Principles of Chemical Engineering

Mass Transfer

Dr. M. Subramanian

Department of Chemical Engineering
SSN College of Engineering

July 8, 2021

Syllabus Contents

Drying - Equipment for Drying

Objectives

- To introduce the role of drying in industries.
- To give an overview of the most common dryers.

Drying

- Drying converts a solid, semi-solid or liquid feedstock into a solid product by evaporation of the liquid into a vapor phase via application of heat.
- Drying is an essential operation in the chemical, agricultural, biotechnology, food, polymer, ceramics, pharmaceutical, pulp and paper, mineral processing, and wood processing industries.
- Drying of various feedstocks is needed for one or several of the following reasons: need for easy-to-handle free-flowing solids, preservation and storage, reduction in cost of transportation, achieving desired quality of product, etc.

Drying (contd..)

- Drying occurs by effecting vaporization of the liquid by supplying heat to the wet feedstock. Heat may be supplied by convection (direct dryers), by conduction (contact or indirect dryers), radiation or volumetrically by placing the wet material in a microwave or radio frequency electromagnetic field.
- Majority of dryers are of direct (or convective) type. In other words, hot air is used both to supply the heat for evaporation and to carry away the evaporated moisture from the product.
- Drying with heated air implies humidification and cooling of the air in a well-insulated (adiabatic) dryer.

Role of Humidity and Temperature of Contacting Air

- Relative humidity of air should be low for faster drying.
- High temperature air is preferred for faster drying, as it can hold more amount of moisture.

Drying Equipments

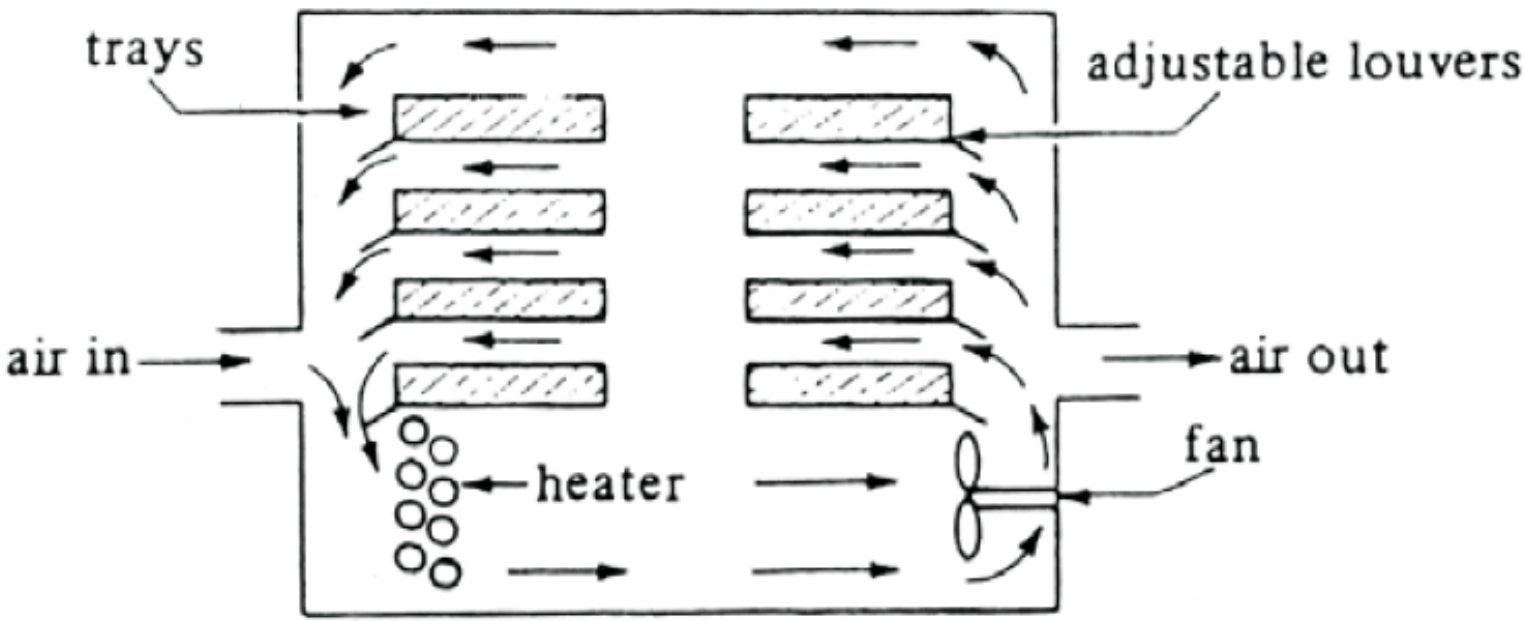
- Tray dryer
- Rotary drum dryer
- Spray dryer

