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PHARMACEUTICAL DRYER: A REVIEW

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ABSTRACT

Drying is a mass transfer process consisting of the removal of water or another solvent by evaporation from a solid, semi-solid or liquid. This process is often used as a final production step before selling or packaging products. A source of heat and an agent to remove the vapor produced by the process are often involved. In bio-products like food, grains, and pharmaceuticals like vaccines, the solvent to be removed is almost invariably water. The process used for drying pharmaceuticals has a high impact on the final product characteristics, both on the active ingredient and the end drug product. The consequences of the process used to dry a pharmaceutical product may be different depending on the development phase

INTRODUCTION:

The drying process may greatly influence the quality of the drug substances in several aspects: the polymorphic form of the active ingredient, the structural changes that may have an effect on the activity of the substance, the degradation products formed due to the drying conditions and the presence of residual solvents undesirable or above the permitted limits after drying. Consequently, it is important to know the influence of all the factors and to establish the product specifications, as well as the nature and limits of residual solvents.

Drying mechanisms:-

In some products having a relatively high initial moisture content, an initial linear reduction of the average product moisture content as a function of time may be observed for a limited time, often known as a "constant drying rate period". Usually, in this period, it is surface moisture outside individual particles that is being removed. The drying rate during this period is mostly dependent on the rate of heat transfer to the material being dried. Therefore, the maximum achievable drying rate is considered to be heat-transfer limited. If drying is continued, the slope of the curve, the drying rate, becomes less steep (falling rate period) and eventually tends to become nearly horizontal at very long times. The product moisture content is then constant at the "equilibrium moisture content", where it is, in practice, in equilibrium with the dehydrating medium. In the falling-rate period, water migration from the product interior to the surface is mostly by molecular diffusion, i,e. the water flux is proportional to the moisture content gradient. This means that water moves from zones with higher moisture content to zones with lower values, a phenomenon explained by the second law of thermodynamics. If water removal is considerable, the products usually undergo shrinkage and deformation, except in a well-designed freeze-drying process. The drying rate in the falling-rate period is controlled by the rate of removal of moisture or solvent from the interior of the solid being dried and is referred to as being "mass-transfer limited". This is widely noticed in hygroscopic products such as fruits and vegetables, where drying occurs in the falling rate period with the constant drying rate period said to be negligible.

Methods of drying:-

Application of hot air (convective or direct drying). Air heating increases the drying force for heat transfer and accelerates drying. It also reduces air relative humidity, further increasing the driving force for drying. In the falling rate period, as moisture content falls, the solids heat up and the higher temperatures speed up diffusion of water from the interior of the solid to the surface. However, product quality considerations limit the applicable rise to air temperature. Excessively hot air can almost completely dehydrate the solid surface, so that its pores shrink and almost close, leading to crust formation or "case hardening", which is usually undesirable. For instance in wood (timber) drying, air is heated (which speeds up drying) though some steam is also added to it (which hinders drying rate to a certain extent) in order to avoid excessive surface dehydration and product deformation owing to high moisture gradients across timber thickness. Spray drying belongs in this category.

Indirect or contact drying (heating through a hot wall), as drum drying, vacuum drying. Again, higher wall temperatures will speed up drying but this is limited by product degradation or case-hardening. Drum drying belongs in this category.

Dielectric drying (radiofrequency or microwaves being absorbed inside the material) is the focus of intense research nowadays. It may be used to assist air drying or vacuum drying. Researchers have found that microwave finish drying speeds up the otherwise very low drying rate at the end of the classical drying methods.

Freeze drying or lyophilization is a drying method where the solvent is frozen prior to drying and is then sublimed, i.e., passed to the gas phase directly from the solid phase, below the melting point of the solvent. It is increasingly applied to dry foods, beyond its already classical pharmaceutical or medical applications. It keeps biological properties of proteins, and retains vitamins and bioactive compounds. Pressure can be reduced by a high vacuum pump (though freeze drying at atmospheric pressure is possible in dry air). If using a vacuum pump, the vapor. produced by sublimation is removed from the system by converting it into ice in a condenser, operating at very low temperatures, outside the freeze drying chamber.

Supercritical drying (superheated steam drying) involves steam drying of products containing water. This process is feasible because water in the product is boiled off, and joined with the drying medium, increasing its flow. It is usually employed in closed circuit and allows a proportion of latent heat to be recovered by recompression, a feature which is not possible with conventional air drying, for instance. The process has potential for use in foods if carried out at reduced pressure, to lower the boiling point.

Natural air drying takes place when materials are dried with unheated forced air, taking advantage of its natural drying potential. The process is slow and weather-dependent, so a wise strategy "fan off-fan on" must be devised considering the following conditions: Air temperature, relative humidity and moisture content and temperature of the material being dried. Grains are increasingly dried with this technique, and the total time (including fan off and on periods) may last from one week to various months, if a winter rest can be tolerated in cold areas.

