

Dried Whey, Types and Their Specification, Manufacturing Techniques

Whey powder production consists of three main operations:

Evaporation:
Whey is concentrated to 42-60% total solids

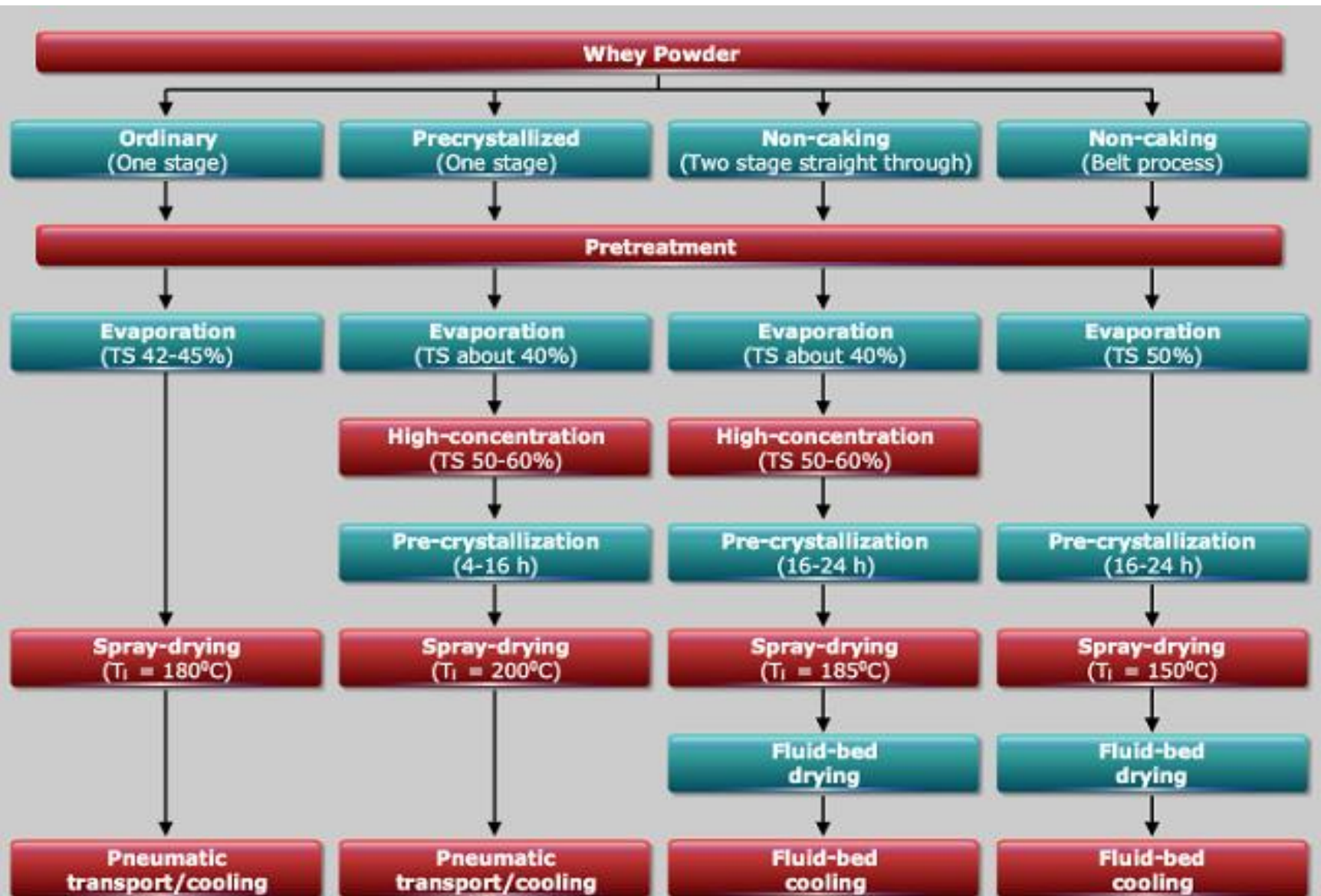
Crystallization: Lactose crystallization prior to drying for whey powder production is inevitable because amorphous lactose is sticky. This causes problems during drying. So, lactose converted into crystalline α -hydrate form

Drying: When dried without lactose crystallization, whey concentrates yield hygroscopic powder and there is risk of powder caking on storage

Advantage of lactose crystallization: Energy savings and improved powder properties

Drying of Whey

- Drying of whey done by spray drier that may be single stage, two -stage and more recently three-stage drying.
- Moisture content of whey powder ranges between 3.5-5%.
- **Characteristics essential to powder quality are powder hygroscopicity and caking tendency.**
- Since 100% lactose crystallization cannot be achieved, target is to gain the largest possible portion of lactose in crystalline form (90-95% α -lactose monohydrate).
- Increased lactose crystallization results in decreased quantity of amorphous lactose and drying is performed at higher outlet air temperatures, allowing intensified evaporation of up to 60% total solids.
- Increase in inlet air temperature by 10 C raises outlet air temperature by 1 C.

