters, the possibilities in enhancing and functionalizing are almost unlimited.

Product optimization is key to success in many industries. Improving ingredient properties for the food and beverage industry and stabilizing active ingredients for dietary supplements and functional foods are just two examples. For effective and economical heat and mass transfer, particularly when dealing with high-quality materials, both plant and process play a critical role.

Author: Dr.-Ing. Michael Jacob, Head of Process Engineering
Process Technology Food, Feed & Fine Chemicals
Glatt Ingenieuretechnik
The fluidized bed principle
One of the main advantages of fluidized bed technology is the ability to combine several process steps – such as drying and particle design – in the same apparatus. On the one hand, this is very economical. On the other, this makes it possible to dry, refine and functionalize – thus to spray agglomerate, coat and encapsulate raw materials in a single procedure step. The required amount of drying is determined by the level of moisture that permits a material to flow freely after it has been spray dried, centrifuged, filtered, and crystallized – or spray granulated in the same process step. An absolute prerequisite for optimized spraying is that each particle can be treated separately. For this to happen, it has to learn how to fly in a controlled manner.

Learning to fly
Particles learn to fly in a classical fluidized bed apparatus. In the fluidized bed, particles behave like a liquid. The basic construction of a fluidized bed apparatus is quite simple: the core elements of the closed process chamber are a perforated distributor plate, air chambers (below), at least one spray nozzle (above) and, depending on the apparatus and the application, a filter system. From below, a flow of often warm process air brings the material filling – the so-called fluidized bed – into motion. The particles are both kept suspended in the air and, at the same time, separated, so that their entire surface can be wetted by spraying liquids, granulated, coated and dried simultaneously.

Appropriate fluidization agents include:
» Air
» Nitrogen
» Superheated steam (solvent or water).

Non-organic binding agents can be:
» Solutions: in aqueous or organic liquids, the dry matter content of totally dissolved solids falls predominantly in the range of 5 - 60 %
» Suspensions: suspended in aqueous or organic liquids, or a melt, the dry matter content of fine solids, when dispersed, is 20 - 70 %
» Emulsions: in aqueous or organic liquid systems (matrices), solids dispersed as droplets or liquids (recyclables) form loads 5 - 30 % in the outer matrix
» Melts: fully melted raw materials, usually at temperatures of 50 - 120 °C, significantly affect the viscosity of the melt and impact both particle formation and process stability as well as the general feasibility.
Spouted bed processes for sensitive raw materials
Whenever a low residence time and/or minimal thermal stress is required, to process sensitive raw materials, such as probiotics, vitamins, enzymes or flavorings, Glatt’s patented spouted bed method is the technology of choice. This also applies to small particle size products or those that are sticky or viscous liquids, and solids that are difficult to fluidize. Spouted bed is an extension of the fluid bed principle: the chamber geometry is different and the process operates without a perforated inflow. This generates unique flow conditions and parameters that can be used to influence the specific product design.

Top-spray or bottom-spray
The top-spray method is commonly used for agglomeration and rather simple granulation or coating processes. Defined by spraying the fluidized bed from above the product, the particles are wetted by the spraying fluid in a countercurrent manner. For spray granulation and coating processes, the bottom-spray method is recommended. The spray liquid is delivered from below, in a direct current way, with the process air into the fluid bed. Depending on the required product quality and the characteristics of the spray medium, and whenever homogeneous (spherical) and compact (high density) products are desired, the bottom-spray method is preferred. Another variant, the Wurster bottom-spray method, provides very uniform and high-quality coatings. Further spray options are available for specific process applications, such as the rotor or tangential spray method for powder layering, pelleting and coating.

Short- and long-term runs
Continuous processes provide maximum reliability, as well as maximum energy efficiency, by minimizing operator intervention. By contrast, batch-based processes ensure perfect mixing and well-defined process times. However, there are more points to be considered in the process development. Additional factors such as production volume, product variety, product changeovers, production cycles, registration, cleaning and more also play major roles. Moreover, the process itself can be critical. Whether to use a continuous or batch-based process will depend on the specific product and application requirements.

Round or square
Batch devices, preferably used when dealing with frequent product changes, high quality functional coatings and manageable product quantities, are characterized by a round process chamber and distributor plate.
Continuously operating granulators are available in several designs, although a round one is often used for spray granulation. For continuous operations, a large number of spray systems, solid and granulate input systems are available. A particular highlight is the optionally built-in product discharge classifier, which ensures that only particles of the required size pass into the discharge pipe to provide dust-free operation.