CLASSIFICATION OF PHARMACEUTICAL PRODUCTS WITH RESPECT TO DRYER SELECTION:-

From the point of view of drying technology, all substances dried in the pharmaceutical industry can be classified into three major groups:

1. Granular materials: Solids in the form of individual particles of the size approximately in the range 0.05 to 5 mm
2. Paste like materials: Solids mixed with liquid to form a free-flowing paste; size of particles approximately in the range 0.1 to 50 mm
3. Solutions and suspensions: Solids dissolved or suspended in liquid in the form of fine (10–50 mm), ultrafine (0.1–10 mm), or colloidal (<0.1mm) suspensions

The criteria of classification are not clear-cut here, and wet granular material of small particle size can as

well be classified as paste like and a thin paste can be classified as a suspension if it is pump able. According to the type of the material, appropriate drying systems are chosen.

Types Pharmaceutical Dryers:-

Dryers are used in a variety of industries, such as the food processing, pharmaceutical, paper, pollution control and agricultural sectors. Diverse materials need to be dried in completely different businesses, such as chemicals for research and medical concerns, paper for printing and packaging operations and edible materials for further processing into popular foods and snacks.

Dryers are used to remove liquids or moisture from bulk solids, powders, parts, continuous sheets or other liquids by evaporation or sublimation. Dryers can be broken up into two main types: direct and indirect. Direct dryers convectively heat a product through direct contact with heated air, gas or a combusted gas product. Indirect dryers conductively heat a product through contact with a heated wall.

There are various types of Dryer used in Pharmaceutical Industries

1. **Spray Dryer**

2. **VacuumTray Dryer**
3. **Fluidized Bed Dryer**
4. **Tray Dryer**
5. **Belt Dryer**
6. **Rotary Dryer.**

Spray Dryer

In Spray dryer, the material to be dried is sprayed as a fine mist into a hot-air chamber and falls to the bottom as dry powder. The period of heating is very brief and so nutritional and functional damage are avoided. Dried powder consists of hollow particles of low density; widely applied to many foods and pharmaceuticals.

Spray Dryers are relatively simple in operation which accept feed in fluid state and convert it into a dried particulate form by spraying the fluid into a hot drying medium.

Vacuum tray Dryer:-

Vacuum tray Dryer is used mainly for drying of high grade, temperature and oxygen sensitive products. Vacuum Tray Dryer is highly suitable for drying hygroscopic substances, which are dried to very low residual moisture, content level. Frequently vacuum drying cabinets are the sole possibility for drying lumpy, glutinous products or products of low pomposity.

- Vacuum Tray dryer is the most commonly used batch dryer. They are box-shaped and loaded and unloaded via a door. Inside are several heating plates mounted one above the other on which the product is placed in trays.
- The bottoms of both heating plates and trays should be as smooth as possible to permit optimal heat transfer between plates and product.
- The medium flowing through the heating plates is water, steam or thermal oil.
- The distance between the heating plates is determined primarily by the surface loading and the foaming of the product.
- To avoid retrograde condensation the cabinet walls are indirectly preheated by the heating plates. Next, the product is introduced and heated at atmospheric pressure. Only after all

individual product trays reach the same temperature the cabinet is evacuated and drying can start.

Fig.1: Vacuum tray Dryer

- The preheating phase is very important in order that the drying curve and the foaming of the product is identical throughout the cabinet.
- During the main drying phase the vacuum is in the range of 40 to 80 mbar abs and in the final drying phase vacuums of only few mbar abs are reached.
- Heating temperatures are normally in the range between 800C and 1100C. Depending on product and surface load, drying takes from a few hours to 1 to 2 days.

➢ **Fluid Bed Dryer:-**

- The fluid Bed Dryer are most suitable for drying granular crystalline, coarse or similar material in pharmaceuticals, fine chemicals, dyes, food and allied products. The fluid Bed dryer is not suitable for drying liquid or pasty materials.
- Fluid bed dryer is designed to introduce the hot air stream at the base of the product container which is filled with the material.

Fig.2: Fluid Bed Dryer

Fluid Bed Dryer occupy lesser floor space compare to conventional dryer and are very easy to operate and can dry material in least time as compared to tray dryer.

- In fluid Bed Dryer, temperature distribution throughout the product is uniform and the heat transfer rate is very high. High production rates are achieved due to reduce drying time.
- As the product is in close contact with drying air at low temperature and also for short duration, the physical and chemical properties of the products are generally not effected and therefore the dryer can effectively be used for heat sensitive products.
- Due to the continuous movements of product during drying lump formation, case hardening etc. are minimized.

