INTRODUCTION

Definitions:
- Drying is a unit operation in which a liquid is separated from a solid by other than mechanical means. This generally requires supplying heat, resulting in evaporation of the liquid.

Drying Fundamentals:
- Removal of a liquid from a solid / semi-solid / liquid to produce solid product by thermal energy input causing phase change (Sometimes converts solid moisture into vapor by sublimation eg. Freeze drying with application of heat.)
- Needed for the purposes of preservation and storage, reduction in cost of transportation, etc.
- Most common and diverse operation with over 100 types of dryers in industrial use.
In pharmaceutical technology, drying is carried out for one or more of the following reasons:

1. To avoid or eliminate moisture which may lead to corrosion and decrease the product or drug stability.
2. To improve or keep the good properties of a material, e.g. flow ability, compressibility.
3. To reduce the cost of transportation of large volume materials (liquids)
4. To make the material easy or more suitable for handling
5. Preservation
6. The final step in: Evaporation > Filtration > Crystallization
PRINCIPLE OF DRYING

- Migration of moisture from the interior of an individual grain to the surface.
- Evaporation of moisture from the surface to the surrounding air.
PRINCIPLE OF DRYING

Energy Input by:
- Conduction
- Convection
- Radiation
- Microwave and Radio Frequency Fields
- Combined mode

Moisture Output by:
- Liquid diffusion
- Vapor diffusion
- Capillary flow (Permeability)
- Knudsen diffusion (Mean free path < pore dia.)
- Surface diffusion
- Poiseuille flow
- Combination of above
TYPES OF DRYER ON THE BASIS OF HEATING MODE

- Convective / Direct dryers / Adiabatic
- Conductive / Indirect dryers / Non-adiabatic
- Dryers by radiant energy
DRYING BASE ON HEAT INPUT

I. Direct (Convective)

Drying medium directly contacts material to be dried and carries evaporated moisture.

II. Indirect (Contact, Conduction)

Heat supplied by heat exchanger (through metal wall)
III. Radiant

Vacuum or low gas flow to carry evaporated moisture away.

IV. Microwave or RF

Electromagnetic energy absorbed selectively by water (volumetric heating)

Typically less than 50% of total heat supplied in most direct dryers is used for evaporation. Water is the most common solvent removed in dryers.
TYPES OF DRYER ON THE BASIS OF FEED

Focusing on herbal industry:
1. Vacuum Belt Dryer
2. Vacuum Tray Dryer
3. Fluidized Bed Dryer
4. Spray Dryer
5. Freeze Dryer
DRYERS FOR SOLIDS

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DRYERS FOR SOLIDS

1. Vacuum Tray Dryer
2. Vacuum Belt Dryer
3. Fluidized Bed Dryer

- At the end of the dryer, the air usually passes upward the screen and the solids; near the discharge end, where the material is dry and may be dusty, air is passed downward through the screen.

- The air temperature and humidity may differ in the various sections, to give optimum conditions for drying at each point.
ADVANTAGES & DISADVANTAGES

**ADVANTAGES:**

1. Suitable for sensitive components.
2. Low temperature during drying process occurs.
4. Protect active ingredients from damage from direct heat of high temperature during drying process.
5. It is quick method because of its large surface area, materials is dried in few seconds.

**DISADVANTAGES:**

1. Highly cost during operation.
2. Expensive machine.
3. High maintenance on machine.
4. Spray Dryer
   - A spray mixes a heated gas with an atomized (sprayed) liquid stream within a vessel (drying chamber) to accomplish evaporation and produce a free flowing dry powder with a controlled average particle size.

5. Freeze Dryer
   - The product will introduce with low temperature between -40 to -80 degree Celsius, the moisture content will freeze and evaporate and the final product will fully dry.
ADVANTAGES & DISADVANTAGES

ADVANTAGES:
1. Convert solution or slurries into particles.
2. Fast drying method for solution or slurries products.
3. Longer expired date.
4. Light in weight.
5. Easy to packing and transport.

DISADVANTAGES:
1. Costly in operation.
2. Expensive machine.
3. Expensive in maintenance.
SELECTION OF DRYING EQUIPMENTS

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IT DEPENDS ON:

1. Physical / Chemical properties of the products.
2. Production capacity (Kg/hr)
3. Initial moisture content and final moisture required.
4. Particle size distribution.
5. Temperature & drying characteristics.
The following are some general considerations for the selection of dryer:

- The dryer must also operate reliably, safely & economically.
- Operating & maintenance costs must not be excessive.
- Pollution must be controlled.
- Energy consumption must be minimized.
It is always wise in case of uncertainty, to run preliminary tests to as certain both design & operating data & also suitability of dryer for particular application.

The final choice is then made on the basis of operability, capital and operating costs.
DRYER SELECTION CHART

Dryer Selection Chart

FEED TYPE

Solution  Thixotropic  Diluent  Cohesive  Friable  Granules  Powder

POWDER TYPE

Fine
Freeflow
Dustless
Granular
Wettable
Agglom
Coated
Lump

Spray
Spray or SBD
Spray Bed

Spin Flash
Flash
Band
Fluid Bed

Tray

Spin Flash + Fluid Bed Agglom.

Band
Granulation

Figure 1. A guide to dryer selection
THANK YOU

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REFERENCES

1. https://www.slideshare.net/m_uet/selection-of-drying-equipment