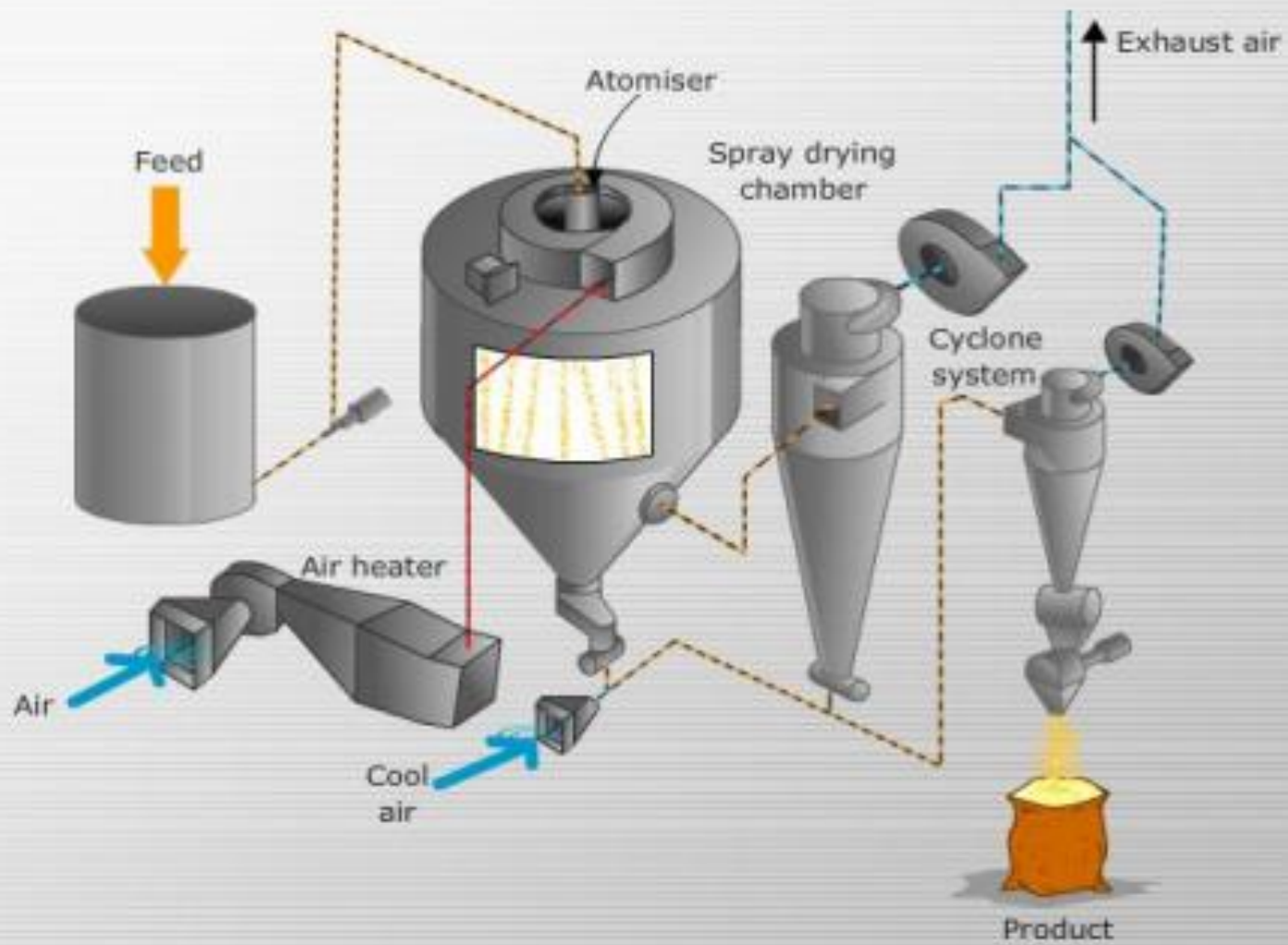


Different processes for the manufacture of whey powder

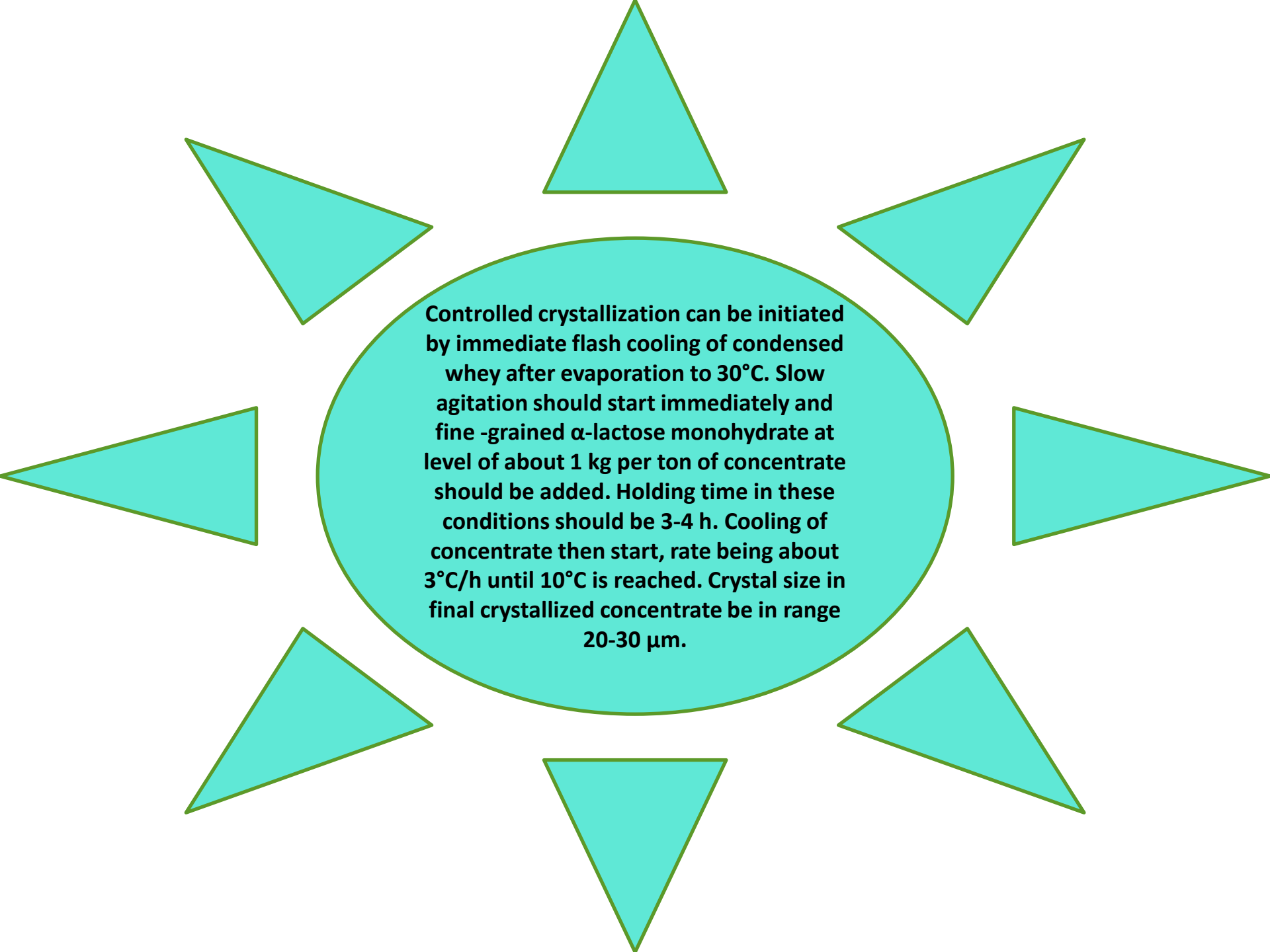
Single-stage process:

- **Product is dried to its final moisture content in spray-drying chamber alone; sometimes pneumatic conveying system is adopted with one - stage drying system.**
- **Ambient air provides both conveying and cooling of powder.**
- **If climatic conditions prevent powder temperature/residual moisture contents to be achieved with ambient air, conveying air must be dehumidified and cooled to usually 8°C.**
- **Concentrated whey is pumped into spray drying chamber.**
- **Both spraying methods are used with pressure or centrifugal (rotating) atomizer.**
- **Inlet air temperature varies from 150-200 C.**
- **Outlet air temperature is 85 C.**
- **Outlet air temperature should be as low as possible, but high enough to prevent powder from sticking and leaving a deposit (“fouling”) in spraying chamber.**
- **Air, evaporated materials, and powder fines are directed through system of cyclones, where powder particles are separated and returned to process.**

- **Most of powder obtained at chamber bottom and joined to powder derived from cyclone is cooled with cold air and pneumatically transported to sifting and packaging equipment.**
- **Powder obtained in such a way is very hygroscopic, with a high caking tendency.**
- **Careful control of drying conditions is necessary to reduce production of undesirable hygroscopic product.**
- **Air flows, which permitted product to contact high temperature surfaces, results in excessive scorched particles in finished product.**
- **In the spray drier, it is possible to dry whey concentrate containing up to around 60% TS, when lactose content is subjected to a crystallization degree of 85 -90%.**



