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Pharmaceutical Sciences **Review Article……!!!**

"A REVIEW ON FLUIDIZED BED TECHNOLOGY: FBD VS FBP"

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KEYWORDS:

Drying, Fluidized bed dryer, fluidized bed processor, fluidized bed technology.

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ABSTRACT

Drying is the method of evacuating dampness or fluid from a substance, typically through evaporation or other means to diminish its moisture content. Fluidized bed technology could be an innovative and versatile process widely utilized in various industries. This technology includes suspending solid particles in a fluidized like state, typically through the introduction of gas or liquid. There are mainly two types of fluidized bed innovations used in pharmaceutical industries. FBD stands for fluidized bed dryer that's well known and broadly utilized equipment in the pharmaceutical granulation area. FBP stands for fluid bed processor that's a flexible innovation for making granules from powders using bridge. The fluidized bed dryer could be pivotal equipment in industrial drying processes employing the principle of fluidization to productively expel dampness from different materials. However this article also gives the information about when to use FBD or FBP. Also, this article delves into the fundamental highlights and operations of fluidized bed dryer and processor.

INTRODUCTION:

The pharmaceutical industry is one in which quality of the final product cannot be compromised. Any deterioration of the product (e.g., by microbial contamination, oxidation, thermal decomposition, contamination by metallic particles or by unresolved organic solvent) must be avoided at any cost. In light of that the Good Manufacturing Practices (GMP) for drug manufacture put various demands on the drying stage of the drug manufacturing process.[1]

Drying can be characterized as the vaporization of absorbed dampness from damp material. It is a heat and mass exchange process that is completed by employing the variety of mechanisms. The basis of this method is the transfer of heat from the material to be dried, which causes the retained water to vaporize that is transferred to and carried by the surrounding air or inert gas.[2]

Drying process can assist in different ways such as:

To spray dry solution and suspensions & to prepare granules and powdered extracts.

To process bulk drug materials such as aluminium hydroxide, lactose etc.

To anticipate microbial growth and preserve the biological products such as blood plasma and serum for prolonged duration.[3]

To anticipate deterioration and or preserve the drug of animal vegetable origin as well as synthetic and semi synthetic drugs for prolonged duration.

To improvise the properties such as solubility, size shape and ensure the free flowing of materials.

To reduce the bulkiness and weight of pharmaceutical ingredients and ease in their transportation and storage.[4]

Factors influencing Drying

The various factors influencing the drying process are:

Density of the product.

Selection of suitable drying equipment for a particular product.

Temperature, humidity and cleanliness of air.

Moisture content of the product.

Physical and chemical characteristics of the product to be dried. Probable drying time for a specific product.[5]

Mechanism of Drying

The mechanism of drying involves two forms:

- ***Heat Transfer***

It involves transfer of heat from heating medium to the solid material.

- ***Mass Transfer***

It involves transfer of moisture from bulk of the solid to its surface and consequent vaporization of dampness into the surrounding.[6]

Applications

Drying is utilized to expel abundance dampness or other volatiles from coatings and different substrates.

It is utilized to diminish and control moisture levels in solid material in the manufacturing of various materials.[7]

It is used to preserve and improve good properties such as flow-ability, compressibility etc of the material.

It is most vital in the processing of highly thermolabile products which are not stable in liquid form. [8]

Drying active pharmaceutical ingredients to upgrade stability and prevent degradation.

Fluidized bed technology

Fluidized bed technology is characterized by excellent heat and mass transfer. All particles are isolated and continuously blended so intensively that a uniform treatment temperature is ensured everywhere in the entire fluid bed.[9] The fluidized particles are accessible all around and in intensive contact with the process gas. This condition is ideally suited for wetting with spray liquid and for simultaneous drying of the resulting liquid film. This not only enables a very well controllable drying process, but also gives gentle treatment for temperature-sensitive materials.[10]

Fluid bed dryers make the thermal treatment of bulk solids particularly effective. The effective heat and mass transfer of a fluid bed makes optimal conditions for quick, effective drying and cooling.[11]

Fluidized bed dryer *(FBD)*

FBD stands for fluidized bed dryer that's well known and broadly utilized equipment in the pharmaceutical granulation area. FBD, as its name recommends is outlined to perform the method involved:

✓ Drying only

It is effective for industrial application to get drying as well as blending of powders.