Tray Dryer

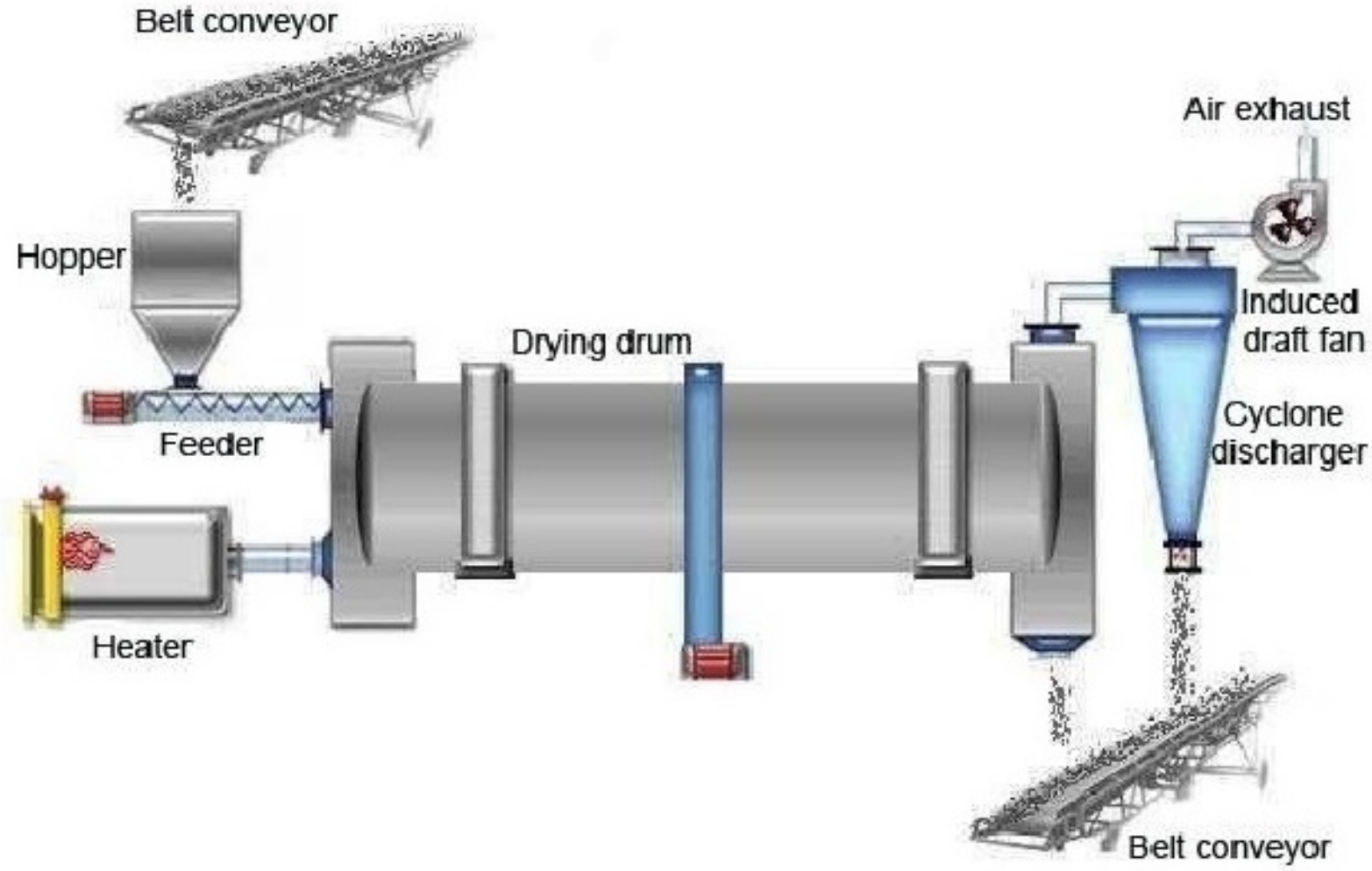
Tray Dryer (contd..)