Single stage spray drying system

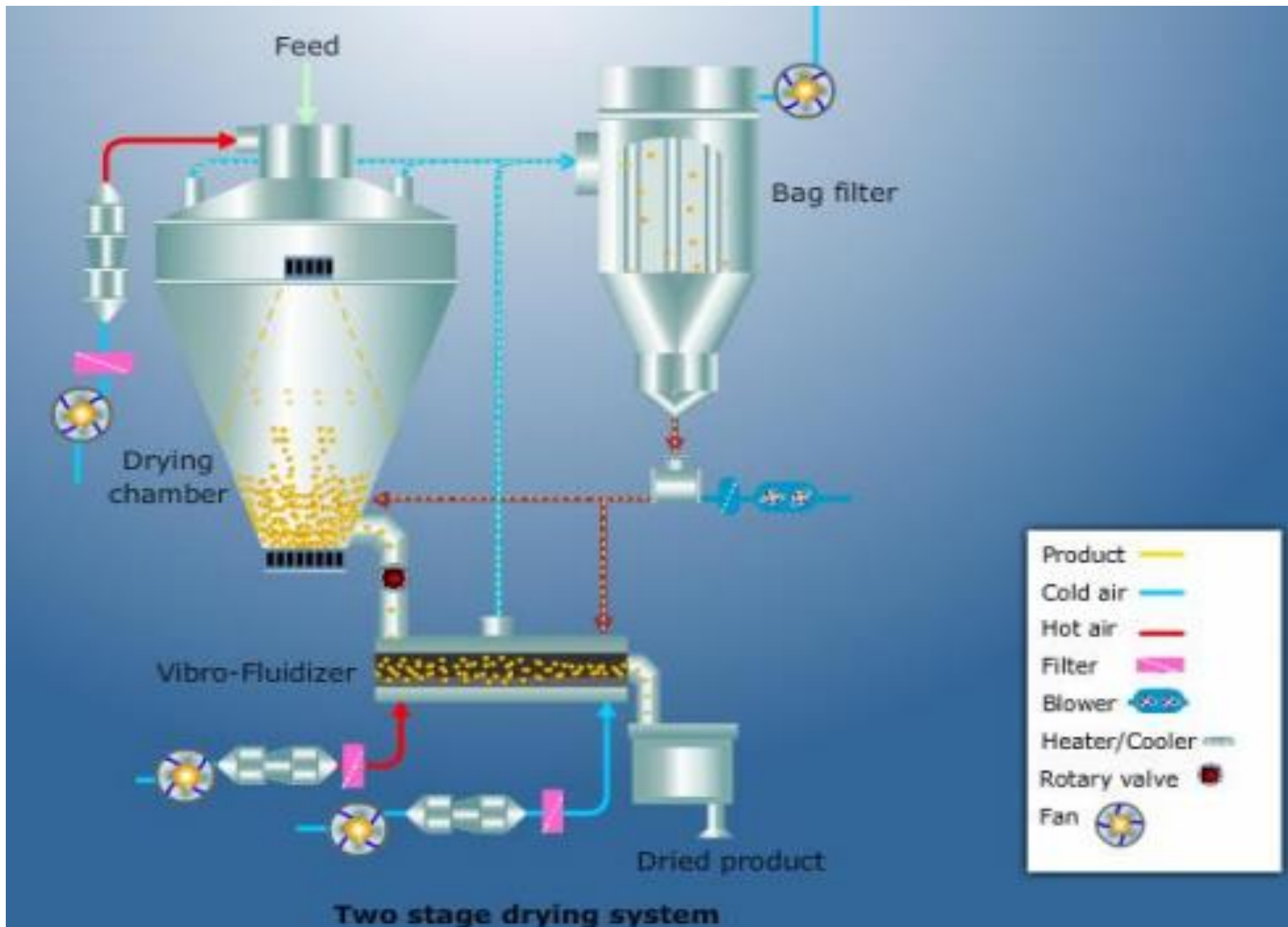


Controlled crystallization can be initiated by immediate flash cooling of condensed whey after evaporation to 30°C. Slow agitation should start immediately and fine -grained α -lactose monohydrate at level of about 1 kg per ton of concentrate should be added. Holding time in these conditions should be 3-4 h. Cooling of concentrate then start, rate being about 3°C/h until 10°C is reached. Crystal size in final crystallized concentrate be in range 20-30 μm .

Two-stage drying:

- **Principle: Combination of spray drying as first- stage drying and fluid bed drying at second stage.**
- **Final drying in integrated fluid bed dryer ensures that desired residual moisture is achieved.**
- **After final drying, powder is cooled in pneumatic cooling and conveying duct.**
- **Installations can be operated with both nozzle and centrifugal atomizers.**
- **Obtain good quality powders and manufacture of non-agglomerated products.**
- **In this process, powders leave chamber and enter attached vibrating fluid bed drier with moisture content of 5-7%.**
- **In the fluid bed, air blown into the first section has an ambient temperature to stabilize the agglomerates, thus avoiding lumping of thermoplastic powder.**

- **Air temperature in second section is 100 C, where excess moisture is removed from powder, while in third section; the powder is cooled down with conditioned air of approx. 11 C, to prevent additional moisture absorption. This lowers drying costs.**
- **Fines are recovered in spray drier and fluid bed cyclones collected and returned to atomizing zone for agglomeration.**
- **Agglomeration gives free flowing powder.**
- **Typical drying conditions are: feed preheating to 80 C, feed concentration of 50-60%, crystallization, and then drying at an inlet temperature of approx. 185°C.**