FBD is quick acting technique; quickly expels moist particles from powder particles before they go forward to the rotary table press machine.[12]

Principle

It works on the principle of fluidization. When hot air is passed through a granular bed (i.e. non-sticky damp granules), friction occurs between the granular surface and hot air, that leads to pressure drop.[13] On expanding the velocity of air, the pressure increases and a point is accomplished at which the pressure is equal to the total weight of the granules. At this point the granules get isolated and encourage increment in velocity of hot air increase the motion of the granules and at last they get fluidized. Fluidization could be an arrange in which the granules are suspended in an air stream without any adhesion.[14]

It comprises of a fluidization chamber made up of stainless steel. A pump is fitted at the bottom along with heaters such that the air entering the chamber gets heated. Feed inlet and product outlet are given on either side. A pre- filter is fitted at the bottom (of chamber) underneath which an air inlet is present. Equipment contains a separator (granule and air separator) which is utilized for collection of dried material from the chamber. Fluidized bed dryer without separator are too accessible which are mainly useful for batch type operations.[15]

Bag filters

These are put over the drying vessel for the recovery of particles and dried material. Different highlights of theses filter bags are:

1. These are made of diverse sorts of material or fabrics- cotton, nylon, polyester, satin, polypropylene.
2. These can bear high pressure of hot air or high flow rates, Durable construction.
3. These are available in several pore sizes, thickness, fabrics, penetrability.
4. Anti-static fabrics are too available.
5. These are accessible in distinctive sizes which can effectively fit in equipment.[16]

Fig 1: FBD Bags

FBD filter bags are available in distinctive sizes that easily fit to equipment's and made with superior quality fabrics. Our FDB filter bags are economical to use and as these are manufactured with required stipulations which regularly meet the international quality standards.[17]

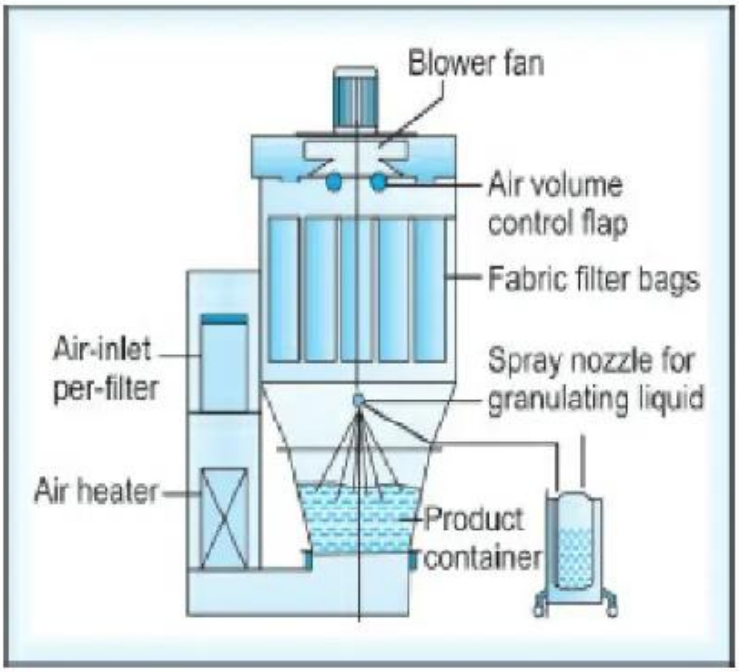

Fig2: FBD (Fluidized bed dryer)

Working

The material to be dried is set into fluidizing chamber through the feed channel. Pump and the heaters are switched on. Hot air enters the chamber from the bottom through the pre-filter. The air streams from the bottom to the top with a high velocity such that the granules get suspended in the air stream and the fluidization is accomplished. Each particle is encompassing by the air, due to which viable drying is achieved.[18] The particles stay fluidized for a period of about 1 to 2 minutes (if only surface liquid is to be dried) or 16 to 30 minutes (if water from inside of porous material is to be evacuated).