Tray Dryer (contd..)

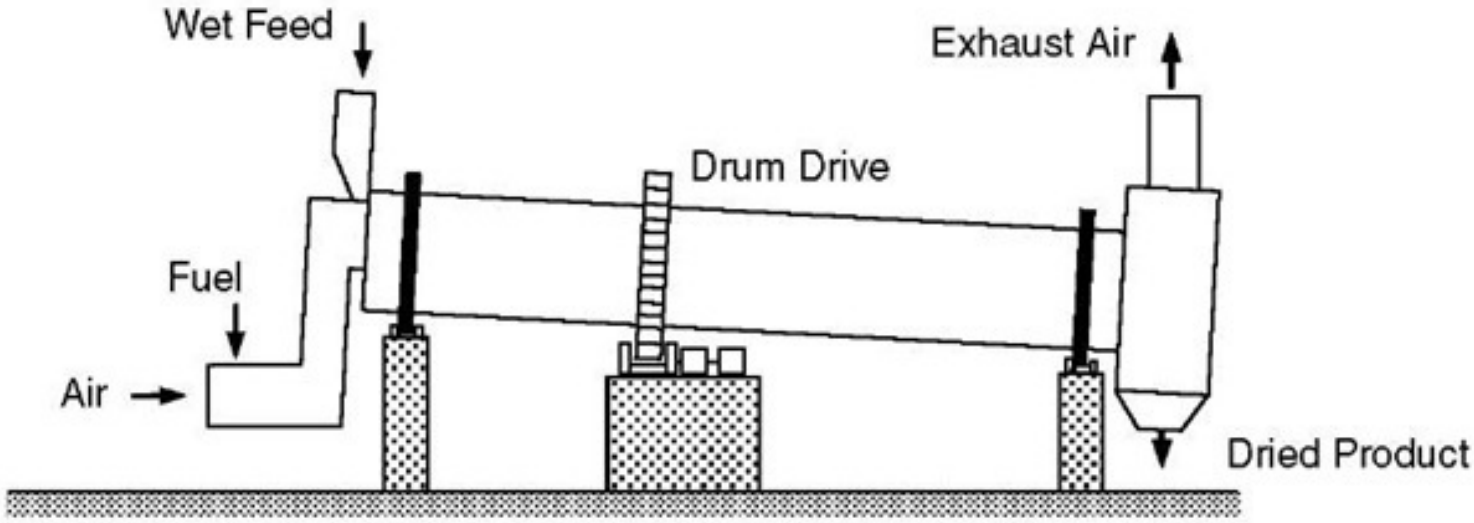
The most common dryer for small tonnage products is a batch tray dryer. It consists of a stack of trays placed in a large insulated chamber in which hot air is circulated. These dryers require large amount of labour to load and unload the product. Drying times are long (10–60 hours).

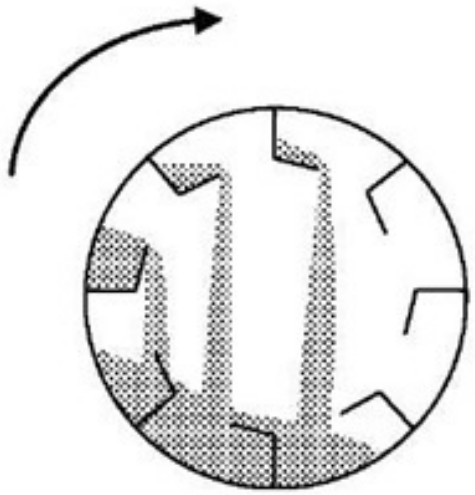


Rotary Dryer



Rotary Dryer (contd..)





End View
of Drum
(Enlarged Scale)

