

Powder creation using spray dryers

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Technology manager



Who we are

About Tetra Pak





Tetra Pak – a single source supplier

Delft  Solids Solutions



Packaging



Processing



Service



Processing solutions and know-how

Line solution for the following area's

- ▶ Dairy, Beverage & Prepared Food
- ▶ Cheese and Whey
- ▶ Ice cream, Filtration and Cosmetics
- ▶ Automation Solutions



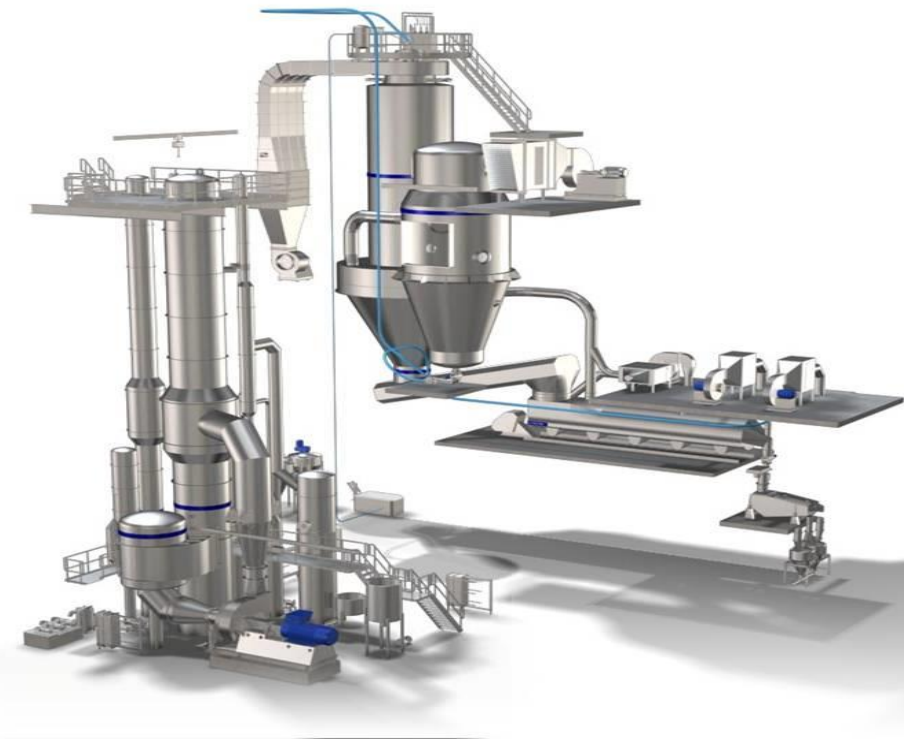


Tetra Pak is global and works locally

Our strength



- ▶ Strong company, able to handle major turn key projects
- ▶ Scope from raw milk silo to powder bag
- ▶ Local presence and local service
- ▶ Taylor made solutions
- ▶ Top quality powders
- ▶ Test centre semi industrial scale



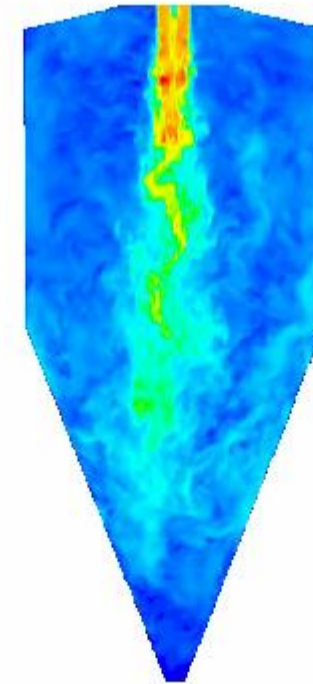


State of the art Technologies – CFD

Fluid Dynamics Services within Tetra Pak CPS



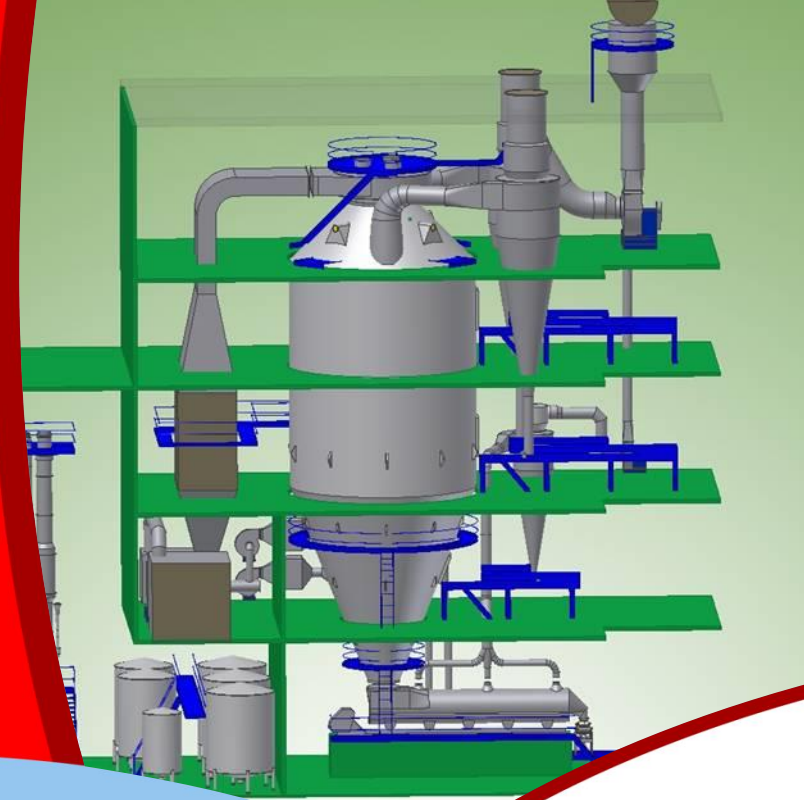
- ▶ Modern software tools for CFD analysis
 - Star-CCM+
 - ANSYS-Fluent
 - ANSYS-CFX
- ▶ Largest computer cluster of Northern Europe, with more than >5000 cpu's



