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FLUIDISED BED TECHNOLOGY: REVIEW

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ABSTRACTS

The advancements in the research have provided an edge to this branch of pharmaceutical sector for uplifting the pharmacy profession and to conquer the diseased state for nurturing the health and humanity. The fluid-bed technology or air-suspension process is the potential tool to develop newer trends and implications in the sector of formulation development with maximum therapeutic efficacy. The fluidized bed technology is used for granulation agglomeration, layering and coating of a wide range of particle size. In addition, the technique can be used for the drying process. The three patterns of the fluid-bed processes could be characterized by the position/location of the spray nozzle i.e. top spray, bottom spray or tangential spray. The aim of this review is to review some of the general aspect of fluid bed granulation & some common techniques which are utilized in pharmaceutical industry.

KEYWORDS: Fluid-bed processor, Palletization, Granulation, Formulation development, Agglomeration.

INTRODUCTION[1,2,3,4]

Now a days FBP (Fluidized bed processor) is an important technology utilized in Pharmaceutical Manufacturing. Initially used as a simple yet highly effective dryer, with the addition of spray nozzle, fluidized bed systems quickly developed into granulators. The main concept of an Fluidised Bed Process or granulation is to spray a granulating solution on to the suspended particles. Which then would be dried rapidly in the suspending air. This system is usedful for the rapid granulation and drying of a batch. In the addition to granulation for tableting the fluid bed top spray method. Which produces a highly dispersible granules with a characteristics porous structure that enhances wettability such granules are used in food, nutritional and chemical products. In addition, the technique can be used for the drying process as well. Use of this equipment helps reduce the time, cost and also the processing steps involved in production of a product. The principle involved in such techniques may be either by bottom spray or top spray or tangential spray process. These principles depend on the positioning of the spray gun in the equipment. The top spray process helps in obtaining the uniform palletization or granulation. The bottom spray process uses Wurster coating unit for the spray. The bottom-spray (Wurster) fluid-bed method is very popular in the pharmaceutical industry for active layering and for coating to modify or control drug release because it produces a superior film compared with other coating techniques. The tangential spray (rotary) method has been used for granulating and pelletizing with subsequent coating**.** Granulation improves flowability and appearance which finds great application in pharmaceutical industries. Dissolution rate, bulk density, reduction in caking formation and strength of granule is also improved. It improves handling of powder which are difficult to handle because of their cohesiveness and low flowability. Among the various granulation techniques, fluid bed granulation (FBG) is one of the most widely used. The term "Fluid Bed" is used because air is forced up underneath the powders or products in the product chamber. The resultant appearance is much like the surface of water being disturbed by waves, hence the term "fluidization" of the product. This action can be gentle or quite high and focused, depending upon the needs of the process.

PRINCIPLE OF FLUIDIZATION[5]

The principle of fluidization is when a gas is sent through a nozzle with a velocity of greater than the settling velocity of particles or solids, the particles tend to suspend in the air provided and continue in the stream of upward gas. When the particles are reaching to the top of the equipment, they tend to gravitational pull and so fall down and the process is suspending continues. This process is called as fluidization of suspended particles.