Drying Equipments

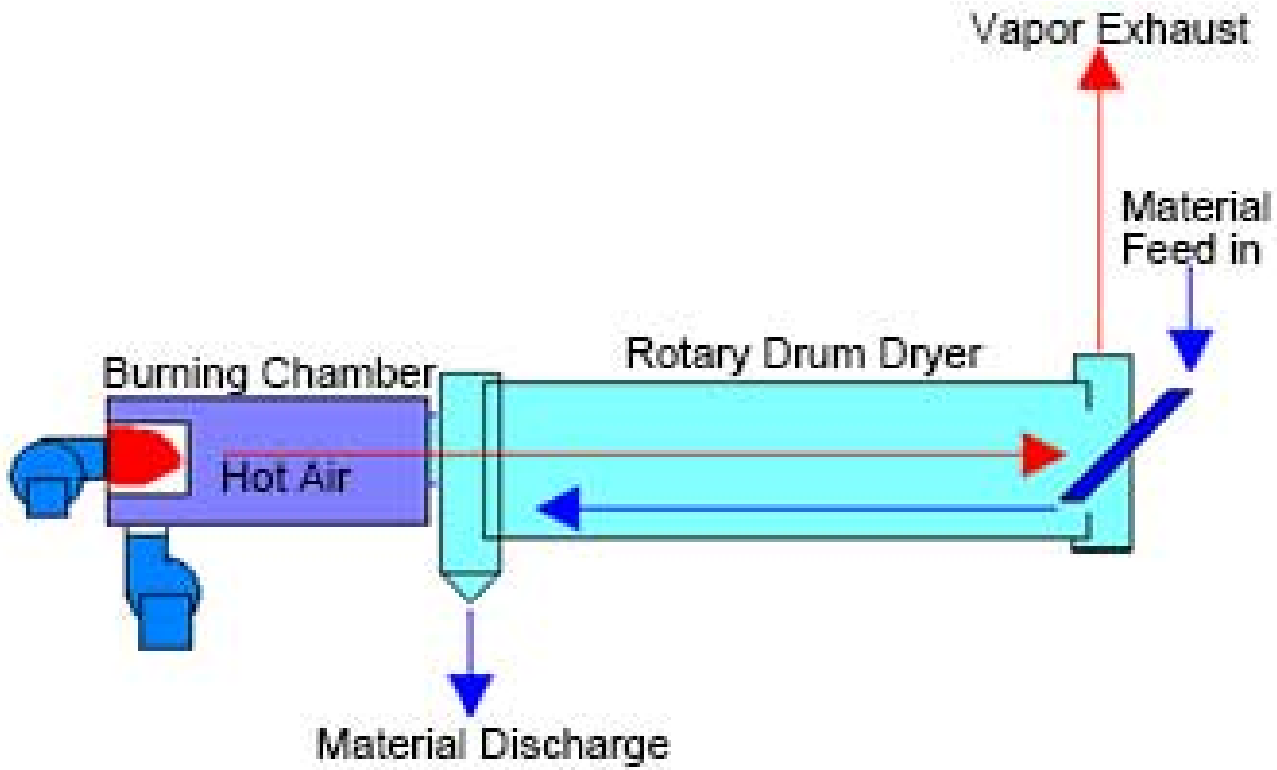
Rotary Dryer (contd..)

The rotary dryer is a continuously operated direct contact dryer consisting of a slowly revolving cylindrical shell that is typically inclined to the horizontal a few degrees to aid the transportation of a wet feedstock which is introduced into the drum at the upper end and the dried product withdrawn at the lower end.