For more robust material movement in the process chamber, appliances with an elongated, angular design are advised. Complex in structure, with multiple air inlets and process zones that can be supplied with different gases when needed, these devices mean that particles can be suspended in various conditions, allowing multiple continuous process steps to be done in the same apparatus.

Everything must match

When developing or optimizing fluid and spouted bed technology based products and processes, it’s important to consider the materials to be processed and all the structural and procedural aspects. Only when all of these parameters are optimized can the best properties be obtained.

From a procedural point of view, the processes involved in preparing or treating disperse particle systems can be thought of as multiphase systems of a gas, solid and liquid. Their interactions during different fluidic and thermal conditions and apparatus configurations form the unique potential of this technological platform.
A variety of factors can influence the overall end product characteristics. The table summarizes some important material properties, which may both influence the product's properties and offer opportunities for design. Technical options also offer additional possibilities for stabilization. Furthermore, the application-specific operating conditions are vitally important, affecting explosion protection, operational safety, hygiene, product safety and more.

### Process influencing factors

<table>
<thead>
<tr>
<th>Gas</th>
<th>Solid</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>spray agglomeration — spray granulation — spray coating</td>
<td>» gas type</td>
<td>» material</td>
</tr>
<tr>
<td>» composition</td>
<td>» composition</td>
<td>» composition</td>
</tr>
<tr>
<td>» moisture loading</td>
<td>» particle density</td>
<td>» density</td>
</tr>
<tr>
<td>» temperature</td>
<td>» bulk density</td>
<td>» pressure</td>
</tr>
<tr>
<td>» pressure</td>
<td>» particle shape</td>
<td>» temperature</td>
</tr>
<tr>
<td>» velocity</td>
<td>» surface treatment</td>
<td>» viscosity</td>
</tr>
<tr>
<td>» flow profile</td>
<td>» crystallinity</td>
<td>» PH value</td>
</tr>
<tr>
<td>» turbulence</td>
<td>» particle size distribution</td>
<td>» surface tension</td>
</tr>
<tr>
<td>» other …</td>
<td>» other …</td>
<td>» solidification enthalpy</td>
</tr>
<tr>
<td>Technical Configurations</td>
<td>» process chamber geometry</td>
<td>» type of nozzle</td>
</tr>
<tr>
<td>» distribution</td>
<td>» height of fluid bed</td>
<td>» spraying direction</td>
</tr>
<tr>
<td>» dehumidification</td>
<td>» feed and discharge</td>
<td>» heating</td>
</tr>
<tr>
<td>» conditioning</td>
<td>» dedusting</td>
<td>» temperature</td>
</tr>
<tr>
<td>» circulation</td>
<td>» classification</td>
<td>» circulation</td>
</tr>
<tr>
<td>» dedusting</td>
<td>» crushing</td>
<td>» distribution</td>
</tr>
<tr>
<td>» cleaning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Operating conditions

<table>
<thead>
<tr>
<th>Gas</th>
<th>Solid</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>» ignition energy</td>
<td>» drop speed distribution</td>
</tr>
<tr>
<td></td>
<td>» explosive pressure</td>
<td>» drop size distribution</td>
</tr>
<tr>
<td></td>
<td>» water activity</td>
<td>» recovery of solvent</td>
</tr>
<tr>
<td></td>
<td>» hygroscopicity</td>
<td>» homogenization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>» dispersions</td>
</tr>
</tbody>
</table>
During thermal drying, liquid or moist raw materials are converted into solid dry products by removing water or other solvents by evaporation. The selection of the most appropriate process and equipment for drying applications is complicated and depends on existing conditions. As a rule, however, it should be considered from a holistic point of view.

Using spray granulation, drying and particle formation are combined in a single process step. In the food industry, for example, phosphates, stabilizers, additives, sweeteners, fatty acids or flavors are spray granulated, and other applications include the treatment of temperature-sensitive products such as enzymes, proteins, yeasts or micro-organisms. This very effective method is preferably carried out in a continuous process.