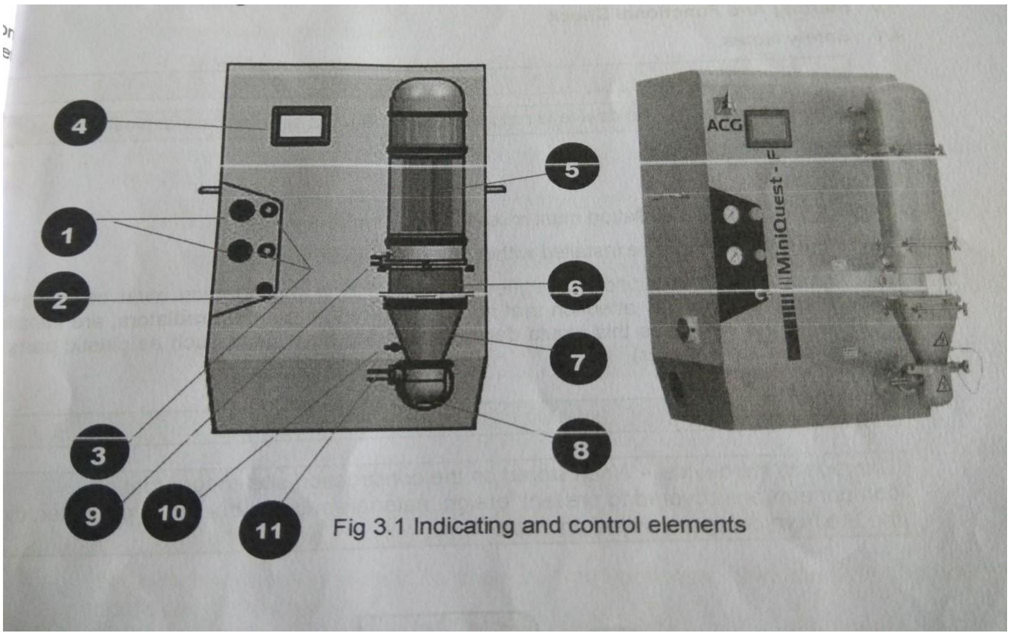

Fig. No. 1: Indicating and Control Elements of FBP.

1. Dial Gauge
2. Atomization Air Nipple
3. Control Switch (Regulator) for inlet airflow & atomization air.
4. HMI (4”)
5. Filter Housing Assembly
6. Expansion Chamber
7. Product Container
8. Lower Plenum
9. Port for Top Spray Nozzle
10. Temperature Sensor
11. Port for Bottom Spray Nozzle

THEORY OF FLUIDIZATION[6]

The following are the stages of fluidization

a. Static bed: When the velocity of the suspending air is low, the supplied air passes through the void spaces of the bed without disturbing the particles by which no air suspension of particles takes place.
b. Expanded bed: At an intermediate flow rate of the air used, the bed gets expanded in the stream, this is called as expanded bed.
c. Mobile bed: When the flow of air stream is very high i.e., with high velocity, the particulate bed is swept off to the top of the vessel. This is called as mobile bed.

d. Bubble formation: When the velocity increases, the bed expands and bubble formation occurs i.e., Pneumatic transport. When the air velocity further increases leading to the blowing of the particles out of the stream.

FUNDAMENTALS ON THE PROCESS

a) Fluid bed drying

During the drying, Process air flows through sieve bottom of the material container and whirls up the material being within it as the air velocity exceeds the setting speed of the particles (fluid bed). The particle ascends within the material container and come in the relief zone. During the flight the full surface of each particle is exposed to the air flow which allows an optimum drying.

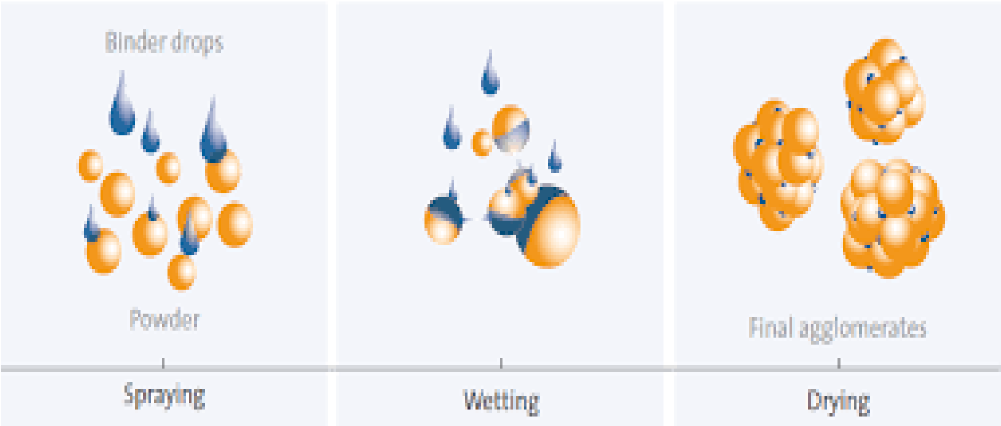

Figure No. 2 Process principle of fluid bed dryer.