Spray dryer air flows in a nutshell
CPU demand: 500 cpu's for 1 month

The machine

Spray dryer components

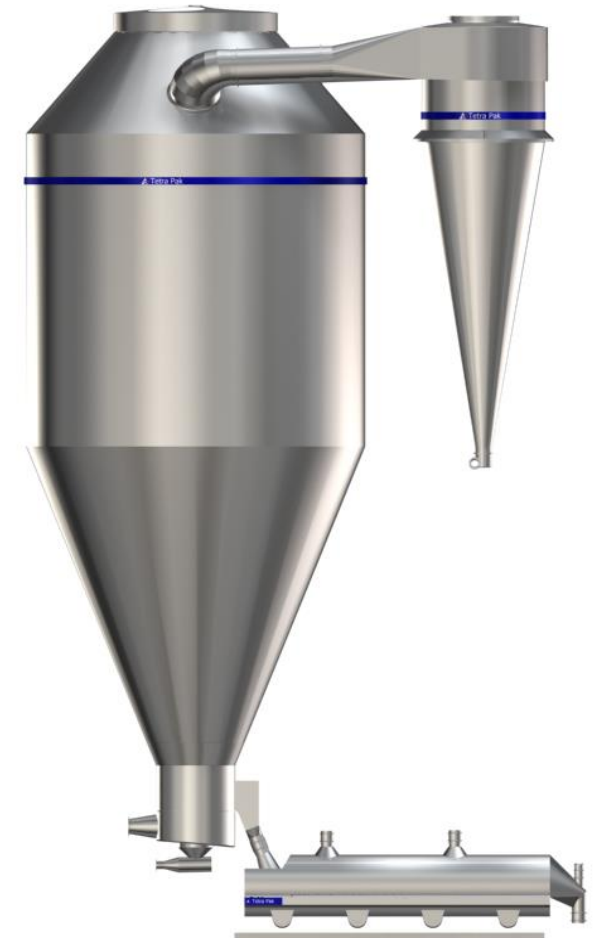




Spray Dryers components

Principle of spray drying

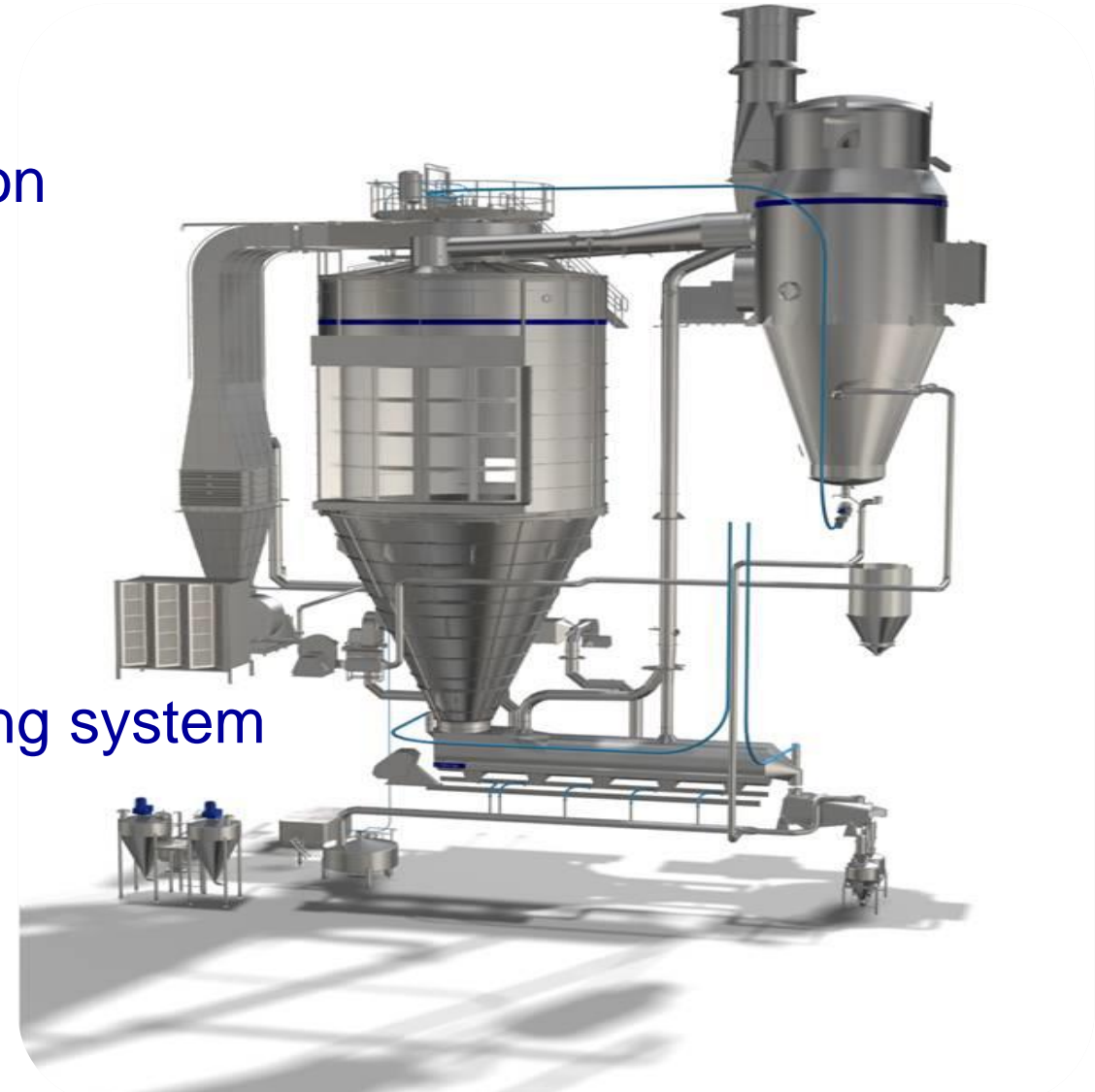
- ▶ To transform a solution into many small droplets (by means of atomisation) which are then exposed to a fast current of hot air
- ▶ Smaller droplets means
 - → larger droplet surface
 - → more rapid water evaporation
- ▶ Atomisation determines shape, size and density of the final particles



Spray dryers components

Spray dryer main components

- ▶ Hot air system and air distribution
- ▶ Drying chamber
- ▶ Concentrate feed system
- ▶ Atomising systems
- ▶ Powder separation system
- ▶ Fluid bed after-drying/cooling
- ▶ Pneumatic conveying and cooling system
- ▶ CIP and safety system
- ▶ Instrumentation and automation





Spray dryers components

Hart of the spray dryer

Delft  Solids Solutions





Spray dryers components

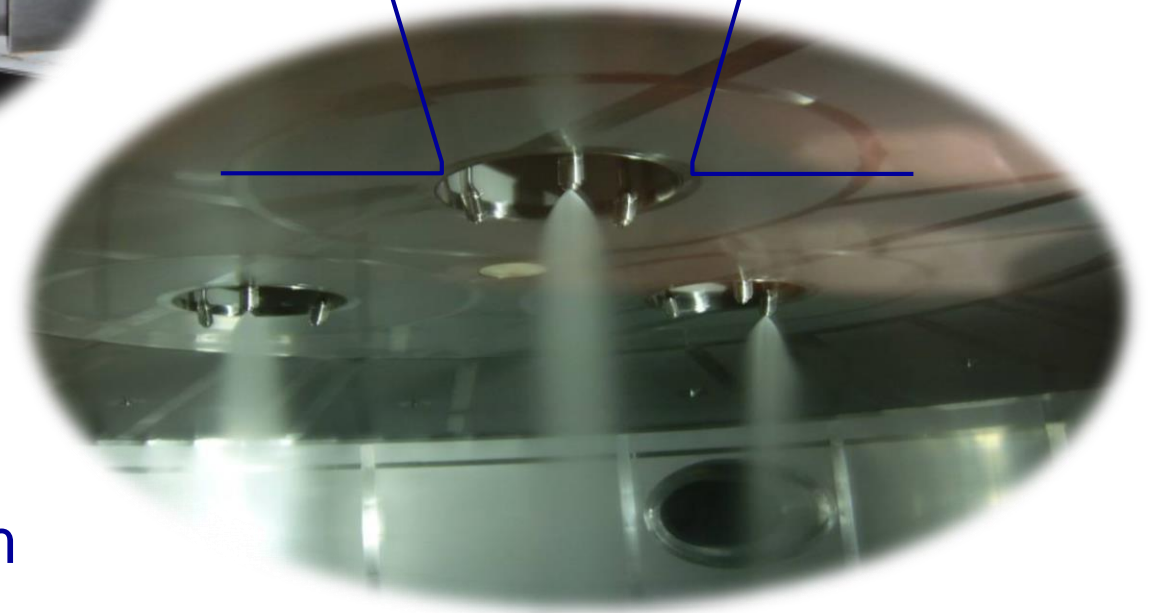
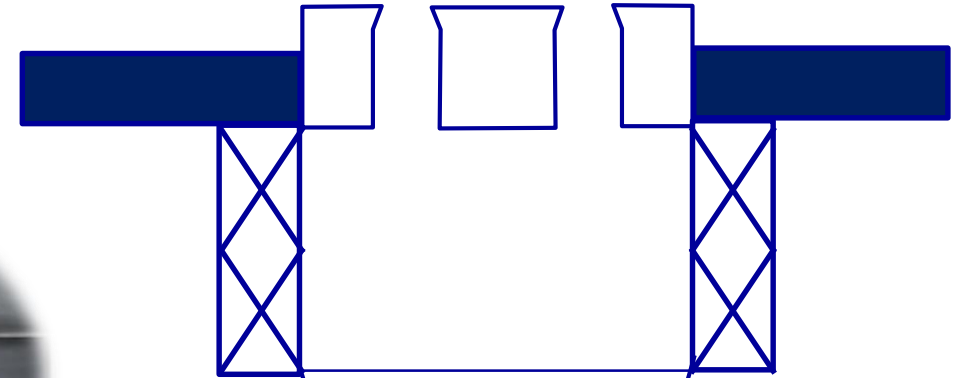
The hart of the dryer