**Granule formation**

Spraying one or more liquids onto particles in the fluid bed produces a free-flowing, dry granulate with a uniform onion-like surface. As such, solutions, emulsions, suspensions, dispersions or melts can be transformed directly into compact, homogeneous granules with a defined particle size distribution and high bulk density. They are largely free-flowing, spherical, abrasion-resistant and dust-free. Small starter particles, which are necessary to maintain a consistently stable granular structure – the granulation cores – are formed during the process. They usually consist of the same material as the sprayed solid in the liquid phase and are either made directly or through internal core pro-
duction, such as spray drying or abrasion, or caused by the recirculation of fine particles. Furthermore, the comminution of larger granules from the sieve-grinding cycle can contribute to building the granule core. When this occurs, no further solid raw material is supplied, just the liquid raw material. In addition, it is possible to add powdered or finely divided solids to the process, which become homogeneously embedded into the granulate structure.

Factors affecting the selection of drying methods:

**Dehydration**
- Raw material handling (stickiness, clumping, wall approach)
- Product handling (adhesion, dusting, electrostatics)
- Variations (distribution of moisture in the raw material, capacity, temperature, aging)
- Product change (frequency, cleaning, transmission)

**Process**
- Pure drying
- Simultaneous formation of particles, granules or complex structures
- Changing properties of solids
- Process management (batch, continuous)
- Process change (change of quality)

**Material properties**
- Drying kinetics (surface moisture, crystal water, sorption)
- Material (maximum temperature load, denaturation, decomposition)
- Flow properties (free-flowing, abrasion, wall approach)

**Engineering**
- Set-up/layout (raw material and material flow, cleanability, hygiene)
- Documentation (GMP, traceability, quality assurance)
- Media (energy, heat recovery, water)

**Product application**
- Stability (strength, sorption, desorption)
- Storage (flowability, hygroscopicity, sintering)
- Application technology (solubility, dispersibility, structure)

**Safety**
- Product safety (contamination, food safety)
- Plant safety
- Explosion protection (ATEX)
- Personal protection
**Product design by granulation**

In terms of process engineering, this basic principle can be influenced in many ways and be used for product design. Several technical options and process parameters are available to adjust the desired granule properties:

- **Spraying fluid**: the height of the solids content, the type (solution, suspension, melt, emulsion, etc.), its viscosity or stickiness, composition (additives, binders, etc.)
- **Spray system performance**: the arrangement of spray nozzles (two- or multi-component nozzles, pressure nozzles, etc.), the type of injection (top spray, bottom spray), the position and number of nozzles, the droplet size and speed
- **Process conditions**: the temperature of the spray liquid (and the atomizing agents), the temperature in the process chamber (product temperature), the intensity of the particle motion (air velocity, flow, etc.), residence time, temperature gradient, drying or solidification rate
- **System technology**: fluidized or spouted bed, batch-based or continuous process, internal core production or sieve-grinding cycle

**Spray granulation**

**Product benefits at a glance**

- Dust-free, round pellets
- Compact structure
- High particle and bulk density
- Low specific surface area
- High particle hardness
- High resistance to abrasion
- Narrow and adjustable particle size and particle size distribution
- Very good dosing
- Excellent flow behavior
- Good solubility
- Good dispersibility
- Low hygroscopicity

Vitamin, spray granulation
The guiding role of fluidized and spouted bed Technologies in particle building processes

or another organic or inorganic binder. By optimizing the heat and mass transfer rates, the moist agglomerates are dried quickly yet gently, with a comparatively low fluidization flow rate and at a low temperature. If necessary, they can even be cooled. The typical product structure – grain to grain – results from contacts between the wetted particles, which join together, condense and solidify during drying until they reach a certain particle size. Finally, the products leave the fluidized bed apparatus.

Owing to the relatively low mechanical forces in the fluidized bed, agglomerates are looser and less dense compared with sprayed or wet granules. They have a low bulk density and are extremely water soluble. The products have a porous structure, capillary-like surfaces and have adjustable particle size distributions of 0.2 and 2.5 mm.