b) Fluid Bed Granulation

During granulation process air flows through sieve bottom of the material container and whirls of the material being within it as soon as the air velocity exceeds the settling speed of the particles (fluid bed). The particle ascends within the material container. Agglomerating liquid is sprayed into the fluid bed from the spray nozzle installed in the relief zone. The granulated particles come further into the relief zone. During the flight the full surface of each particle is exposed to the air flow, which allows an optimum drying during spraying This process generates dust-free pourable granulates from very fine powders.

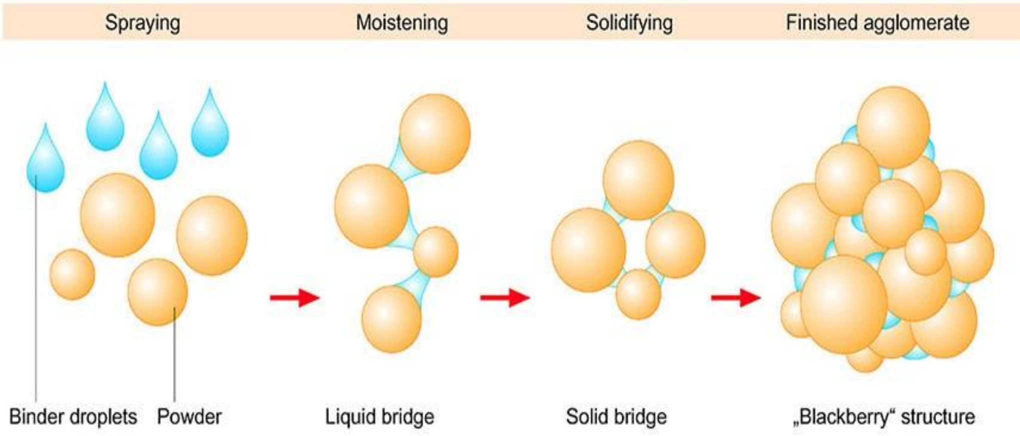

Figure No. 3 Process principle of fluid bed granulation.

c) Fluid Bed Coating (Wruster Process)

During Fluid bed coating, the product is coated with suspension or dispersion. Attention must be paid that the liquid phase of the suspension is not evaporated before the droplet has wetted the particles in the fluid.

For the wruster process, the special design of the material container (With one internal ascending pipe) and the spray nozzle located on the sieve bottom ensure the desired particle movement and the desired spray pattern of the spraying agent. the optimum process is when the product ascends within the ascending pipe in a rapid whirling motion and slowly falls back to the product container bottom out of the ascending pipe.

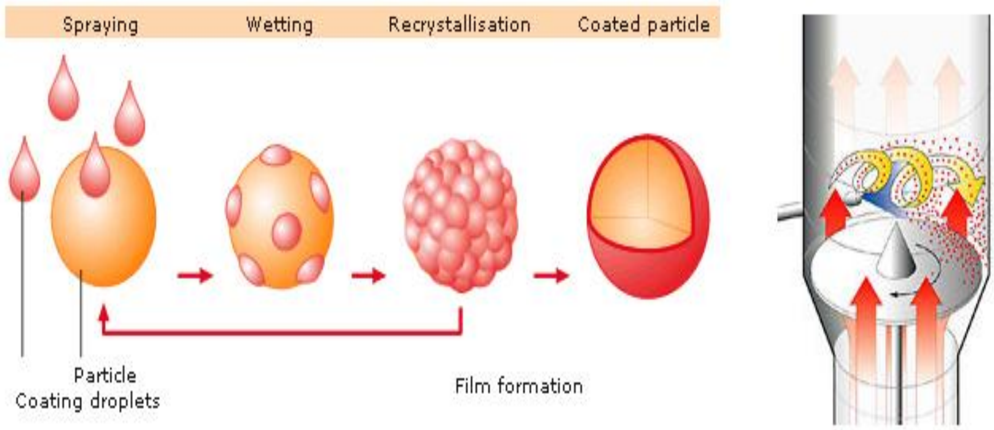

Figure No: 4 Process principle of fluid bed coater.