Sunflower air distributor

STAD

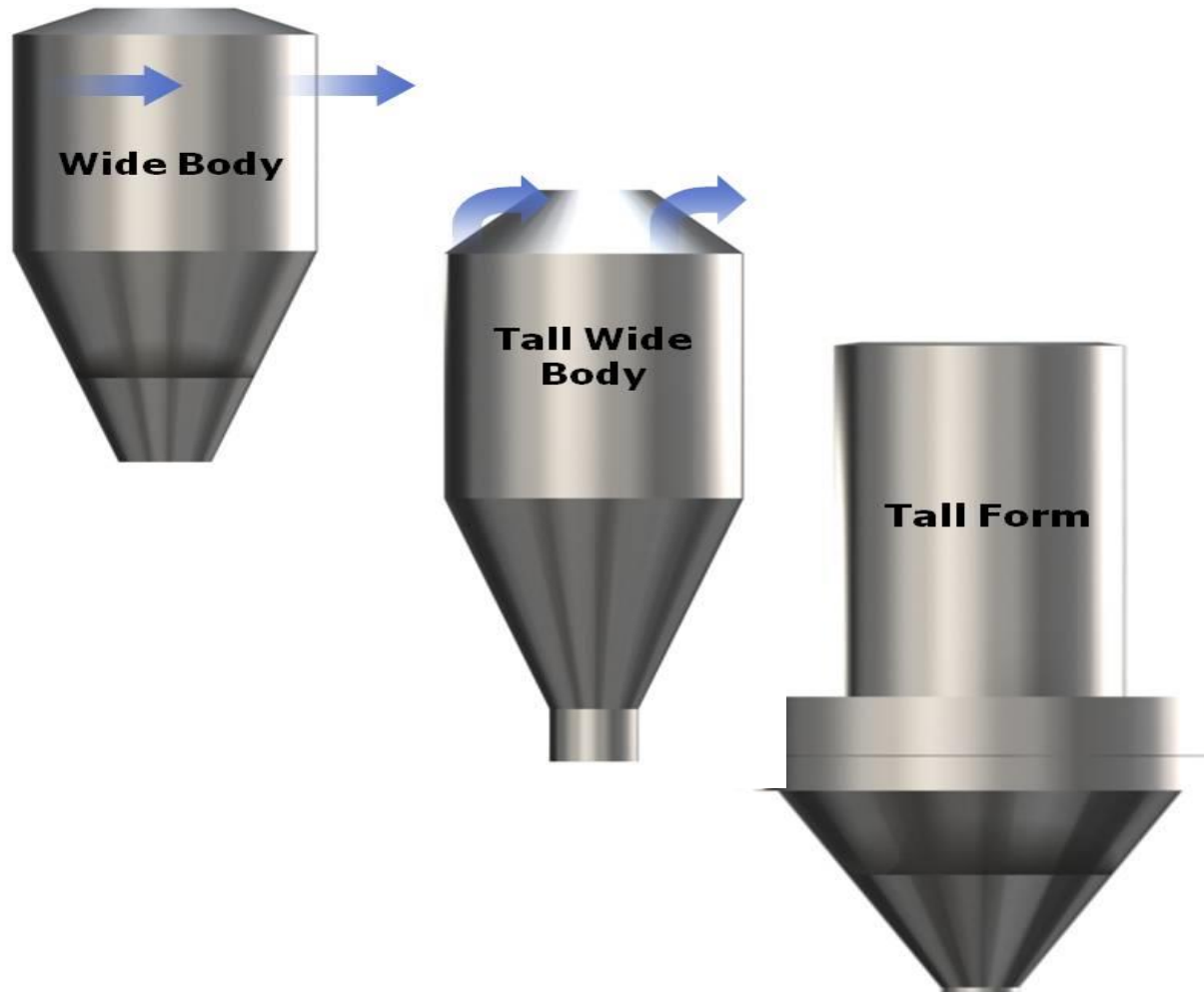
Aim: low pressure drop & uniform temperature and flow profile





Spray dryers components

And the body



Our concepts

Tall Wide Body

- Co-current airflows
- Reduced fouling compared to TFD
- Better cleanable

Tall Wide Body

- Wide body concept
- For more difficult drying products

Tall Form Bustle

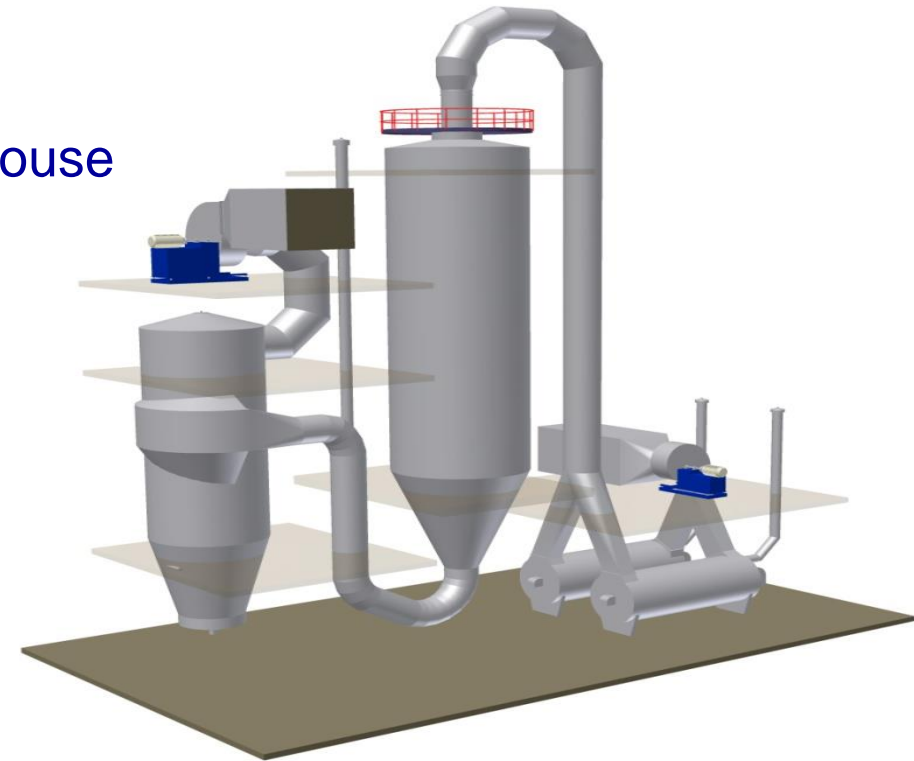
- Better powder separation in cone than wide body
- Less recirculation of fines