Binding agents

Binding agents can facilitate the process. They ensure that lasting and stable links are formed between the raw materials, increase their ability to agglomerate and support the formation process. They need to be compatible with both the product and the application – fat content,

Natural substances:

- Cellulose derivatives
- Hydroxypropylmethylcellulose
- Hydroxypropyl cellulose
- Gelatine
- Alginates
- Starch
- Dextrin
- Sugar
- Waxes

Inorganic binders:

- Bentonites
- Silicates
- Clay

Synthetic polymers:

- Soluble polymers in water or solvents
- Polyvinyl pyrrolidone
- Polyvinyl alcohol
- Polyethylene glycol

Salts:

- Lignosulfonate
- Sodium chloride
- Sodium sulfate / magnesium sulfate
for example – and should comply with the legal requirements of the pharmaceutical and food industries. Organic binding agents include alcohol, casein, gelatin, gum arabic, paraffin and sugar, whereas inorganic binding agents are alkali metal silicates, magnesium salts, sulphates and water.

**Thickening agents**
Thickeners increase the network effect, bind water and raise – at a certain concentration – the viscosity of the sprayed liquid binder. Pectines, silicates, locust bean gum, cellulose ethers and polyvinyl alcohol rank among the best known thickening agents that influence the consistency and improve the texture. Thickeners must be indicated on the ingredient list.

**Emulsifiers**
Food additives such as emulsifiers are always in demand when oils or fats are combined with watery media to form a stable mixture for an extended period of time.

*Instant tea with milk and sugar, spray agglomeration*
Example: instant cocoa
For instant cocoa powder, it is vitally important that emulsifiers interact with extant carbohydrates or saccharides. Lecithin is frequently used for instant products such as cocoa because it can be implemented as an emulsifier, antioxidant and universal agglomeration aid. Oil-based flavors can be easily incorporated into the spray solution by using lecithin. The source milk and cocoa powder also contain fat. Solubility can be improved by using viscous binding agents during agglomeration, then fluidizing gently, increasing the temperature slightly while keeping the spray pressure low during the drying process to ensure large spray droplets.

Example: tomato powder
To be incorporated into instant soups or baked goods, spray dried tomato powder must be agglomerated to form compact, solid pieces. The desired solubility can be achieved by carefully selecting process parameters and the binding agent. By using an original solution as a binding agent, for example, it is possible to get stable granules with large particle size and low bulk density. The direction of spray will also influence both size and stickiness.

Example: olive powder
Olive powder obtained from whole, pitted olives is rich in fatty substances. By using additional lipophilic binding agents, stable, large and non-abrasive agglomerates can be formed.
Overcoming instantizing challenges

- Agglomerates must be large enough to wet easily and sink quickly through liquid surfaces.
- To prevent sinking too rapidly and forming a sediment, agglomerates mustn’t be too coarse.
- Powder mixtures should show a homogeneous distribution of components; an extreme range of individual component particle sizes in mixtures is unfavorable.
- Abrasion resistance and agglomerate strength decrease with increasing solubility and dispersibility.
- For a long shelf-life, agglomerates need to be uniformly dried, irrespective of particle size.
- The unique particle size and bulk density properties of agglomerates can be effectively combined.
- Temperature- and oxidation-sensitive materials, as well as starting materials, can be spray agglomerated with ease, even though they are difficult to fluidize.

Spray agglomeration

Product benefits at a glance

- Dust-free particles
- Porous structure
- Low bulk density
- Excellent wettability
- Optimal instant behavior
- Easy to form into tablets
- Adjustable particle size and particle size distribution
- Very good homogeneity with ideal component distribution
- Good dosing
- Good flow behavior

Herbs mixture, spray agglomeration
To safely transport sensitive substances such as sustained release dosage forms, probiotics or vitamins to the intestinal tract and ensure their release, they must be equipped with a functional protective coating. By coating using fluidized bed technology, particles are fluidized, sprayed with liquid and dried.

Functional product characteristics can be created, modified or customized by coating solid particles. The coating of choice depends on the transport path and the ambient environment to ensure the appropriate release profile of the active ingredients, be it spontaneous, delayed or sustained. At the same time, the solid casing serves as protection against external influences such as moisture, UV radiation, oxygen or reactive ingredients. With the help of coatings, solid particles can be refined and perfected with additional colorants, flavorings and surface properties. Moreover, the same method can be used to mask and reduce undesired taste and odor components. Furthermore, by binding and reducing dust, physical bulk density properties such as flowability can be improved to obtain a manageable final product.
Layer by layer
The coating process, a special fluidized bed application, places a closed shell around solid cores. By atomizing the spray liquid in the fluidized bed, it spreads across the surface of the resident particles. High energy and material exchange between the particle surface and the fluidization gas then enables the solidification process. The spray fluid may consist of solid-containing solutions, suspensions, emulsions or melts. With repeated sprayings and drying, multiple layers can be applied and the particle growth can be influenced.