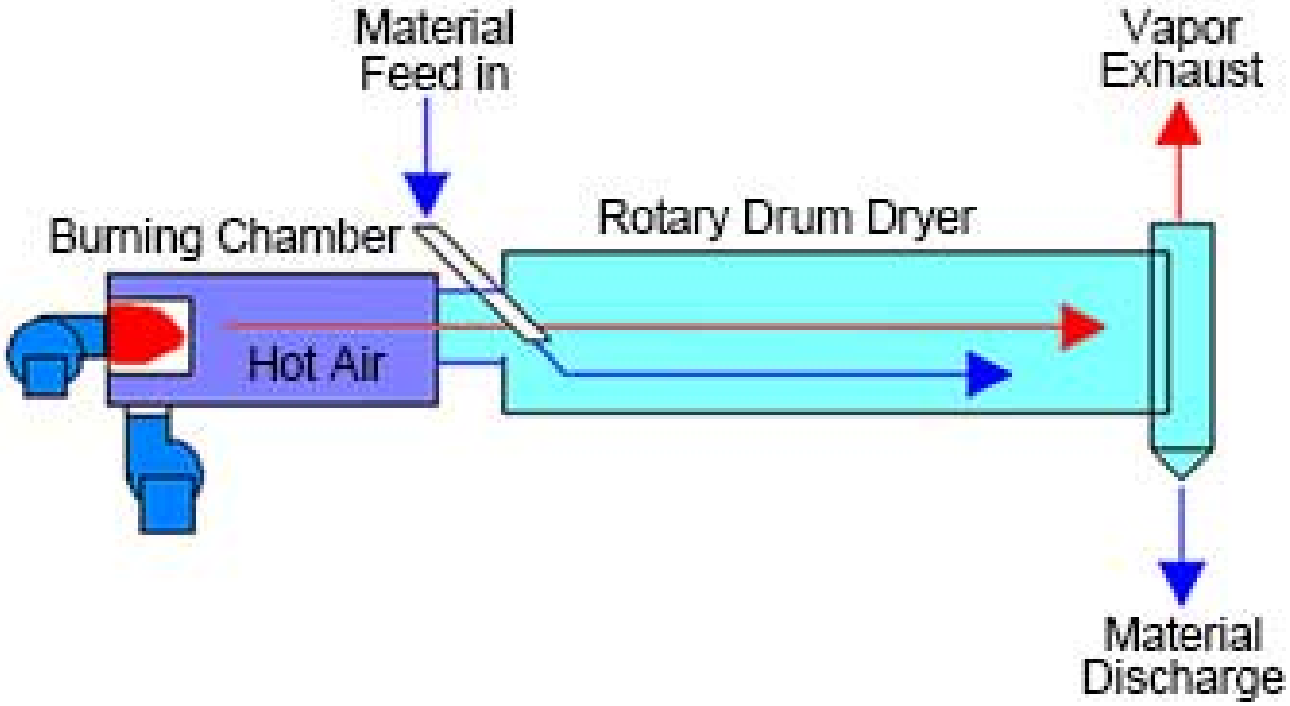
Rotary Dryer (contd..)

- The drying medium (hot air, combustion gases, flue gases, etc.) flows axially through the drum either cocurrently with the feedstock or countercurrently.
  - The countercurrent mode is preferred when the material is not heat-sensitive and needs to be dried to very low moisture content levels.
  - The concurrent mode is preferred for heat-sensitive materials, and for higher drying rates.
- Rotary dryers are especially suited for high production rates.