Spray dryers components

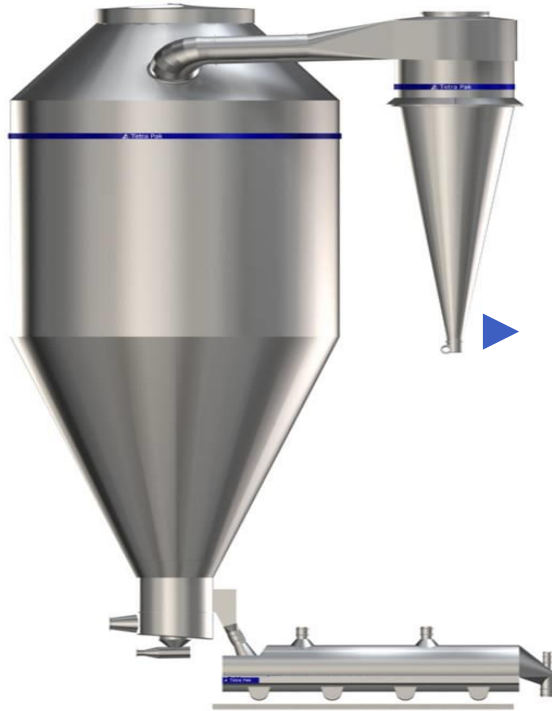
Other Chambers

- ▶ U-tube dryer
 - Single stage dryer
 - Powder separated by cyclones or baghouse



Spray dryers components

Other Chambers

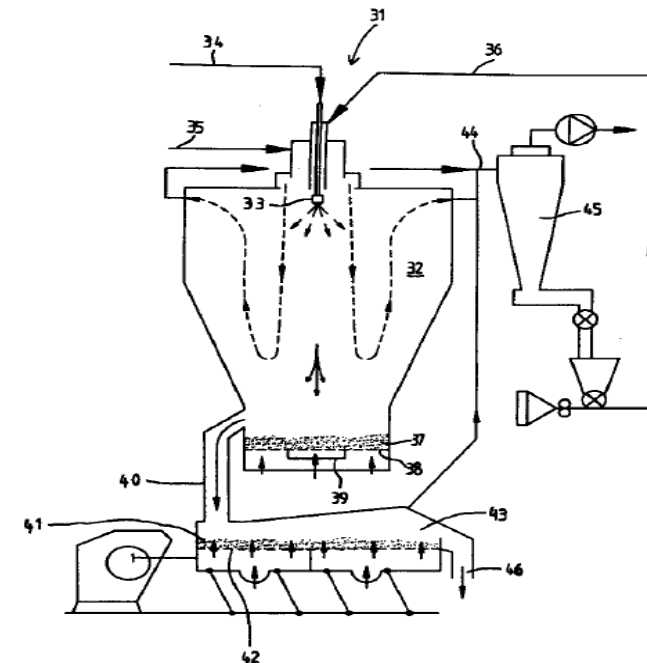


► Multi-stage dryer

- Two or three stage drying
- 10-30% of air is supplied by internal bed
- Larger beds can only handle agglomerated products

► Rewetter

- Used when straight through agglomeration is not possible
- Produces stronger and coarser agglomerates

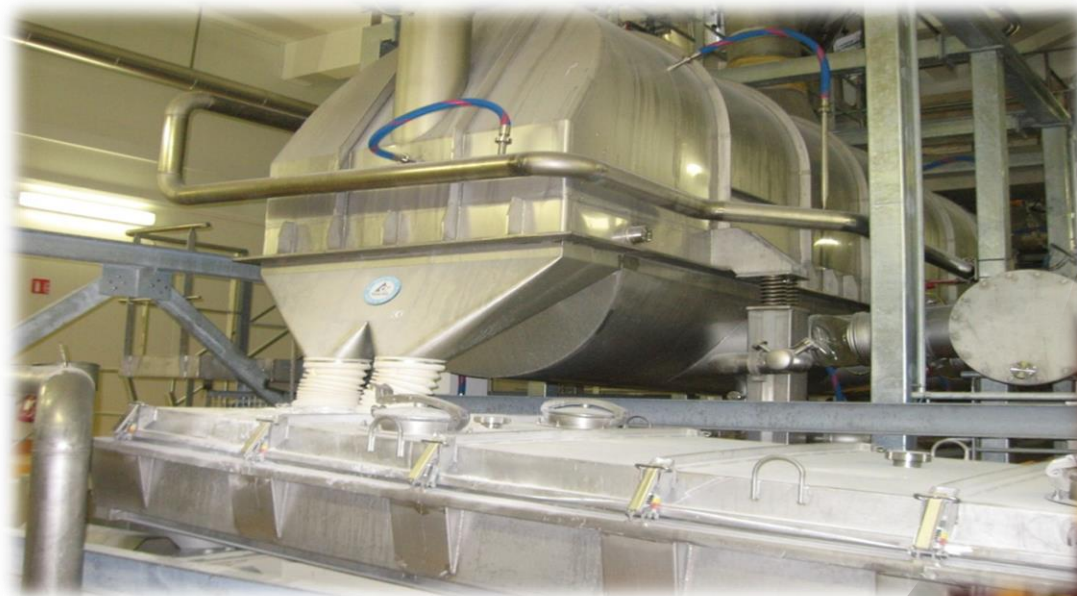


Spray dryers components

Fluid Beds

alternatives for second stage drying:

- Static well mix bed
- Shaking bed
- Vibrating bed





Spray dryers components

Fluid Beds

- ▶ **Static Bed**
 - Secondary drying or cooling
 - Ensures homogeneous moisture and temperature profile
 - Removes stickiness for sticky products
 - Air exhausts into the chamber
 - Diameter 1.4 – 2.5 m
 - Temperature: 40 – 120°C