Solid particles of smaller size, extending from 1 to 2.5 undergo fluidization. When coarse particles are to be dried, they must be blended with a little amount of fine particles for way better fluidization. So also, addition of few coarse particles encourages better fluidization of fine particles.[19]

The dried particles move from the chamber to separator through a interfacing pipe. Here, the air together with dust is eliminated and the dried material is

collected from the product outlet (at the bottom). Nearness of separator encourages ceaseless operation.[20]

In a few fluidized bed dryer, isolated rectangular compartments are present for fluidization, in which successive stream of solid from inlet to outlet taken place, which is called as plug flow system. Cold air is circulated within the final compartment, due to which the material gets cooled before it is discharged.

Merits

- It is simple to handle and requires less time when compared to tray dryer.
- Low labour cost.
- High heat transfer coefficient.
- Drying can be done either batch-wise or continuous.
- Apart from drying, it can also be utilized for coating, blending and granulation etc.
- Thermal efficiency is much more prominent (2 to 6 times) when compared to tray dryer.
- Appropriate for both small and large scale drying.
- Drying capacity is more than tray dryer.
- Valuable for thermolabile materials.
- Fluidized bed dryer requires less time to complete drying. i.e., 20 to 40 min.
- Hot spots are not observed within the dryer, since of its amazing blending and drying capacities.
- The thermal productivity is 2 to 6 times more prominent than tray dryer.
- It can be utilized either as batch type or continuous type.[21]

Demerits

- Electrostatic charges may develop due to collision of particles, subsequently earthing of dryer is obligatory.
- Due to collision, granules may break, thereby forming fine particles.
- Not reasonable for sticky materials.
- Particle break up is common.
- A possibility of fine product loss.
- Non uniform stream pattern and troublesome to foresee.
- In Fluid Bed – drying sticky material is exceptionally troublesome.

- Due to complexity of fluid bed dryer behaviour, there are frequently troubles in attempting to scale-up from smaller scale to industrial units.[22]

Applications

- It is a productive strategy for drying granules.
- Solutions and slurries can be dried by appropriate adjusting the equipment.
- Modified fluidized bed dryer is utilized for coating for granules.
- FBD are utilized in powder layer coating using tangential roto granulator to mini-tablets and capsules.
- Utilized to decrease the risk of contamination.
- Utilized to agglomerate particles.
- Dryers too offer assistance in agglomeration, the process of assembling material particles into cohesive units like pellets or granules, as this process makes it easier to transport fine powders due to their loose packaging. [23]

Fluidized Bed processors *(FBP)*

FBP stands for fluid bed processor that's a flexible innovation for making granules from powders using bridge. This can be well-suited innovation designed to perform the processor involved;

✓ Granulation
✓ Drying
✓ Coating

Subsequently minimizing the number of equipments required for each parameter.[24]

Components

❖ Base part
❖ Inlet
❖ Exhaust
❖ Control panel
❖ Bottom plate
❖ Spray nozzle
❖ Moveable product Equipment parts like Top and Bottom spray.
❖ Expansion chamber.
❖ Filter chamber

- Product Bowl

Principle

A fluidized bed is a bed of solid particles through which hot air is passed at high pressure through air distribution plate or bottom of container.

The particles are lifted from the bottom and suspended in air stream. This condition is called fluidized state.

With the assistance of spray nozzles granulating liquid or coating solution is sprayed to produce granules or coating of particles separately and after that dried with hot air.[25]

FBP includes getting the powder in a fluidized state after being pressurized with hot air and getting passed below the product bowl. Hot air continuously holds the particles in an air medium to get dry; this is also known as fluidized state.