Advantages of two-stage process:

Gentler handling of product, thereby reducing product degradation

Improved efficiency achieved by increasing temperature difference between supply air and outgoing air

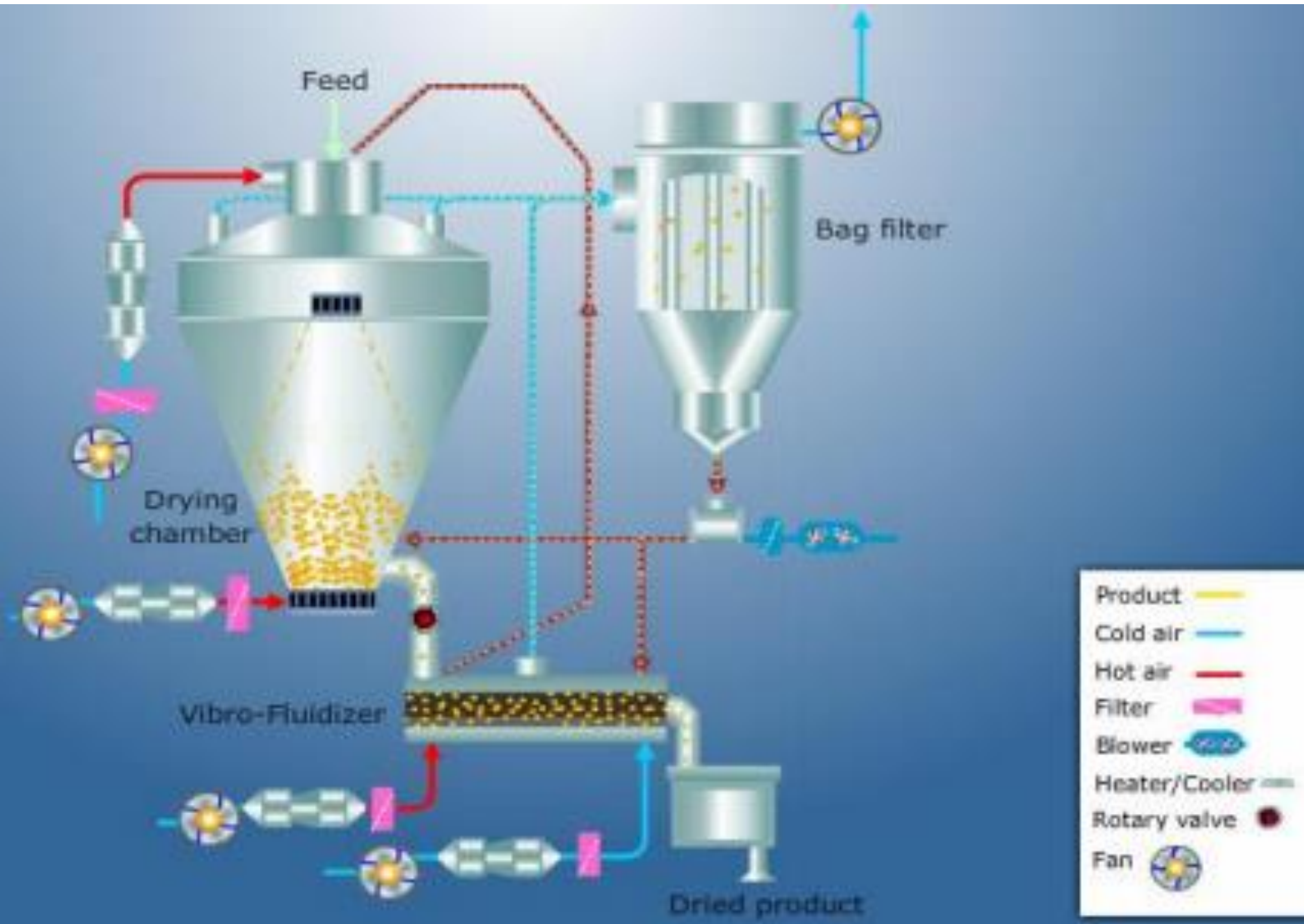
Energy required for drying is about 10-15 % lower than in single - stage process

Cost of whey drying is reduced to 5.0 kg steam/kg of powder

Three-stage drying:

- **Involves transfer of second drying stage into the base of spray drying chamber and having final drying and cooling conducted in third stage located outside drying chamber.**
- **It consists of a main drying chamber, static integrated bed chamber and vibro fluidized bed chamber.**
- **Primary drying of droplets takes place in main chamber as they fall from the atomizer to base of chamber.**
- **Second drying stage takes place as drying air is sucked through powder layer.**
- **Moisture content of powder falling on integrated bed is 12-20 % depending upon type of product.**
- **Second drying stage reduces moisture content to 8-10 %.**
- **Moisture content is important to achieving exact degree of agglomeration of product and porosity of powder layer.**