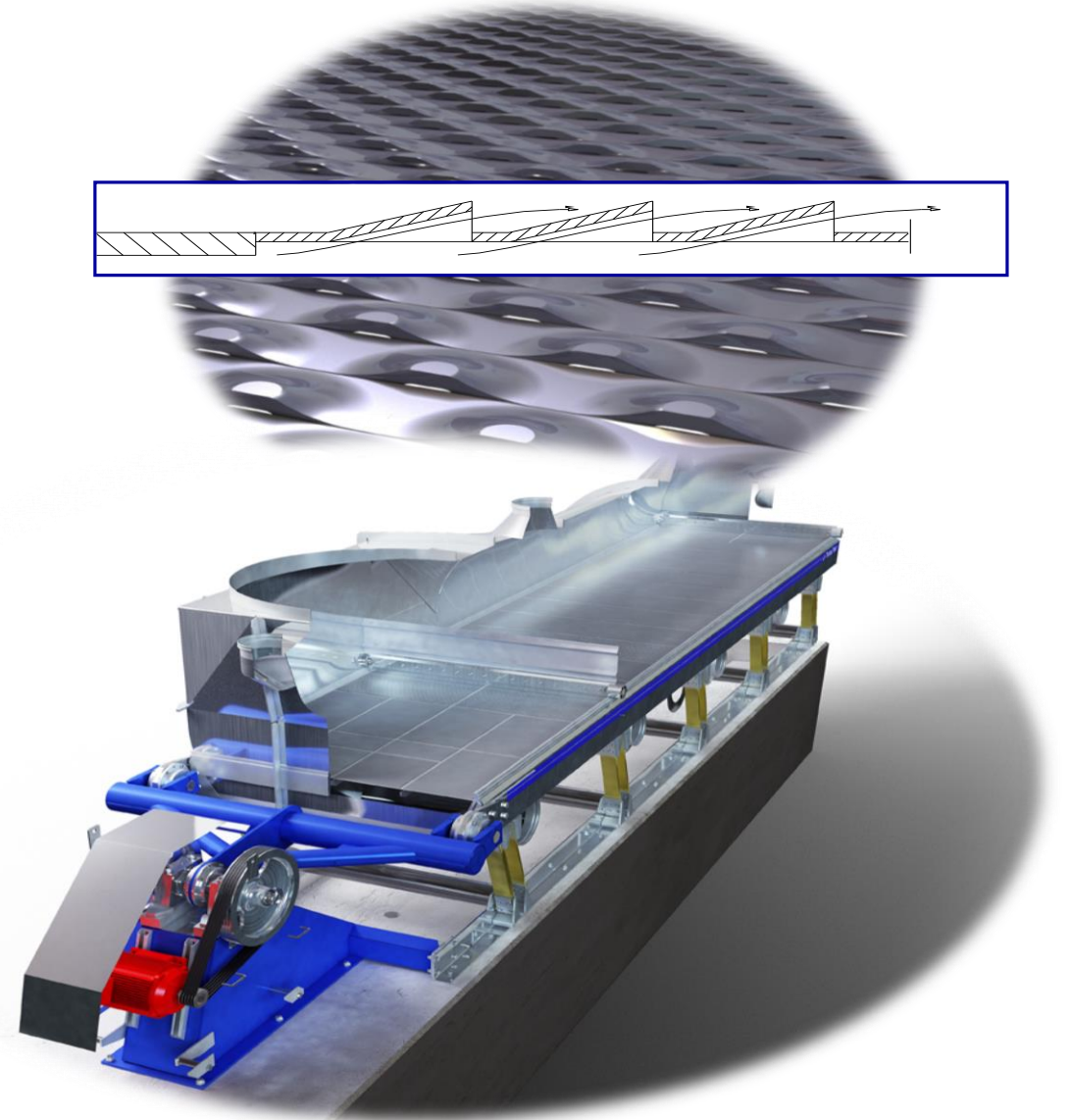




Spray dryers components

Fluid Beds

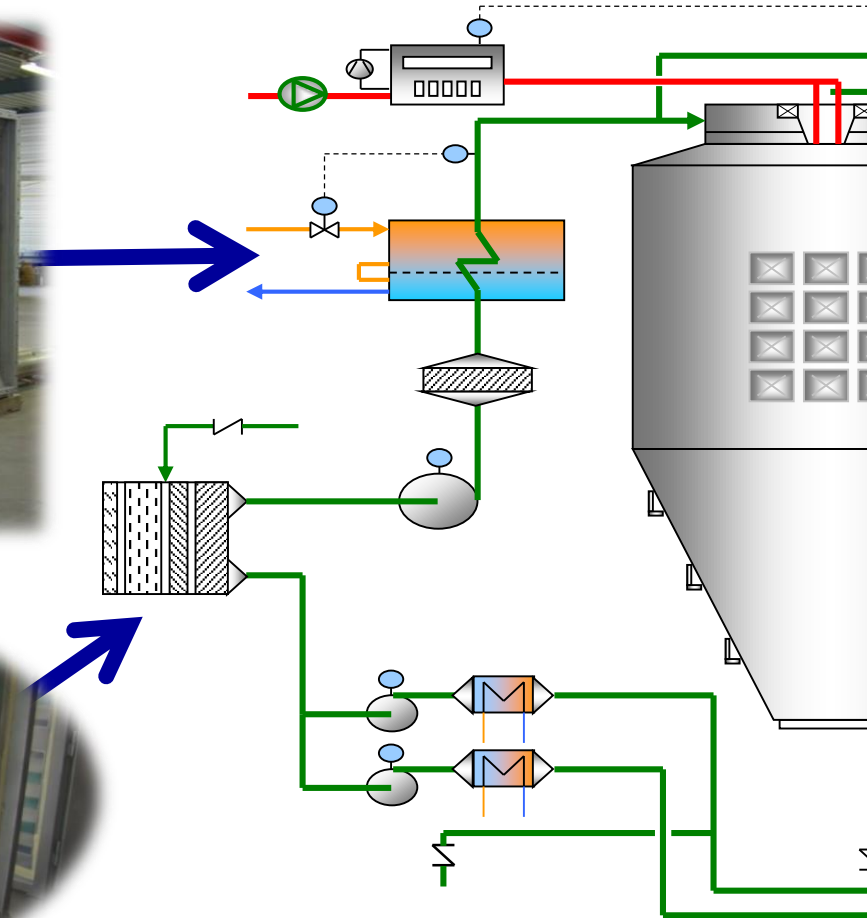
- ▶ Shaking or vibrating beds
 - Shaking or vibrating movement
 - Improve fluidization
 - minimum to powder particles damage
 - Well-mix and plug flow sections possible
 - homogeneous moisture and temperature profile
 - Secondary drying
 - Removes stickiness
 - Cooling
 - Bed width: 0.6 – 2.0m
 - Bed length: 4 – 14m



Spray dryers components

Filtration and Heating

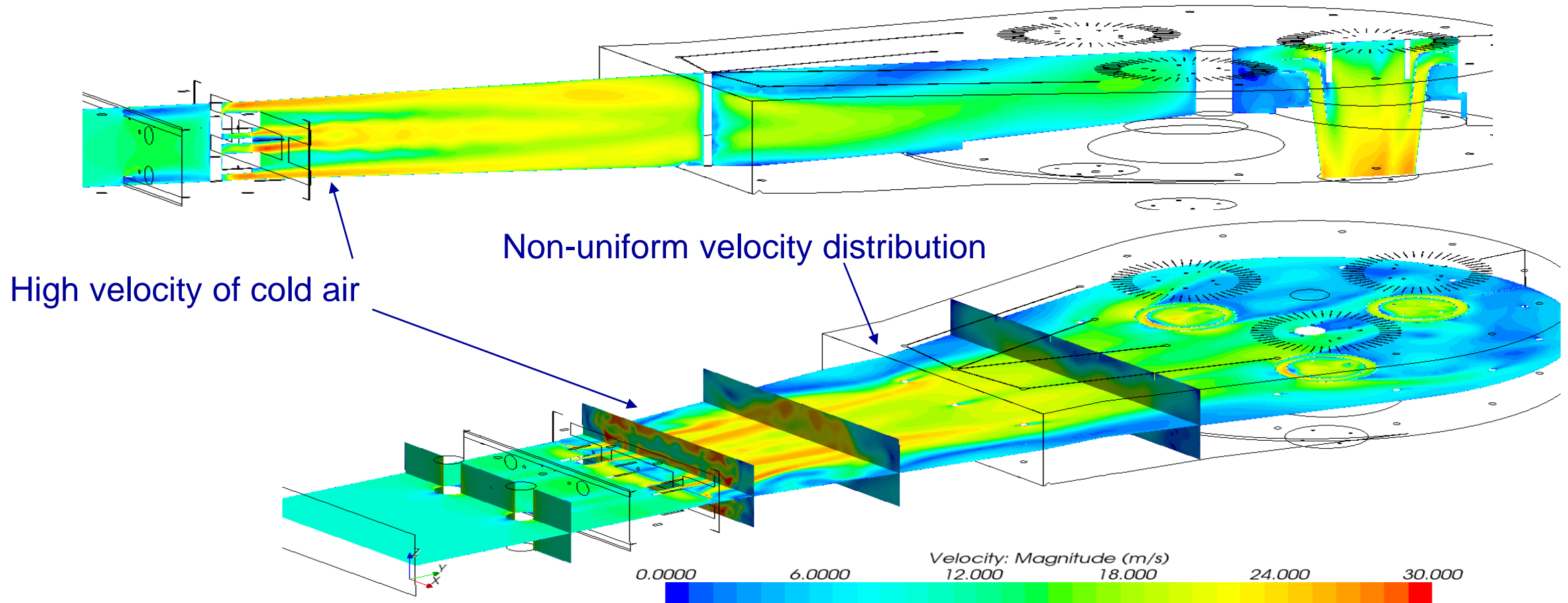
- ▶ To clean and heat inlet air
- ▶ Types of heating:
 - Steam heating
 - Indirect gas heating
 - Direct gas heating
 - Electrical heating
 - Thermal oil heating
- ▶ Choice depends demands and available utility