Fluidized bed processor includes suspending solid particles in a fluid like state by passing a gas or liquid through a granular material.

Key Highlights: Fluidization, Homogeneous processing, heat transfer, reaction control.

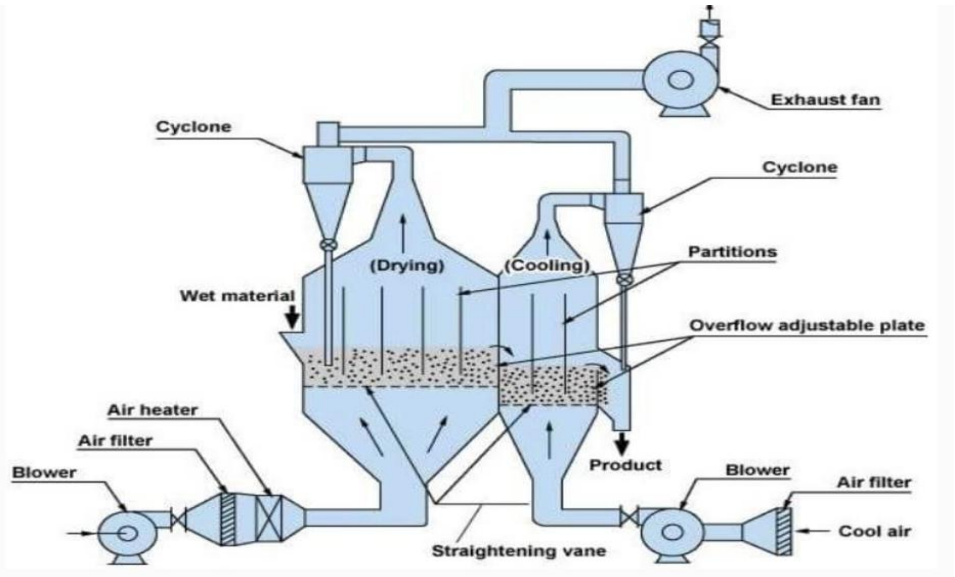

Fig3: FBP (Fluidized bed processor)

Working

The working principle of FBP is divided into three sections:

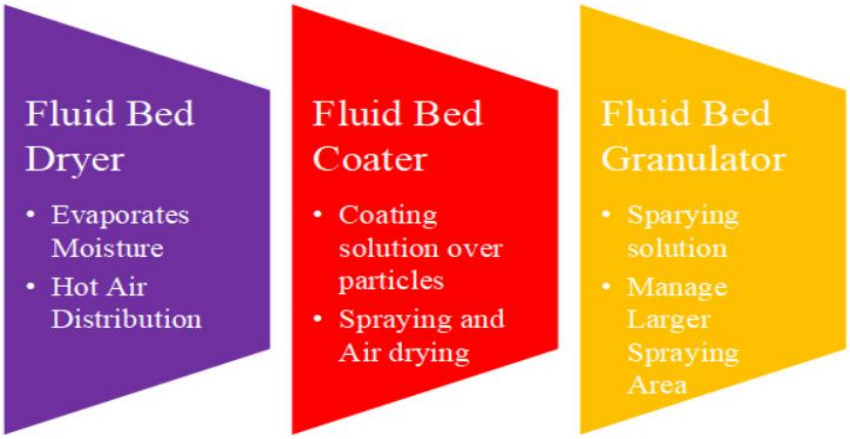

Fig 4: Components of FBP

1. Material to be dried is set within the bowl type vessel.
2. Air is introduced from the top and heated at required temperature by the heaters.
3. The air is filtered through the filter and after that passes through the bed of the material at the bottom.
4. The airflow is produced by the fan fitted at the top of the equipment.
5. The operating temperature is adjusted by the control panel.
6. As the flow of air increases, the bed expands and particles of powder begin to rise up.
7. The regular contact with air causes the material to dry.
8. The air clearing out the FBD passes through the filter to collect the fine particles of the material.
9. Fluidized bed dryer incorporates a high drying rate and the material is dried in a very short time.
10. Material remains free streaming and uniform FBD bags have finger like shape to increase the volume of the drying bed that makes a difference to extend the drying rate and decreases the drying time.[26]