Factors influencing product quality
Depending on the process, parameters such as layer mass, spray pressure and rate, process gas temperature, flow and humidity, as well as nozzle position, all affect the quality of the final product. For very homogeneous and closed coating layers, Wurster coating is recommended. Owing to the specific system configuration, Wurster coating induces a directional circulating movement of particles around the nozzle; the combination of the fluidized bed and pneumatic transport allows a uniform spraying and subsequent drying of the solid particles.

Criteria for quality evaluation
To assess the coating quality, the release kinetics of the active ingredient — which can also be used to detect a completely closed coating layer — are determined. Another quality feature is mechanical strength, which can prevent the subsequent destruction of the coating layer during transport or further processing steps, for example.
Probiotic case study: when the journey is the reward

To reach their destination, the gastrointestinal tract (GI), alive and functional, probiotic cultures must be sent on their journey with a protective sleeve. A study with *Lactobacillus plantarum* 299v, conducted in Glatt’s Technology Centre of Engineering in Weimar, Germany, demonstrates the benefits of fluidized bed technology.

The task

Use gentle process parameters to prevent damaging the temperature-sensitive micro-organisms, protect them from the acidic environment of the stomach and deliver a pH-controlled release profile.

A suspension of *Lactobacillus plantarum* 299v was sprayed into the fluidized bed on microcrystalline cellulose pellets as a shaping carrier material and gently dried in the same process step. The spray solution contained a nutrient medium. Additionally, skim milk powder formulations were tested as a protective substance and to optimize the survival of the micro-organisms. During the experiment, product and process air temperatures, as well as the composition of the formulation, were adjusted. To assess the influence of fluidized bed drying on the survival rate of the micro-organisms, a viable cell count was deter-

Results

Pretreatment with skim milk powder before the coating process increased the survival rate of *L. plantarum* by 53%. The ideal thickness of the shellac coatings was 3 mg/cm².

Spray coating

Targeted control of:

- Release behavior
- Odor/taste
- Storage compatibility
- Visual attractiveness
- Surface structure
- Solubility
- Flow behavior
- Sorption behavior/hygroscopicity
- Thermo stability
- Chemical compatibility
- Oxidation stability
- Mechanical durability
- Multi-layer coating for graded functionality

mined after processing. Results showed that the survival rate of the micro-organisms could be increased by 53% up to 95% by using a protective substance. Subsequently, a protective shellac layer was applied to prevent the destruction of the micro-organisms in the acidic environment of the stomach. Using a GI simulation, it was possible to detect viable and fully functional bacteria in the appropriate section of the bowel.
The guiding role of fluidized and spouted bed Technologies in particle building processes

Lavender oil, spray encapsulation

such as conventional spray drying, the particle and bulk properties can be adjusted quite easily. Thus, depending on the properties of the liquid, the particle size and structure, the spraying conditions and the residence time can all be modified. With this process, nearly spherical particles can be produced in a size range of 200 μm up to a few millimeters. The mass fraction of the encapsulated component can be up to 40%. Microcapsules produced in this way have a closed surface and a compact structure, resulting in a stable, long-term inclusion of the active substance.

Can you name an example?
If you want to granulate sensitive vitamins, such as fat-soluble vitamin A acetate and vitamin E acetate, then it’s crucial to granulate them before they oxidize and, in particular, develop a stable formulation and appropriate process parameters. In one series of experiments, we studied various spray emulsion formulations and aqueous solutions with different mass fractions of hydrolyzed and modified corn starch and microcrystalline cellulose. Each vitamin was dispersed into these solutions in different proportions as a fine discontinuous phase. By adjusting the product temperature, spray rate and spray pressure in the fluidized bed, we influenced the shape, structure and size of the resulting microencapsulation, based on fluidized bed technology, is the inclusion of a solid, liquid or gaseous core substance in a solid matrix. Microcapsules provide an ideal vehicle for controlling and protecting vitamins, flavors or PUFAs, as well as volatile essential oils. Here, Arne Teiwes, Process Engineer at Glatt Ingenieurtechnik, discusses fine tuning the process parameters that are key to achieving customized features and economical production methods.