Use of CFD in optimization dryers

Improving air supply to a direct fired gas burner

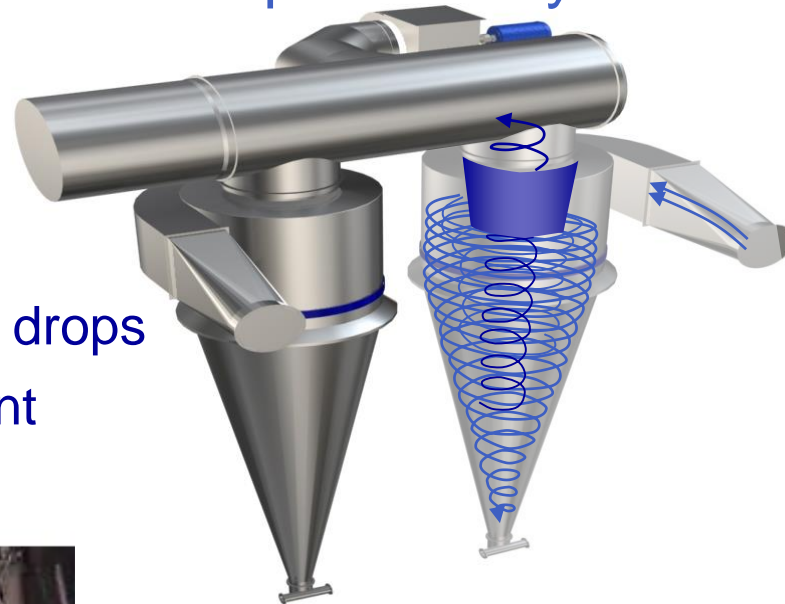


Spray dryers components

Two choices for powder separation system

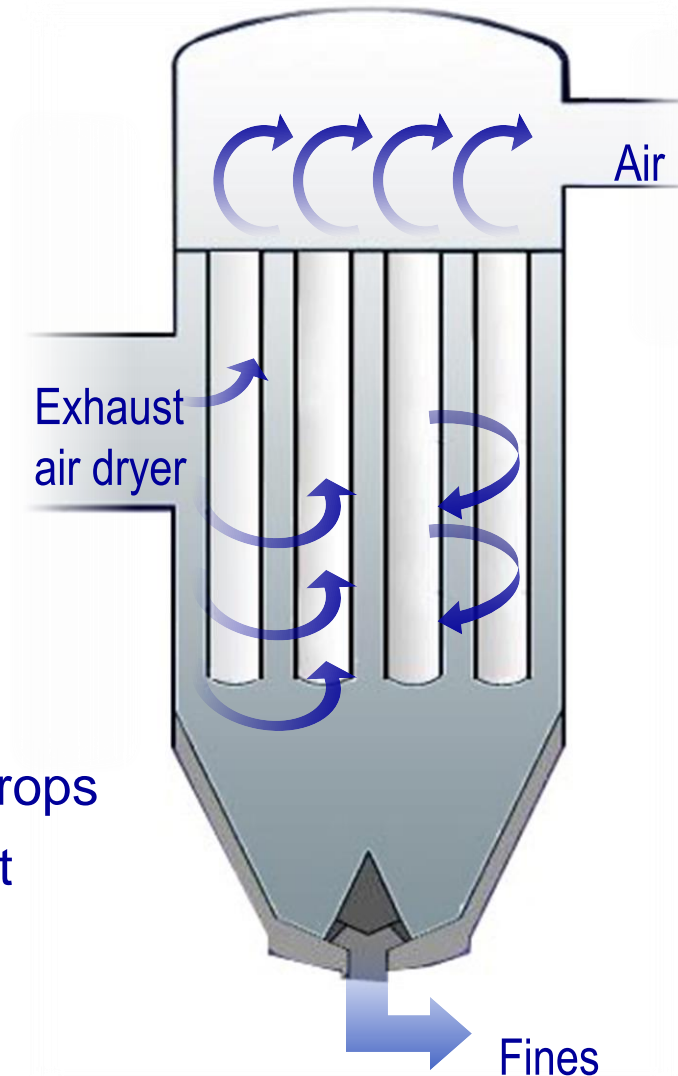
► Cyclones

- Higher losses
- Higher pressure drops
- Lower investment



► Bag filters

- Lower losses
- Lower pressure drops
- Higher investment



Powder creation

In a spray dryer



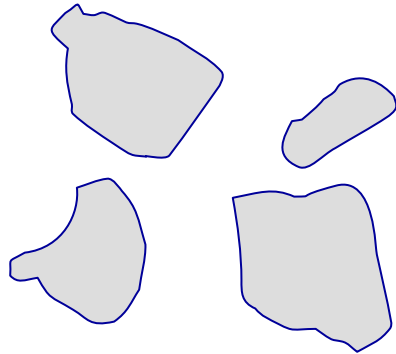


Agglomeration

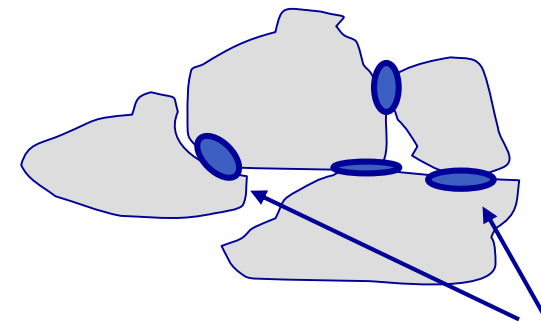
Agglomeration

- ▶ Getting smaller particles to adhere to each other to form a powder consisting of bigger conglomerates/agglomerates, which are essential for an easy reconstitution in water.