Rotary Dryer - contercurrent flow

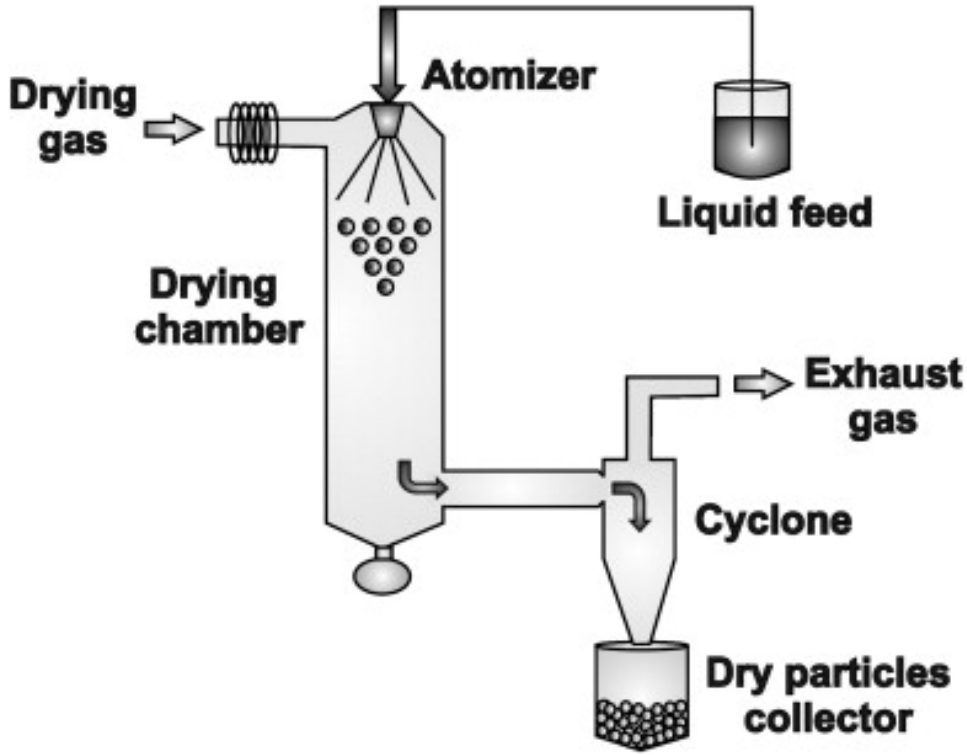


Rotary Dryer - cocurrent flow



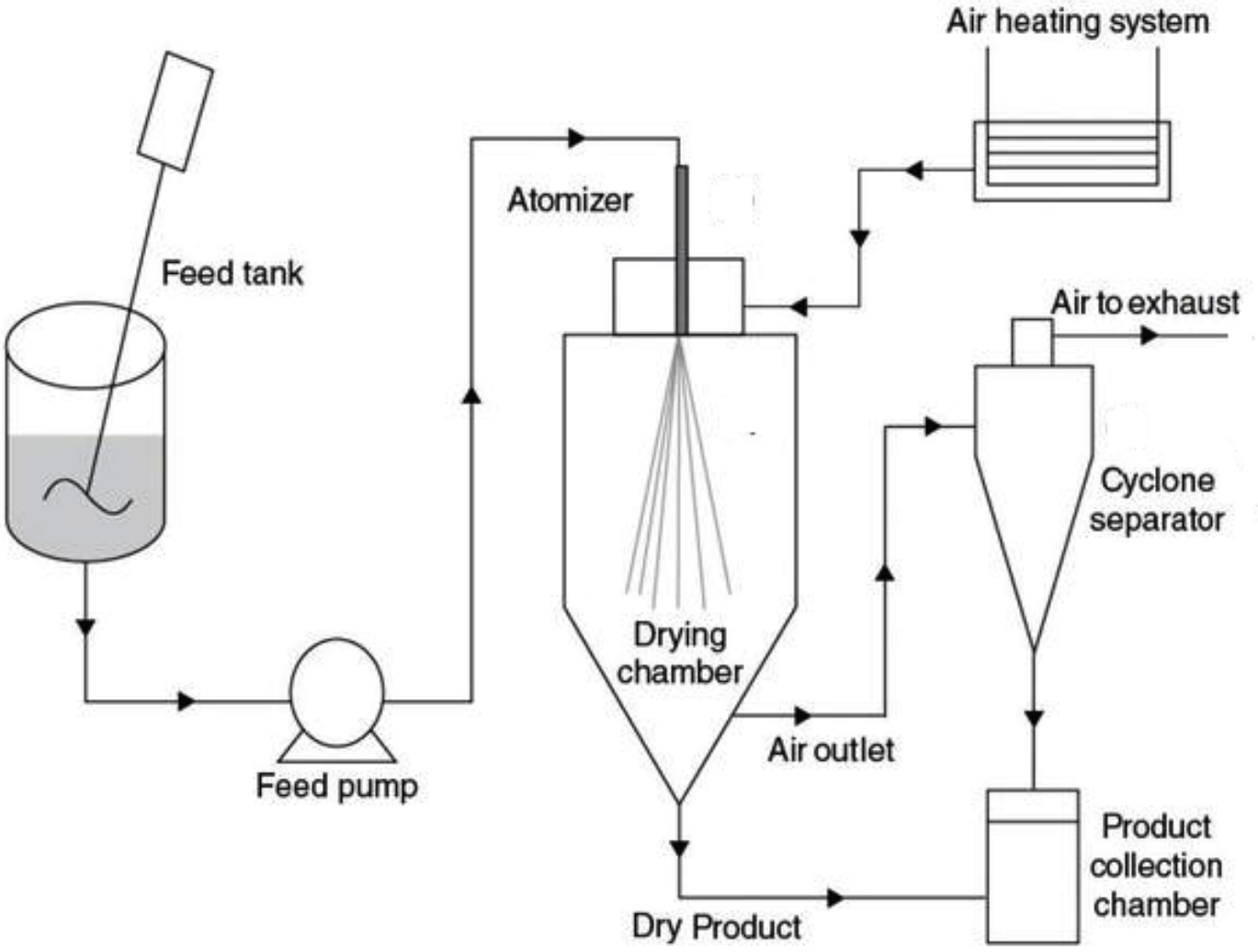
Spray Drying

Spray-drying is a rapid, continuous, cost-effective, reproducible and scalable process for the production of dry powders from a fluid material by atomization through an atomizer into a hot drying gas medium, usually air.



(Ref: https://www.sciencedirect.com/science/article/pii/S0001868615000767)

Spray Drying (contd..)



Quiz

1. What are the required conditions of air for increasing the rate of drying in direct-contact dryers?

2. Differentiate between cocurrent and countercurrent contact in rotary drum dryers.

3. Explain about the various types of dryers.