Why is it better to spray encapsulate by fluidized bed?
The basic principle of fluidized bed-based spray granulation involves spraying a liquid onto fluidized particles to wet their entire surface area. By simultaneously drying and hardening the liquid film, the particles grow, layer by layer. Compared with other drying-based encapsulation processes, such as conventional spray drying, the particle and bulk properties can be adjusted quite easily. Thus, depending on the properties of the liquid, the particle size and structure, the spraying conditions and the residence time can all be modified. With this process, nearly spherical particles can be produced in a size range of 200 μm up to a few millimeters. The mass fraction of the encapsulated component can be up to 40%. Microcapsules produced in this way have a closed surface and a compact structure, resulting in a stable, long-term inclusion of the active substance.
particles. As such, and because of the formula, we were able to control the recovery rate. The objective is always to obtain the maximum yield of the active substance in the product.

**So recovery rate is a benchmark of success?**
Yes, with oxidation-sensitive substances such as vitamins, the choice of fluidization medium – ambient air or nitrogen – has a significant impact on the recovery rates. But even when encapsulating essential oils and other active substances, the recovery rate is a significant and economic factor. It’s the yield that counts, so the recovery rate represents the ratio of theoretically achievable active substance from the formulation to reality.

**Why is it impossible to recover the entire active ingredient?**
There are many reasons. For example, an encapsulating material can decompose or become volatile during certain process steps. This starts with the formulation of the raw materials and ends with storage. Another reason could be that a matrix material only provides a limited barrier to the active substance. A good formula, targeted process management and optimized process steps help to reduce the loss of valuable materials to a minimum and increase the overall recovery rate.

**How does microencapsulation work?**
In general, sensitive, dangerous, odor- or taste-intensive liquid actives are encapsulated to protect them from the environment or vice versa. Both handling and process-ability can be enhanced by microencapsulation. Selecting the right matrix materials makes targeted release of the active substance possible. Various chemical and physical methods, such as spray granulation in a fluidized bed, can be used to achieve these goals.

**How can essential oils be encapsulated?**
Essential oils, like many other materials, are encapsulated by spray granulation. However, essential oils present a particular obstacle because they are usually quite volatile with a relatively high vapor pressure; they’re also sensitive to oxidation. Ideally, the encapsulation process is done in a continuous manner in a spouted bed. In this case, the particular flow profile of the spouted bed provides two advantages: a short residence time, which prevents thermal damage and reduces loss by volatilization; and, thanks to the punctual inflow principle, even sticky materials can be reliably mixed. This would be difficult using a conventional fluidized bed processes.

**How can volatile substances be captured?**
A stable emulsion formulation is the base. Film-forming and surface-stabilizing agents such as modified starches
facilitate the preparation of stable emulsions that are unaffected by pumping and atomization. During the granulation process depending on the emulsion, solid particles with very fine distribution of trapped oil can be obtained. Recovery rates of up to 80% are possible, depending on the essential oil, because of the thermodynamic equilibrium conditions that exist, whereby some of the oil to be encapsulated is discharged from the granulation zone by the fluidization air. So, not only do you lose a lot of the precious target substance, you might also encounter problems trying to comply with the volatile organic compounds in industrial emissions limits.

**What are the causes?**
In addition to the material challenges, the main cause of these problems is managing the open gas flow which is currently the technical standard. We looked at these conditions and revised the microencapsulation construction concept in a fluidized bed. The aim was, in addition to increasing the recovery rate, to minimize the overall loss in the process and – with the help of alternative exhaust air purification technologies – to improve the economic efficiency. Among other things, we tested catalytic exhaust air purification and linked the process to heat recovery. Above all, we have transformed gas flow management in a closed cycle system.

**So, process gas management is key?**
Exactly. In fact, gas management plays a key role. The cycle operation has proven itself to be particularly economical and safe during various granulating applications, especially with oxygen-sensitive and explosive materials. In these cases, granulation is done under a nitrogen atmosphere and needs considerably less nitrogen than open system operations. In applications without a fresh gas flow, the required process humidity must be maintained by using a condenser. A beneficial side-effect is the ability to enrich the oil in the process gas. As it’s almost saturated, the process gas absorbs no more oil, so it remains where it should – in the granules. Noting this, and by varying the spray rate, layer temperature and condenser settings, we discovered the optimal encapsulation conditions to produce a closed particle surface with uniform structure. In experiments with carvacrol as the active substance, the recovery rate could be increased to more than 90%. Thanks to the condenser and a comparatively low exhaust gas mass flow, the loss of carvacrol within the process air could be reduced by up to 99%.