Advantages

- High rates of moisture removal
- Highly effective in material drying
- Handling is easy
- Wide extend of materials can be defined

- Product loss

Disadvantages

- Sticky material is very troublesome
- High capital and maintenance cost
- Skilled person required

Applications

- Drying of granules within the generation of tablet.
- Coating of the tablet.
- Agriculture, Pharmacy, food & Dairy.
- Polymer film coating.
- Drying moist.
- Top spray granulators.
- Formulation, development and production.
- A fluid bed processor is utilized to enhance product quality.
- It can be utilized to make sustainable release coating and enteric coating drug.

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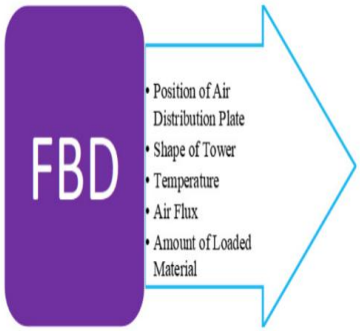
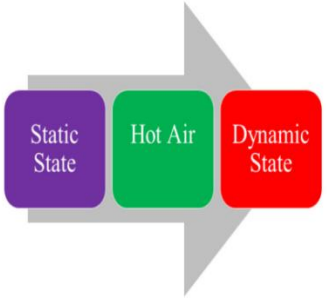
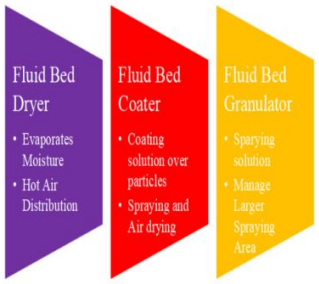
TABLE I: DIFFERENCE BETWEEN FBD AND FBP

S. NO.	TITLE	FBD	FBP
1.	**Description**	FBD stands for Fluidized bed dryer that's well known and extensively used equipment within the pharmaceutical granulation area. FBD as its name recommends is designed to perform the Drying.	FBP stands for Fluidized bed processor that's a flexible innovation for making granules from powders employing a liquid bridge.
2.	**Processes involved**	**Drying only** It is proficient for industrial application to get drying as well as blending powders.	**Granulation** **Drying** **Coating** In this manner minimizing the number of

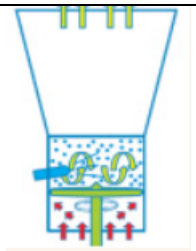
			equipment required for each parameter.
3.	**Taking into considerations**	**Granulation:** FBD is a fast-acting innovation; swiftly removes moist particles before they go forward to the rotary tablet press machine. FBD is utilized to make powder particles acceptable for the tableting process.  	**Particle coating**: FBP is a commonly utilized method for particle coating. Bottom spray fluid bed coating is an excellent strategy in fluidize the bed coating system. **Pelletizing:** FBP blends and humidifies the powder particles during pelletizing followed by an addition binding solution or solvent. The continuous solid centrifugal force produces granules that are spheronized into dense pellets. **Agglomeration:** FBP forms or agglomerates granulates from particles; machine dry or cool down the wet granules as well. **Drying:** FBP is an efficient means of drying particles. The equipment is capable to evaporate fluid particles from each single solid particle.
4.	**Processing**	**Drying**	**Drying**