PARAMETERS AFFECTING FLUID BED SYSTEMS (10,12,13,14)

A. Equipment parameters

- Position of air distribution plate

- Shape of instrument body
- Nozzle height during coating
- Pressure applied during process
- Inlet and outlet temperature
- Spray rate

B. Processing parameters

- **Drying parameters**
- **Temperature:** Rate of drying increases as inlet air temperature increases. This should be carefully monitored as the exposure of the thermolabile substances gets degraded on increasing the temperature of inlet air.
- **Humidity:** Humidity plays an important role in drying of the compound. If humidity is less in the inlet air, the drying process gets completed in a faster rate when compared with that of the inlet air with high humidity.

- **Granulation parameters**
- Position of nozzle: Based on the bed height, the position of nozzle should be adjusted, for better drying.
- Spray rate: Spray rate should be optimized for prevention of over granulation.
- Spray pressure: Pressure should be monitored continuously as the change in pressure leads to improper drying and granulation process.
- Coating parameters:
- Distance of spray nozzle: Distance of spray nozzle plays an important role in deciding the coating process as the more distance leads to evaporation of the coating solution and the less distance leads to over wetting of the particles or the dosage forms.
- Droplet size: Droplet size is inversely proportional to the efficiency of coating. The lesser the droplet size, the more is the uniformity of coating of the solution.
- Spray rate: the spray rate should not be too fast or too slow. Optimum spray rate is to be maintained for better coating to take place.
- Spray pressure: Atomization of coating solution depends on the spray pressure. Moisture in the equipment leads to degradation of hygroscopic substances. Coating solution is to be dried well so that uniform coating occurs so, the temperature should also be monitored for a better coating solution. Time of drying also plays a major role in coating process. If the time of drying increases, the coating layer may get brittle and leads to processing

problems and if the coating layer is not well dried, the doublets and the triplets are formed due to the sticking of the tablets to one another. The coating solution is to be selected based upon the parameters used. If the coating solution is an organic solution, it may catch fire due to the high temperature inlet air used. During a coating process, the opposite nature materials is to be used. i.e., when hydrophilic material is used as starting material, the hydrophobic material is to be used as coating material and vice versa.

Advantages[7,8]

- Liquid like behavior, easy to control
- Rapid mixing, uniform temperature and concentrations.
- Resists rapid temperature changes, hence responds slowly to changes in operating conditions and avoids temperature runaway with exothermic reactions.
- Applicable for large- or small-scale operations.
- Heat and mass transfer rates are high, requiring smaller surfaces.
- Continuous operation.
- Ease of process control due to stable conditions.

Disadvantages[7,8]

- Bubbling beds of fine particles are difficult to predict and are less efficient.
- Particle comminution (breakup) is common.
- Pipe and vessel walls erode due to collisions by particles.
- Non-uniform flow patterns (difficult to predict).
- Size and type of particles, which can be handled by this technique, are limited.
- Due to the complexity of fluidized bed behavior, there are often difficulties in attempting to scale-up from smaller scale to industrial units.

Applications of Fluid Bed Processing[9,10,11]

- **Drying:** Fluid bed drying is an especially effective way of drying solids. During fluidization, liquid is withdrawn from the entire surface of every single particle. The advantages are excellent heat exchange, ideal drying time.
- **Granulation/ agglomeration:** Agglomeration in the fluid bed is a modern method of creating granulates from powder disusing liquid bridges. The sprayed liquid can be either water or an organic solvent or another binder. The moist granulates are dried or cooled.

As a result, the agglomerates are loose, have a low bulk density and are outstandingly soluble in water.