➢ **Tray Dryer:-**

- A tray Dryer is an enclosed insulated chamber in which trays are placed on top of each other in trolleys. Tray Dryer are used where heating and drying are essential parts of manufacturing process in industries such as Chemicals, Dye stuff, Pharmaceutical, Food Products, Colours etc. The material to be dried either wet or solids are placed in the trays. Heat transfer is by circulation of hot air by electric heaters or steam in radiator coils.
- Blower fans are installed inside to ensure proper circulation and transfer of heat. A control panel to control the temperature and other parameters is fixed outside the dryer. These dryers are available in Mild Steel, Stainless Steel or construction. Tray dryer is used for drying pigments, food, bakery, electrodes, chemical and plastic powders

Fig. 3: Tray Dryer

➢ **Belt Dryer:-**

- Belt dryer is continuous drying equipment. Belt Dryer is widely used for chemical, food, pharmaceutical industries. It is especially suitable for drying raw materials that are good in breathability and in the shapes of piece, strip or granule. It is also possible to dry the pasted raw material such as filter cake after shaped through granulator or extruder.

- In the Belt dryer, the raw material to be treated is distributed on the conveyor belt through right mechanism such as star distributor, swing belt, crusher or granulator.
- The conveyer passes through the channel consisting of one or several heating units, which are equipped with air heating and circle system. Each channel has one or several damp discharge systems.
- When the conveyer passes through it, hot air will pass through the raw material up and down. In this way the raw material can be dried evenly.

Fig. 4: Belt Dryer

➢ Rotary Dryer:-

- Rotary dryers feed material into a tumbling or rotating drum or tumbler. The drum is then heated or heated air is fed into the unit. The internal surface of the drum may have baffles or louvers to channel the hot air or cascade the material.
- In direct heat rotary dryers a continuous feed of wet particulate material is dried by contact with heated air, while being transported along the interior of a rotating cylinder, with the rotating shell acting as the conveying device and stirrer.
- In the counter-current operation dried material is exposed to the hottest air helping to achieve very low moisture content. The hot gases may enter the dryer at very high temperature.

Advantages of the dryers:

- Dryers are very efficient heat sensitive
- Materials can be dryers in containers or enclosures

- Average drying temperature is much lower than standard dryers
- Drying action becomes faster as heat is easily transferred throughout the body of the dryers, due to its large surface area
- Dries large moisture as compared to normal dryers
- Quality of dries material is better than that of the normal dryers

Limitation of dryers:

- Drying process is batch type drying process It has low efficiency.
- Pharmaceutical dryers are expensive
- Pharmaceutical dryers require skilled labour to operate
- Cost of maintenance are high

Application of the dryers:

The Pharmaceutical dryers find application in various type of the industries such as:

- Chemical process industries
- Food processing
- **Pharmaceutical**
- Plastic
- Timber
- Paper and other industries

PHYSICAL MECHANISM OF DRYING

Drying does not mean only removal of the moisture but during the process, physical structure as well as the appearance has to be preserved. Drying is basically governed by the principles of transport of heat and mass. When a moist solid is heated to an appropriate temperature, moisture vaporizes at or near the solid surface and the heat required for evaporating moisture from the drying product is supplied by the external drying medium, usually air or a hot gas. Drying is a diffusional process in which the transfer of moisture to the surrounding medium takes place by the evaporation of surface moisture, as soon as some of the surface moisture vaporizes, more moisture is transported from interior of the solid to its surface. This transport of moisture within a solid takes place by a variety of mechanisms depending upon the nature and type of the solid and its state of aggregation. Different types of solids may have to be handled for drying crystalline, granular, beads, powders, sheets, slabs, filter-cakes etc. The mechanism of moisture transport in different solids may be broadly classified into

(i) transport by liquid or vapour diffusion (ii) capillary section, and

(iii) pressure induced transport.

The mechanism that dominates depends on the nature of the solid, its pore structure and the rate of drying. Different mechanisms may come into play and dominate at different stages of drying of the same material.

SELECTION OF DRYING EQUIPMENT

In view of the enormous choice of dryer types one could possibly deploy for most products, selection of the best type is a challenging task that should not be taken lightly. The first consideration in selecting a dryer is its operability. Above all else, the equipment must produce the desired product in the desired form at the desired rate. The quality required in a finished product, and its necessary physical characteristics, are determined by its end use. A wrong dryer for a given application is still a poor dryer, regardless of how well it is designed. Although variety of commercial dryers are available in the market, the different types mare largely complementary, not competitive, and the nature of the drying problem dictates the type of dryer that must be used, or at least limits the choice to perhaps two or three possibilities. The final choice is then made on the basis of capital and operating costs.

Attention must be paid, however, to the costs of the entire drying system, not just the drying unit alone.

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