**What is the winning formula for granulation and encapsulation processes?**
It is most economical to start small and do tests on a laboratory plant with small quantities of raw materials. Glatt provides test facilities with various process operations, system
configurations and, just as important, a well-equipped laboratory at its Technology Centre. With the help of in-process analyses of the active substance content or other important particle characteristics – such as size and bulk density – processes can be quickly adapted to obtain the desired product properties. A team of experienced food and process engineering experts accompanies the usual week-long test series. For a reliable scale-up to the production scale, Glatt also has local pilot lines available, which are especially useful when continuous process management is the goal.

**Artificial neural networks and modern simulation tools**

Neural networks provide valuable information about product and process optimization. A process model is created from the records of the experimental conditions and the associated product properties. The aim is to provide accurate predictions for targeted experiments, so they can be planned and conducted in a cost-effective way.

As soon as the process conditions to produce a high quality product are found, using the flow sheet simulation makes optimizing the individual process steps and developing heat and power strategies much more convenient. The result: custom-made products from economically optimized processes.

Image captions:

- Granule with oil encapsulated in the matrix
THE GUIDING ROLE OF FLUIDIZED AND SPOUTED BED TECHNOLOGIES IN PARTICLE BUILDING PROCESSES

CHECKLIST FOR PLANT ENGINEERING

Questions to be answered for product optimization and plant planning:

**Raw materials**
Specific information on the properties of the starting materials, the type and number of components, etc., depending on
» Solid substances (powder, granules)
» Liquids (solutions, suspensions, melts, emulsifiers, dispersions)

**Quality-determining characteristics of final product**
» Bulk volume, bulk density
» Particle size distribution
» Component distribution
» Flowability
» Instant performance
» Wettability
» Residual moisture
» Melting point
» Solubility
» Enhanced tabletting properties
» Dosability
» Release profile
» Thermostability
» Odor, taste, visual attractiveness
» and much more

**Food law requirements**
» Regulations
» Declaration obligations

**Fundamental process questions**
» Continuous or batch-wise operation – depending on requested product quantity, operation mode, quality requirements, documentation obligation, frequency of product changes
» Explosion protection
» Fire protection
» Top spray or bottom spray
» Heat recovery, gas flow cycle
» Automation / control system

**Hygiene design conditions**
» Approved materials and components
» System cleaning capability
» Approved / necessary cleaning media
» Clean rooms (wet and dry)
» Ventilation technology / filter classes
» Product changes

**Product handling**
» Conveying
» Dosing
» Blending
» Storing
» Filling and packaging

**Process influencing conditions**
» Location
» Climate
» Utility supplies, i.e. electricity, gas, oil, water, steam
» Limit values for emissions, i.e. dust, noise, wastewater

**Structural basic conditions**
» General spatial conditions
» Platform heights
» Media supplies
» Cable routing and pipe routs
ABOUT GLATT INGENIEURTECHNIK

Glatt Ingenieurtechnik engineers, designs and implements international projects, from the expansion or modernization of existing production sites to the construction of completely new plants. Throughout its activities, the company combines professional engineering with in-depth technology expertise. Projects focus on processes for the manufacturing of solid, semi-solid, liquid and sterile drug dosages as well as on the development, optimization and processing of bulk materials such as powder, granules and pellets for food, feed and fine chemicals.

Glatt Ingenieurtechnik is headquartered in Weimar, Germany. Further affiliated enterprises are located in Wiesbaden, Dresden, Switzerland, Russia, India and the USA. Integrated within the global network of the Glatt group, the company benefits from the know-how of about 2000 specialists. Numerous representative offices offer Glatt’s complete services for various projects to customers around the world.
THE GUIDING ROLE OF FLUIDIZED AND SPOUTED BED TECHNOLOGIES IN PARTICLE BUILDING PROCESSES

Glatt Process Technology Food, Feed & Fine Chemicals