Non-agglomerated



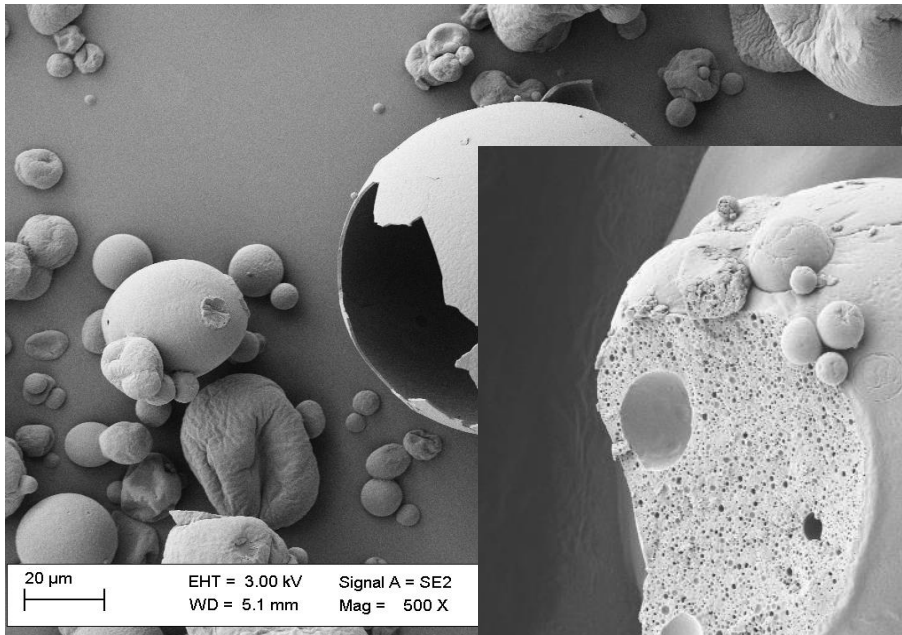
Agglomerated



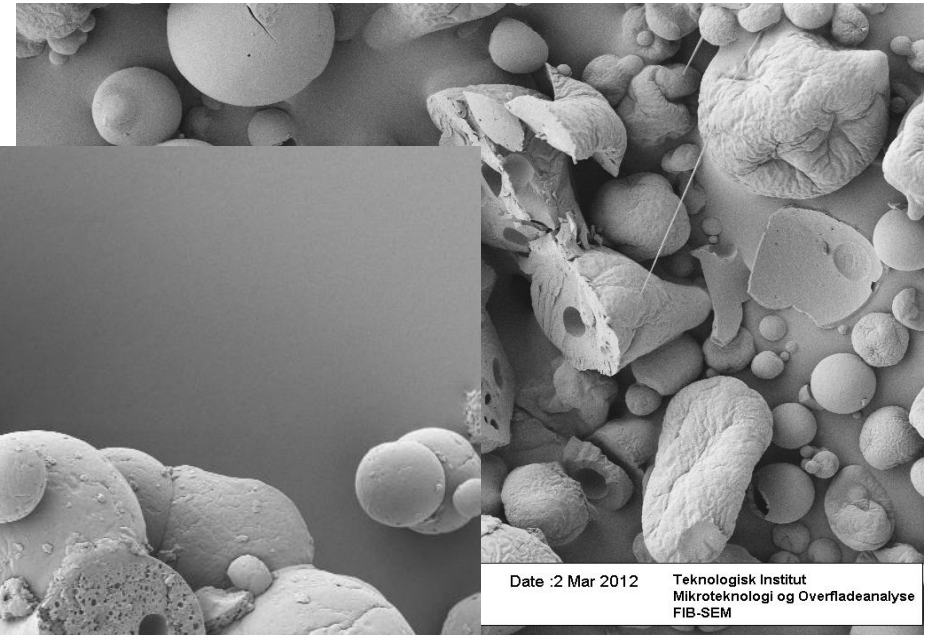
Bridging particles

Agglomeration

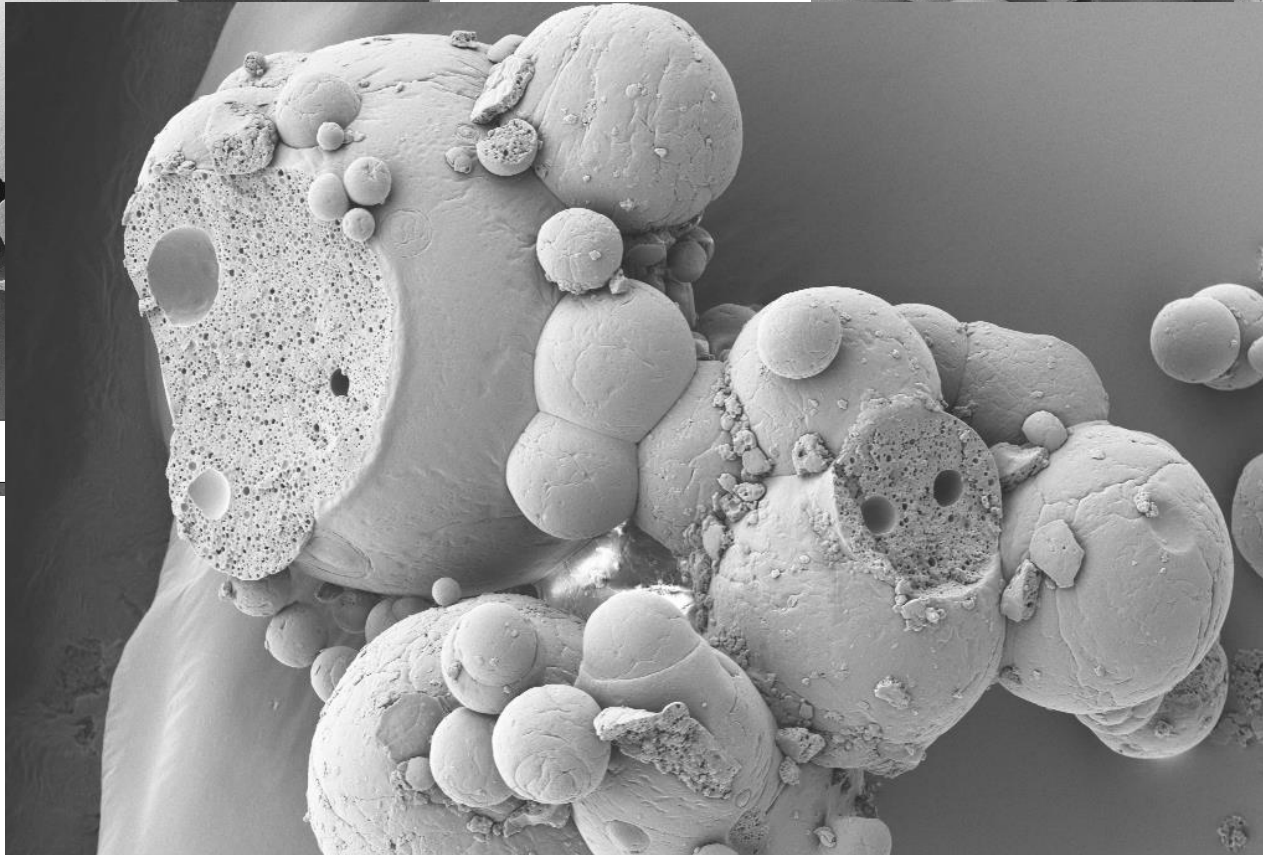
FIB-SEM micrographs of powders



20 μ m | EHT = 3.00 kV | Signal A = SE2
 |-----| | WD = 5.1 mm | Mag = 500 X



Date :2 Mar 2012 | Teknologisk Institut
 Mikroteknologi og Overfladeanalyse
 FIB-SEM

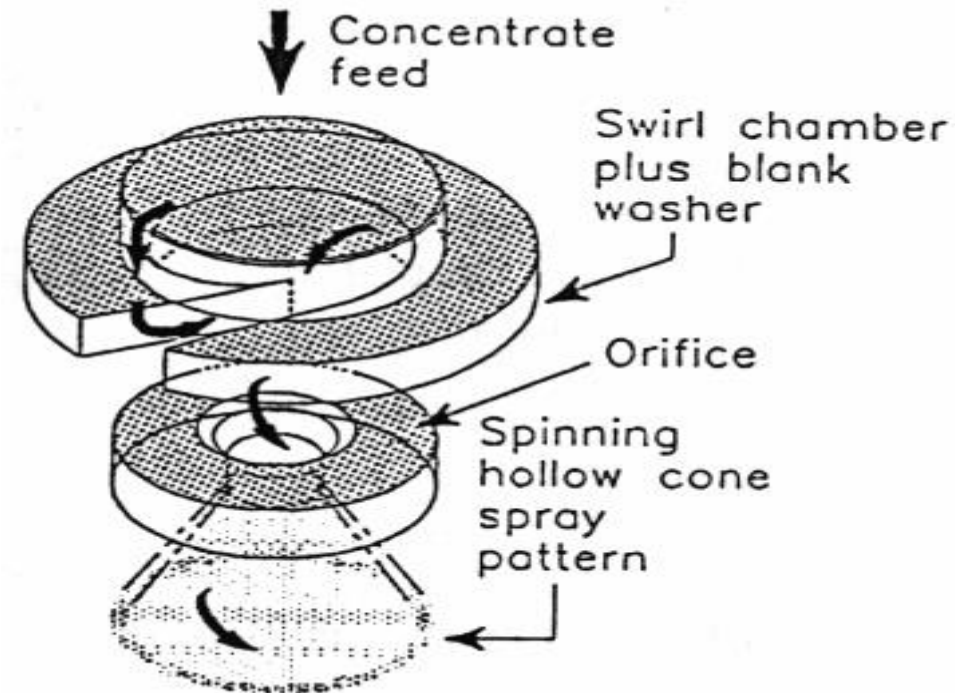


10 μ m | EHT = 3.00 kV | Signal A = SE2 | Date :14 Apr 2015 | Teknologisk Institut
 |-----| | WD = 7.9 mm | Mag = 1.00 K X | Center for Nano- og Mikroteknologi
 FIB-SEM

