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Drying of bio refinery product streams : Technological diversity and opportunities

Challenge of drying temperature sensitive slurries

Extraction and dewatering are central processing steps in bio refinery R&D. Subsequent drying of temperature sensitive slurries to a powder is often a problematic last step. The challenge is to create a functional half product, with an economical feasible process. Mild drying conditions are preferred to keep the nutritional and organoleptic functionality, while the economical constraints demand high dry matter content of the feed, low energy use and low capital costs of the installation.

Technological diversity

There are literary hundreds of different drying methods and technical varieties. Applicability of each technique is mainly determined by the consistency of the feed and method of heat transfer

	Drying technology	Pumpable solution or suspension	Sludge or Soft Paste	Hard paste or cake	Powders < 0.5mm	Granules 0.5 - 5mm	Fibrious	Solid chunks >5mm	Batch	Vacuum	IR/MW	Product Temperature			Residence time			Mild
Convective	Spray Drying	X										60	130	°C	5	30	sec	?
	Pneumatic, Flash Drying		spin	grind	X	surface						60	150	°C	10	60	sec	
	Fluidized Bed Drying		backmiX	grind	X	X	X	puffed	Opt		Opt	60	100	°C	2	20	min	
	Convection Belt Drying		foam	preform		X	X	X			Opt	50	80	°C	0.5	3	hr	
	Rotary Tumble Drying			preform		X	X					60	100	°C	0.2	1	hr	
	Convective Tray/Silo Drying			preform		X	X	X	X		Opt	40	60	°C	3	10	hr	
Conductive	Drum Drying	X	X									80	130	°C	10	30	sec	
	Vacuum Drum Drying	X	X							X		40	80	°C	20	60	sec	x
	Thin Film Belt Drying	X	X									50	90	°C	10	60	min	?
	Vacuum Belt Drying	X	X							X		40	70	°C	5	15	min	x
	Agitated Film Drying	X								X		50	80	°C	30	100	sec	x
	Paddle Agitated Drying		X	X	X	X	X					80	110	°C	5	50	min	
	Agitated Vacuum Dryer			X	X	X			X	X		30	50	°C	4	8	hr	x
	Vacuum/Freeze Drying		X	X	X	X	X	X	X	X	Opt	-20	30	°C	5	48	hr	x

Mild Drying

Mild drying conditions are preferred for minimal negative impact on the quality. Drying should be fast and/or under protective conditions.