- **Third and last drying stage takes place in vibro fluidized bed dryer where moisture content of powder reduces to 3-5%.**
- **Fluidized bed chamber is supplied with heating and cooling section.**
- **Only small amount of powder leaves plant together with drying and cooling air as fines.**
- **Powder is separated from air in a cyclone.**
- **Powder is re-circulated, either to main chamber or to point in the process appropriate to type of product and agglomeration required.**



- Product
- Cold air
- Hot air
- Filter
- Blower
- Heater/Cooler
- Rotary valve
- Fan

Three stage drying system

Advantages of three-stage process:

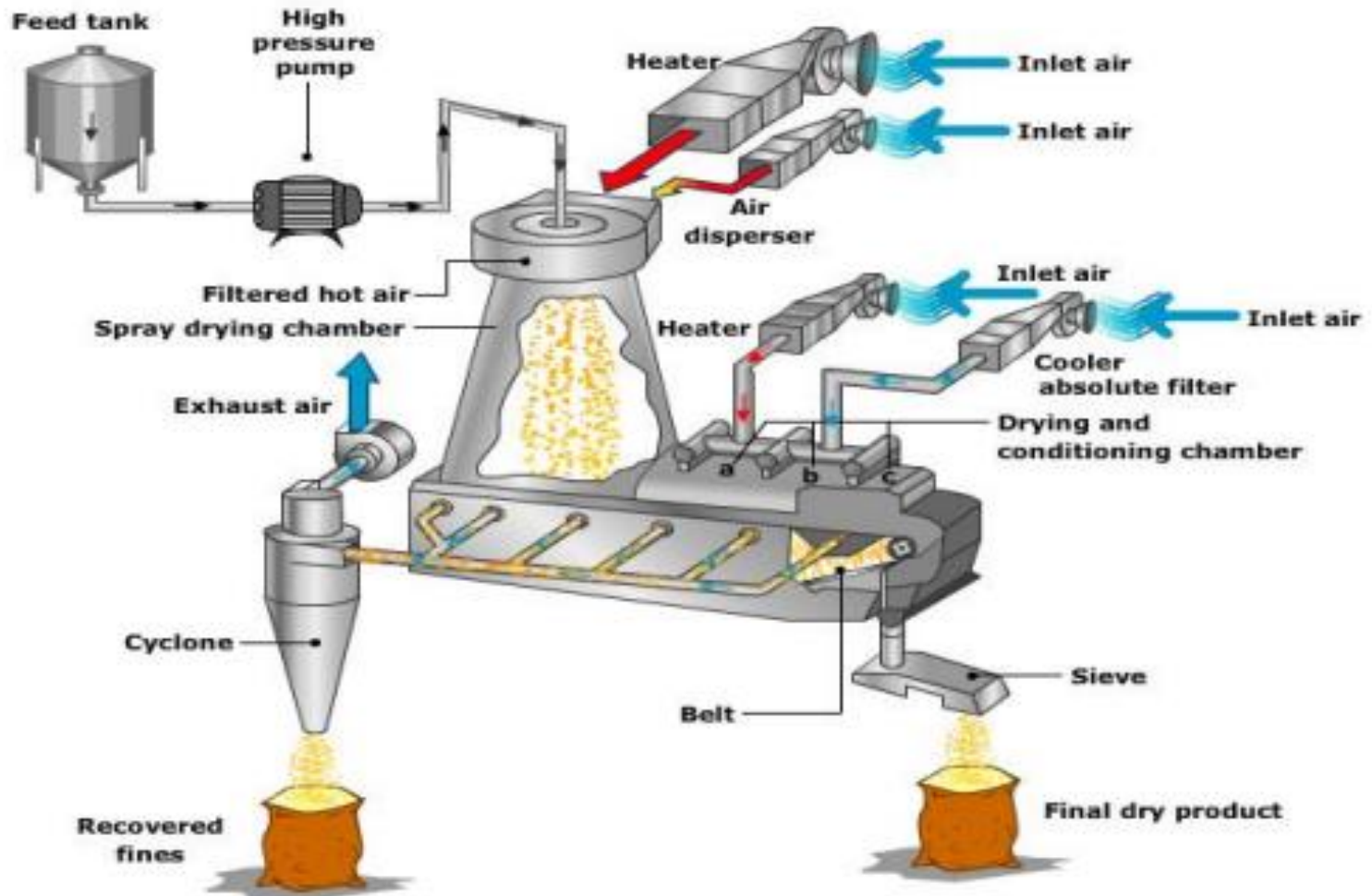
Allows supply air temperature to be increased and outgoing air temperature to be lowered

Reduces specific energy requirement by further 10-15%, improves particle agglomeration and reduces product degradation by using lower drying air temperatures

Skim milk powder and whey powder are manufactured cost-effectively

Belt process:

- **Lactic acid in dry form is very thermoplastic even at low temperature and difficult to dry by conventional spray drier (this type of powder is extremely sticky during spray drying process).**
- **Especially advantageous in drying lactic acid whey.**
- **High moisture content of powder leaving spray drying chamber ensures that crystallization will continue in powder to an even greater extent than two-stage process using fluid bed drier.**
- **This crystallization is improved if wet powder is kept at high moisture content for 10-15 mins.**
- **Done on belt conveyor mounted between chamber outlet and fluid bed, where final drying takes place.**
- **Resulting powder consists of large agglomerates, with low bulk density and non-caking properties.**
- **To avoid condensation in cyclones, hot air is introduced into exhaust system of spray dryer to increase relative humidity.**

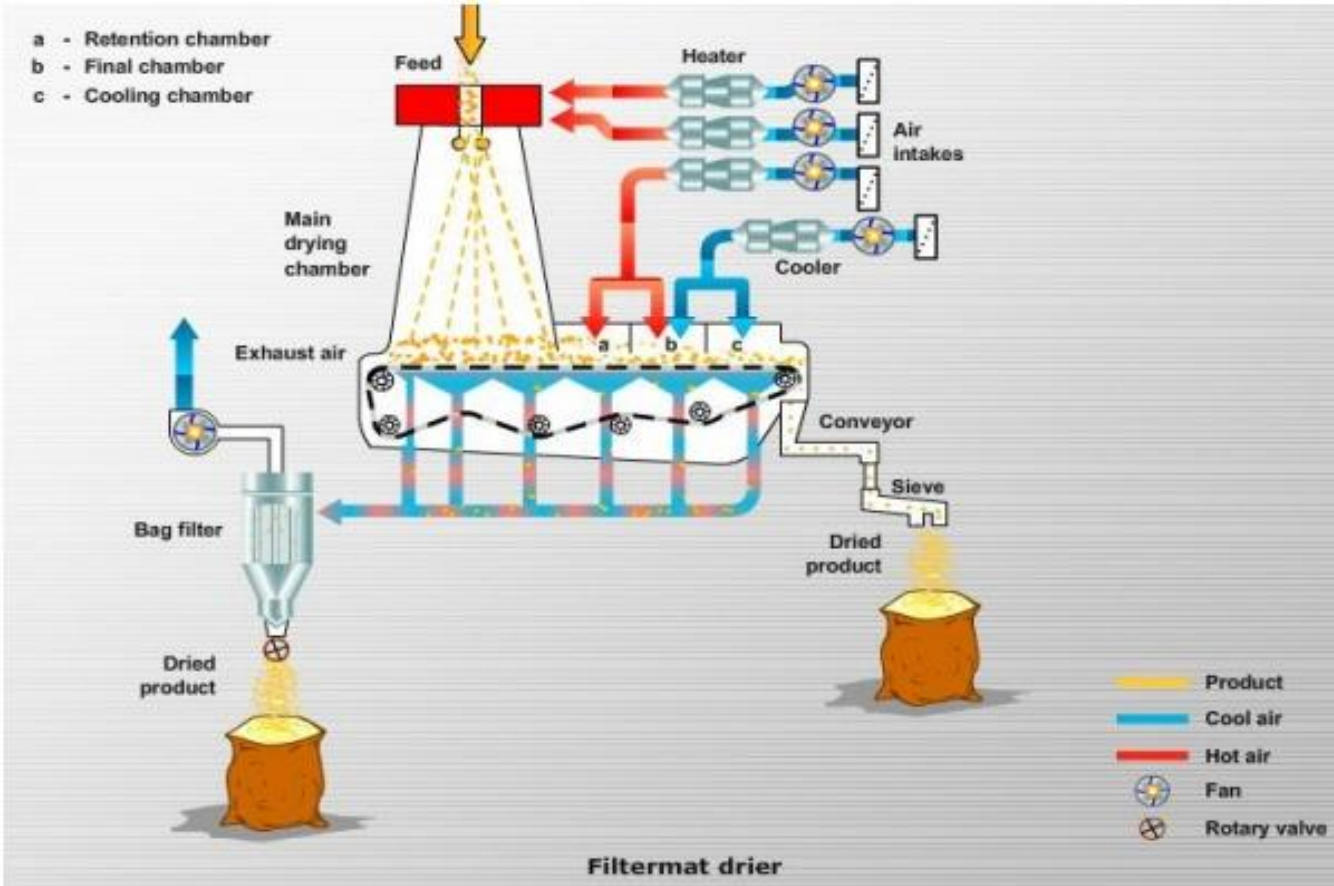


Belt system of acid whey drying

Consists of main drying chamber and three smaller chambers for crystallization, final drying and cooling. Typical drying conditions involve preheating to 80°C, feed concentration to 50%, spray drying at inlet temperature of 150°C and outlet temperature of 55°C to moisture content of 12-15%.