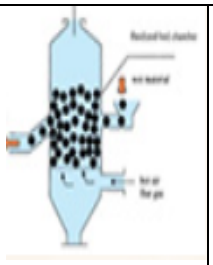
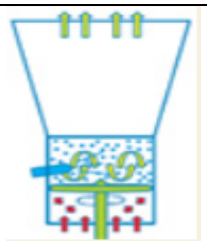
	parameters	➢ Position of air distribution plate: it directly influences the airflow pattern inside the machine. ➢ The shape of the tower: The shape of the tower has a strong impact over drying rate; an annular shape is preferred. ➢ Temperature: increased temp.; increases rate of heat and mass. An optimized temperature must be maintained. ➢ Air flux: it must be not too fast or too slow. ➢ Amount of loaded material: Large batch size need more drying time than smaller batches.	➢ Temperature: Very high or too low temperatures both are undesirable. ➢ Humidity: the humidity needs to be controlled as much as possible. ➢ Air flow: uniform airflow is critical to accomplish proper drying. **Coating** ➢ Spray nozzle distance: efficient coating depends on appropriate distance. ➢ Droplet size: for proper coating droplet size has to be neither small nor large. ➢ Spray rate: the specified rate of flow must not to be too low or too fast. **Granulation** ➢ Spray pressure: this is mandatory to optimize spray rate for proper solution binding. ➢ Spray rate: An optimized spray rate well ensures the successful granulation of particles. ➢ Nozzle location: a suitable location ensures better granulation with a

			binder.
5.	**Working**	 **Drying** With the help of a perforated air distribution plate; hot air is introduced with high speed causing them comparable to gravitational force. This made fluidization where solid particles appear like a boiling bed of liquid. Indeed, each particle gets uniform and productive drying by this process.[29]	 **Fluid bed dryer** The principle of a fluid bed dryer is to evaporate excessive moisture out of the particles. The hot air is blown out to pass through them with high pressure through an air distribution plate that lifts the particles from the bottom and keeps them suspended within the air stream.[28] **Fluid bed coater** The fluid bed coater is involved with the spraying of granulating or coating solution over the bed of particles individually. After this process, the coated granules or particles are dried using hot air. **Fluid bed granulator** Certainly, there are negligible operational

			differences between fluid bed granulators and fluid bed coater. The application of gas is of the same speed and the spraying area can cover a huge segment of the particles bed. This type of machine is meant for the granulation process by suspended particles beneath fluidized air accompanied by a spraying binding agent from distinctive points (above, below or tangentially).[30]

TABLE II: PROCESSING OF FBD & FBP[30]

Series	Process	Drying	Granulation	Pellet coating	Direct pellet-zing	Powder layering for Pallet
FBP (Top spray coater / granulator)		✓	✓			
FBP (Tangential spray coater/ granulator)		✓	✓	✓		

FBD		✓				
FBP (Bottom spray coater/ Granulator)		✓	✓	✓		
FBP (Tangential spray/Rotor)				✓	✓	✓

CONCLUSION

The reason of this review article is to introduce the information of fluidized bed technology. In this review article, we discussed the introduction and techniques of the fluidized bed technology which confer a varied description of the fluid bed process such as drying, granulation and coating.

Fluidized bed technology has developed as a vital tool in advanced designing and industry due to its capacity to optimize different processes, improve energy efficiency, and decrease natural impacts.

Fluidized bed has numerous advantages as gas – solid reactors or powder handling processors because of its advantages of high heat and mass transfer, temperature homogeneity and blending property.

Fluidized bed dryers represent a highly effective and adaptable solution for drying particulate materials. Their capacity to provide precise control, minimize product degradation, and promote sustainability makes them a basic component of numerous industrial processes.

Fluidized bed processors offer a flexible and productive arrangement for a wide range of particle processing needs across multiple industries. Their ability to achieve precise control uniformity, and enhanced product quality makes them an essential tool for

manufacturers seeking to optimize their processes and convey high-quality products to the market.

Fluidized bed dryers have become indispensable in various industries due to their effectiveness, versatility, and adaptability. Ongoing research and development continue to refine this technology, addressing challenges and extending its applications. As industries demands more sustainable and efficient drying solutions, fluidized bed dryers, with their continuous innovations, are balanced to play a pivotal role in forming long run of drying technology.

What is the difference between FBP and FBD? The objective of these procedures is to establish a well- controlled setup to create a quality formulation. The fluidized bed system has broad pharmaceutical applications to ensure the protection of the drug from external impact with extended shelf life.

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