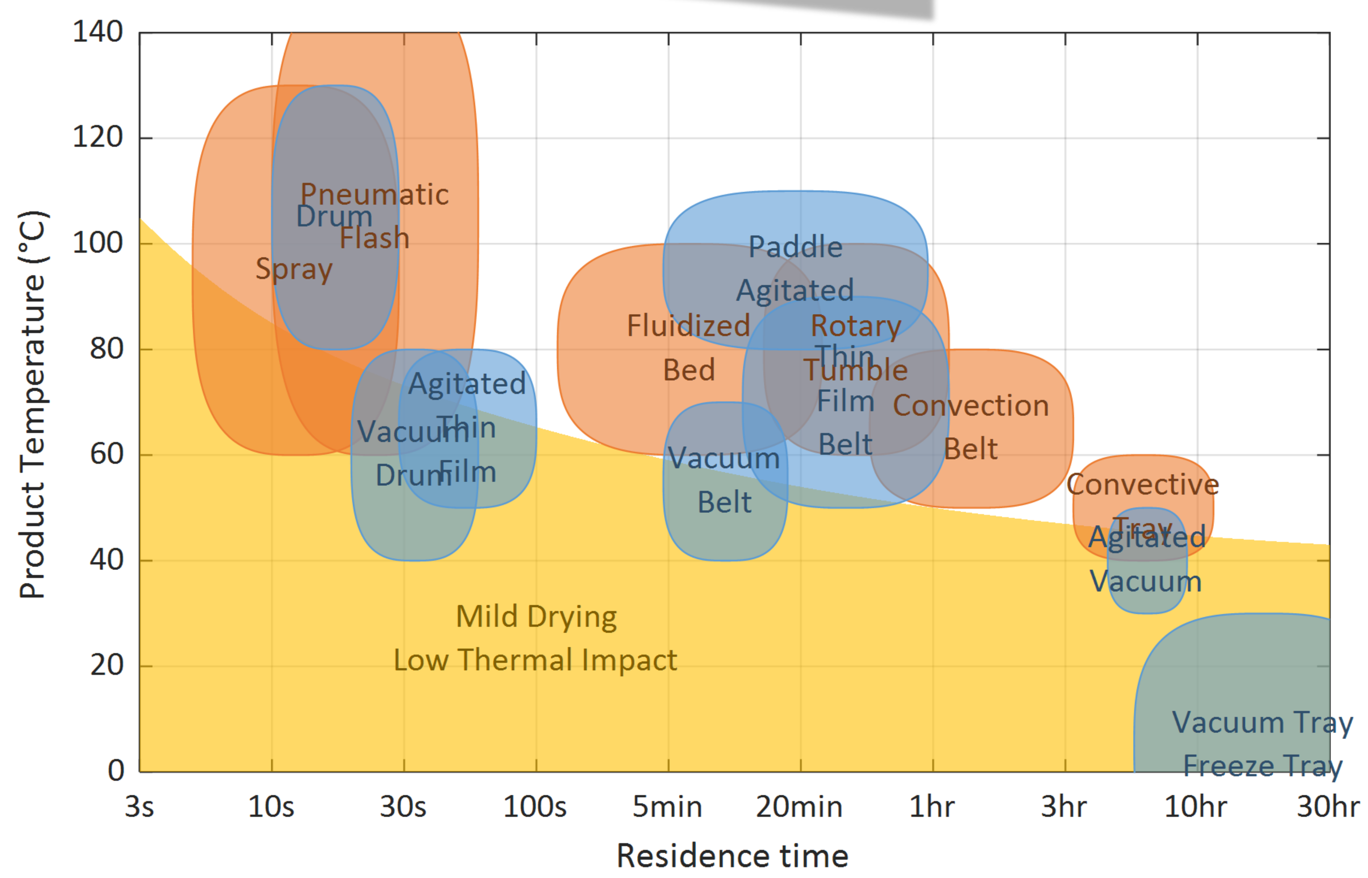
Problematic phenomena

- Stickyness
- Foaming
- Browning
- Denaturation
- Oxidation
- Crystallisation
- Loss of volatiles
- Inhomogeneity
- Fines, Lumps

Protective measures

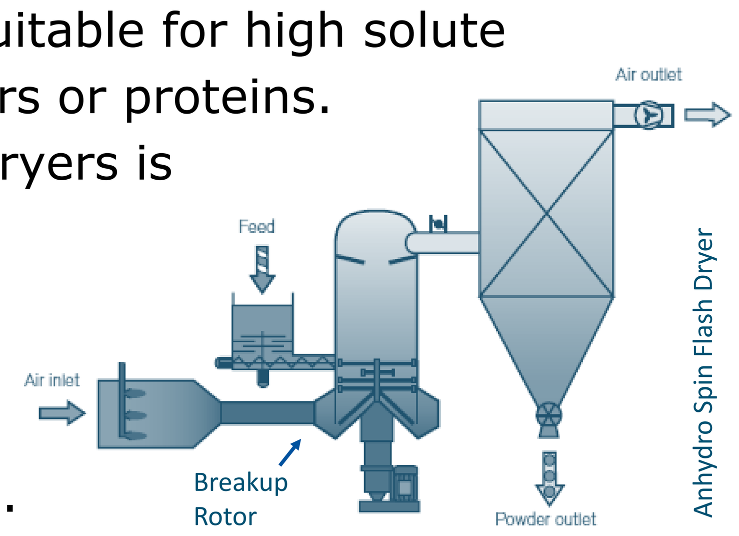
- Decrease particle size
  - Flash drying at WB temp.
- Lower the temperature
  - Partial vapour pressure
- Remove air (oxygen)
- Dry long enough to low Aw
  - Batch vacuum drying
- Mix and agglomerate
  - Disperse wet on dried

Size reduction and porosity are the key to a fast drying process, as the rate is eventually determined by internal moisture diffusion. Mild drying of larger particles requires low temperatures and long drying times.



Convective air drying of a slurry or paste

Atomisation in a spray dryer is an excellent way of size reduction. High dry matter content, leading to large droplets, can be problematic as the particles do not dry completely in free flight. **Multistage** dryers with internal and external fluidized bed can create extra leverage. **Filtermat** spray dryers are especially suitable for high solute concentrates of fruit, vegetables, flavours or proteins. Convective drying of pastes with flash dryers is possible with a fast **breakup** rotor, and cyclone collection of the dried fraction. Fluidized bed drying requires **back-mixing** of the partially dried solids with the wet feed on the air inlet screen.