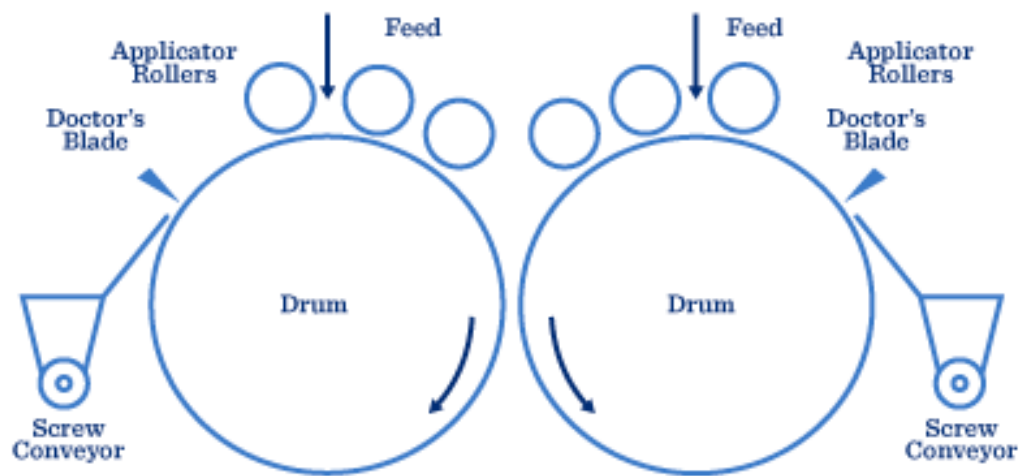
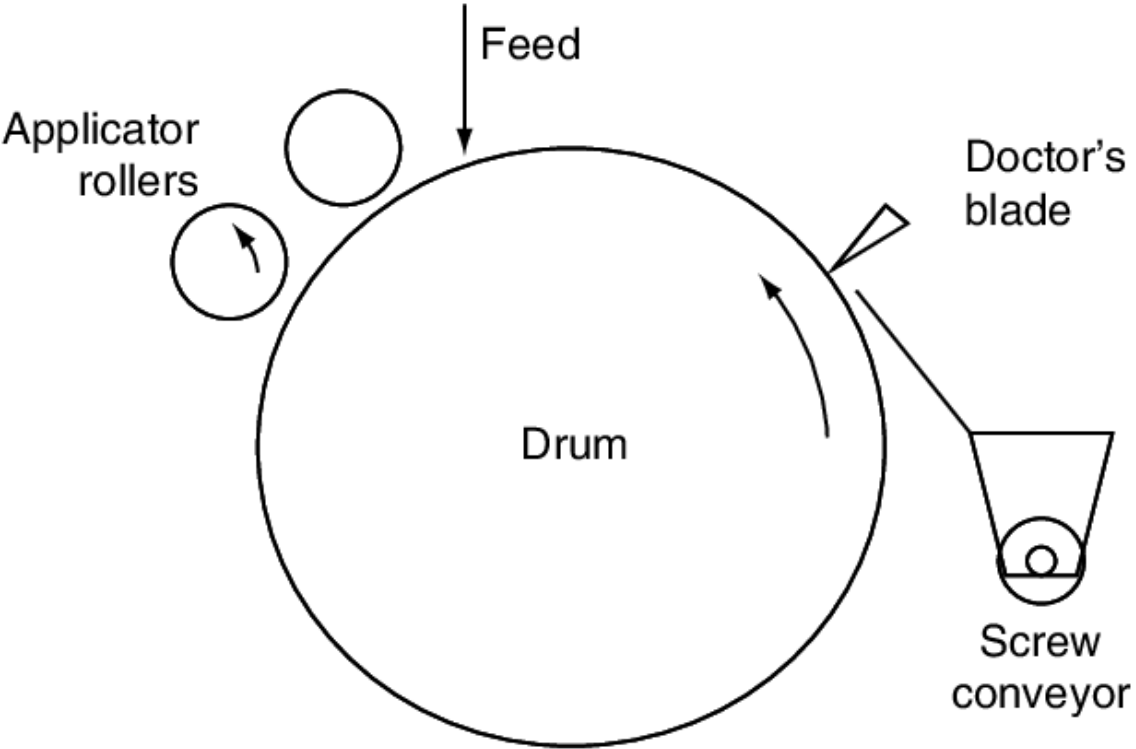
Filtermat concept of drying:

- Concentrate is atomized by pressure nozzle in low profile drying chamber.
- Conveyor belt collects powder from bottom of chamber.
- Conveyor belt contains three sections. First section for agglomeration and crystallization, second section contains warm air for drying and third section for cooling of powder.



Roller Drying of Whey

- Harsh heat treatment effects diminish for producing high quality whey based powders.
- Whey powder obtained by roller drying is very hygroscopic since most of the lactose is in amorphous form.
- Dark colour caused by Maillard reactions: Between proteins and lactose.
- Roller-dried whey powder is not easily soluble.
- **Advantages:** Low cost investment, relatively small space necessary for operation, economical processing, easy operation and maintenance.
- **Vacuum roller drying:** Whey is dried below 100 C at 91-98 KPa (effects of oxygen and high temperature are reduced). Product has better properties in comparison to roller drying under atmospheric pressure.



Twin Drum Dryer with Applicator Roller Feeds