- **Powder coating / Particle coating:** Modern film coating selectively influences the product characteristics through the application of protective films. A very uniform application of the coating material is important during coating. The coating must provide an absolute seal without mechanical damage or tears. Film coating is a technically demanding process that can be used over a very wide spectrum.
- **Pelletizing:** During pelletizing, powder is mixed and moistened. At the same time, a solvent or binding agent can be added. The centrifugal motion produces agglomerates which are spheronized into uniform, dense pellets. Selective product characteristics can be realized through direct pelletizing or layering.

Innovations In Fluidized Bed Processor[14,15]

❖ **Pulsed Fluid Bed Dryer:**In pulsed fluid bed dryer, at a given time period, the fluidizing gas flows through a fraction of grid surface area and is then redirected to consecutive sections in fast succession (the gas plenum chamber is divided into several sections). While in conventional fluid bed dryer, the fluidizing gas flows through the entire surface area of grid surface.

Advantages

- For easy fluidization for irregularly shaped particles such as fibers, flakes, needles
- For fluidization of material having a wide particle size distribution
- For fluidization of bed of particles with 30 to 50% less air
- It operates with improved fluidization uniformity (reduced channeling)
- For fluidization of fragile particles

❖ **Fluidized Spray Dryer**

The Fluidized Spray Dryer FSD™ is one often most successful designs of spray dryers combines fluidization and spray drying technologies, enabling the size and structure of particles to be easily controlled. Therefore, the FSD™ is often used as a spray dryer agglomerates or spray dryer granulator. Another important feature which makes this concept ideal for producing heat sensitive products in dried form.

Advantages

- Produces free flowing powders in agglomerated or granulated form.

- Produce powders having a very low content of small particles (dustless).
- Many thermoplastic and hygroscopic products those are problematic in other designs can be dried.
- Ideal for heat sensitive products as particle temperatures are kept low throughout the drying process.
- Drying is completed at low outlet drying temperatures, giving high energy utilization efficiencies.

❖ **Precision Granulation**

Fluid Bed Granulation and High Shear Granulation are presently the most important wet granulation techniques employed in the pharmaceutical industry. Precision Granulation TM, a new bottom spray method, is evaluated for comparison with the conventional granulation methods. The objective of this study was to compare Precision Granulation™ (PG) with Top Spray Fluid Bed Granulation (TS-FBG) and High Shear Granulation (HSG) for tableting. Finally, they conclude with: PG produced good quality granules with adequate flow and strength for tableting. The quality of these tablets was comparable to those of tablets prepared from TS-FBG and HSG Porosity, strength, bulk density and tapped density of PG granules were intermediate to those of HSG and TS-FBG granules. PG granules had the lowest Carr index and Hausner ratio values. For equivalent tablet weight and hardness, PG tablet batches showed faster disintegration times. Preliminary studies with the two grades of lactose and powdered sugar suggested that PG can offer an alternative to existing methods for investigating granulation of "difficult-to-granulate" materials. Real Time Process Determination TM (RTPD) is a software program that can be integrated with the granulator controls system for enhancing process monitoring and control.

❖ **Multi-Function Fluid-Bed Granulator and Coater**

Vanguard's VPL Series Fluid Bed Granulators and Coaters have multi-functional systems. The top spray system is the third generation of the top spray granulator. It is more efficient than most common fluid bed granulators in the industry. This type of advanced series equipment integrates three fluid bed processes including the top-spray granulating, bottom spray coating, and tangent spray pelleting and coating such that it achieves both economic and technological advantages in solid dose processing and other applications.

Features

- Highly efficient dryer
- Granulator meeting different requirement
- Bottom spray coating system
- Tangent spray rotor system for powder layering, pelleting, coating
- Intelligent control system

CONCLUSION

The purpose of this review article is to get knowledge of fluidized bed technology. In this review article we try to discuss the principle and application of the fluidized bed technology also presented a varied description of the fluid bed process such as drying, granulation, coating and palletization. We focused on types, factor affecting on Fluidized bed technology, and Criteria for selection of fluidized bed technology.

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