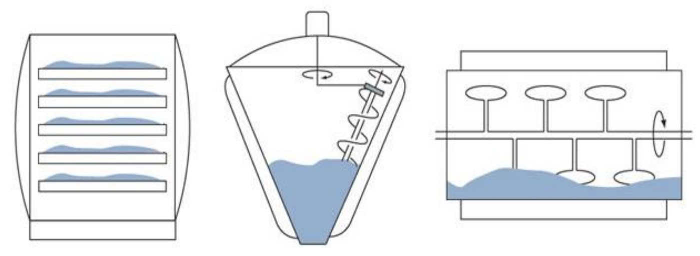
Thin film drying of a slurry or paste

Regular Drum Dryer at Unilever | Refractance Window Dryer at ILVO | Vacuum Drum Dryer at Andritz | Agitated Thin Film Dryer at Bodec

Thesis Jun Qiu, FPE -WUR (2019) *Systematic comparison of tomato powder quality prepared by four different conductive dryers.*

In regular **drum drying**, a thin film is spread on a drum where the vapour boils off quickly. Thin film drying at temperatures below 100°C requires extended residence time which can be achieved with **refractive window drying** on a large Mylar belt. Intensified low temperature thin film drying is possible with either **vacuum drum drying**, or **agitated thin film drying** (ATFD). In ATFD, a thin layer is spread on the inside of a vertical heated tube. Fast rotating blades continuously refresh the film, which critically depends on the rheology.

Vacuum versus very dry air.



Vacuum Tray Dryer | Rotary Cone Dryer | Paddle Dryer

Drying of very hygroscopic or bioactive ingredients at low temperature requires **batch** processing. The low partial vapour pressure can be achieved via either vacuum or very dry air. Ambient drying with **dehumidified air** is interesting for particulate feeds >5mm, where the internal diffusion is rate limiting. Air recirculation volumes however increase dramatically when dew points ≪ 0°C are required. For these conditions **vacuum** and **freeze drying** give excellent results, but need expensive vacuum vessels. Various ways of heat transfer are applied to speed up the process; via the tray, vessel wall or paddles. Vacuum microwave drying is matured and getting applied.

Take advantage of drying experts networks

Knowledge and expertise is scattered among groups and institutions.

You can't know it all: Team Up!

- Academia - CRO
  - WUR – WFBR
  - Nizo – Bodec – TNO - HAS
- Industries
  - FC, Danone
  - DSM, Cosun, Unilever
- Technology providers
  - Gea, Hosokawa etc et
- Engineering firms
  - Ebbens, Blue Terra
- Consultants ...

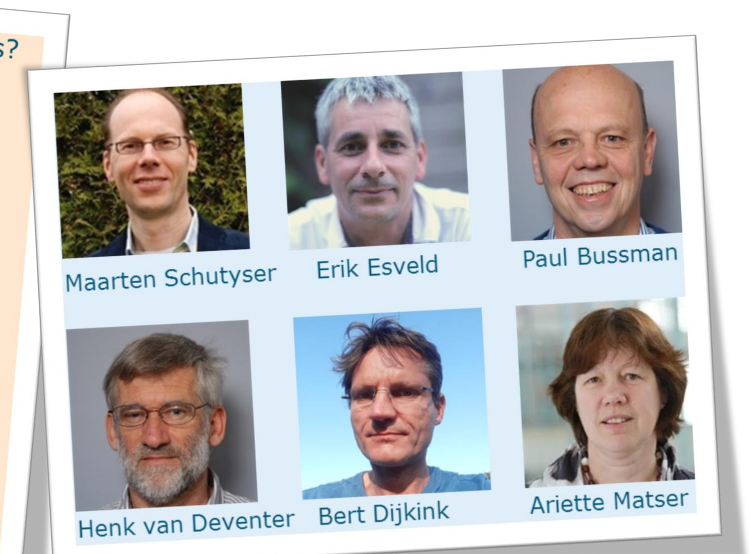
How do we find the right persons?

- Local Experts Network
  - WFBR Drying cluster
  - NWGD
  - ISPT

Ask arround, internal, externally

- Vendor or tolling facilitator
- Producers of similar products

Team-up with diverse backgrounds in biorefinery and drying



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