Atomization

High pressure nozzle

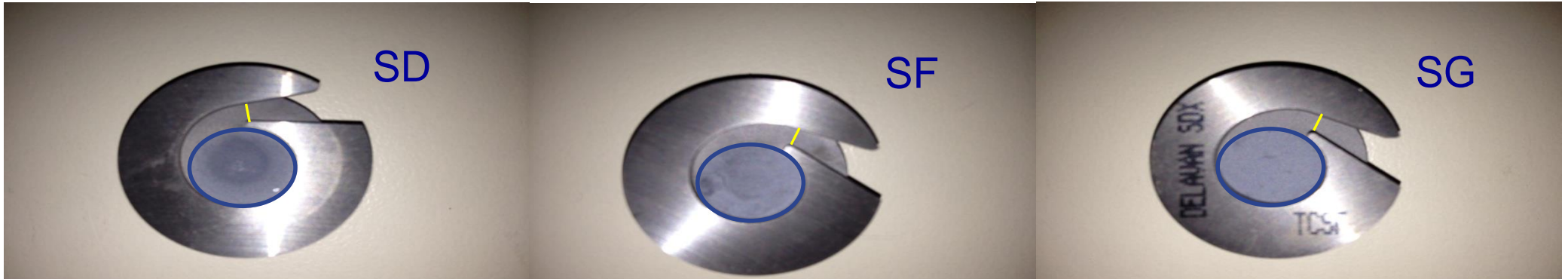
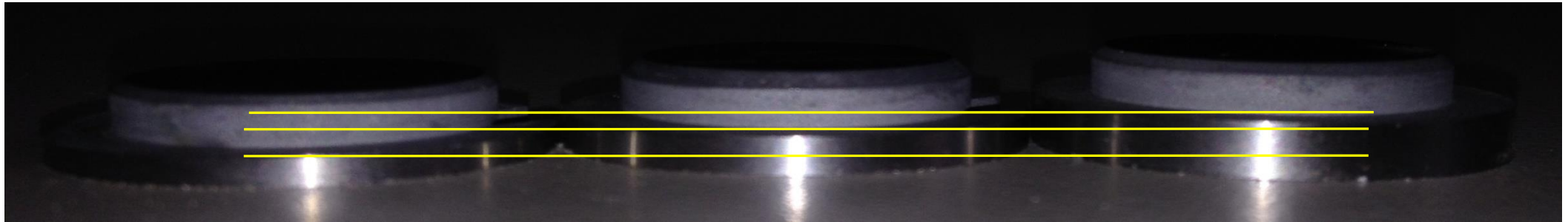
- ▶ In a nozzle atomizer pressure is used to atomise the concentrate
 - concentrate is pumped at high pressure through a swirl chamber and orifice, inducing rotating motion
 - concentrate leaves the orifice as a thin film at about 200 m/s which breaks down into small droplets.
 - nozzle pressures 150 to 300 bar





Atomization

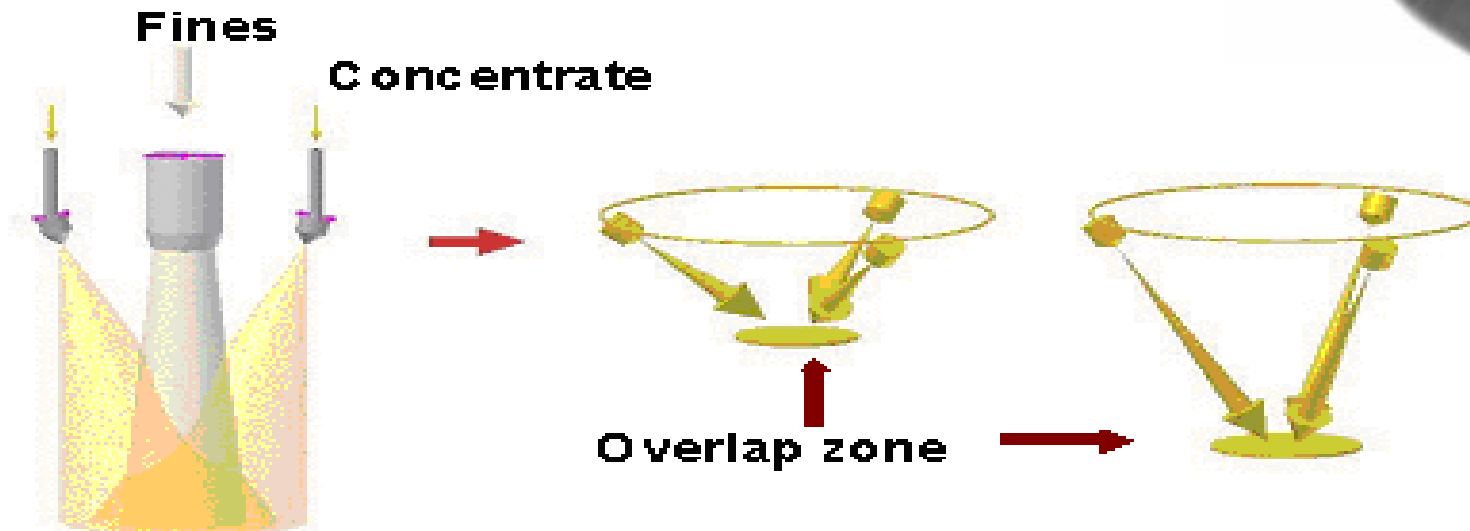
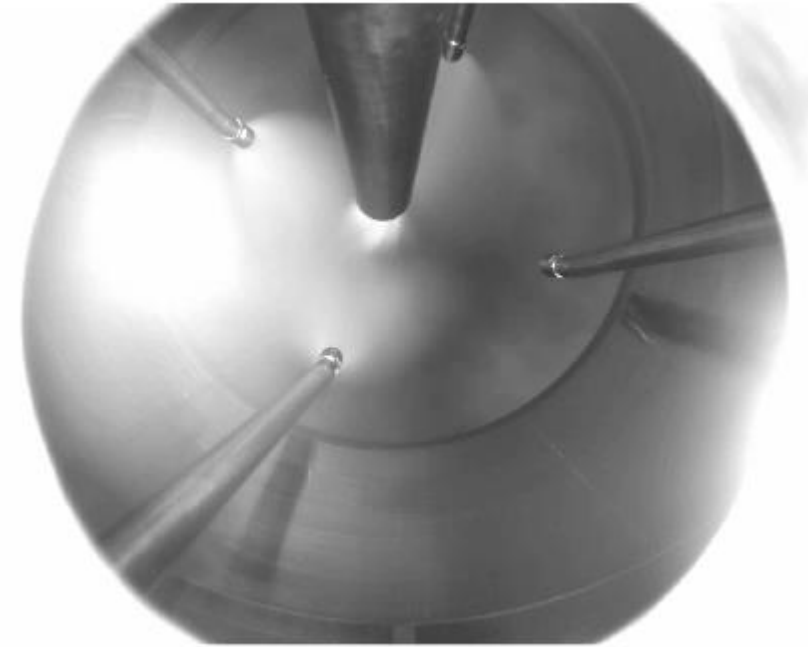
Differences between nozzles



Agglomeration

Agglomeration principles

- ▶ Agglomerates will form as a result of:
 - Collision between droplets
 - Collision between droplets and dry particles





Atomization

Adjustable swivel system

- ▶ Adjustable swivel system will manipulate the distance the of the nozzle tip to each other



Individual spray
No agglomeration



Inter spray mixing
Agglomeration

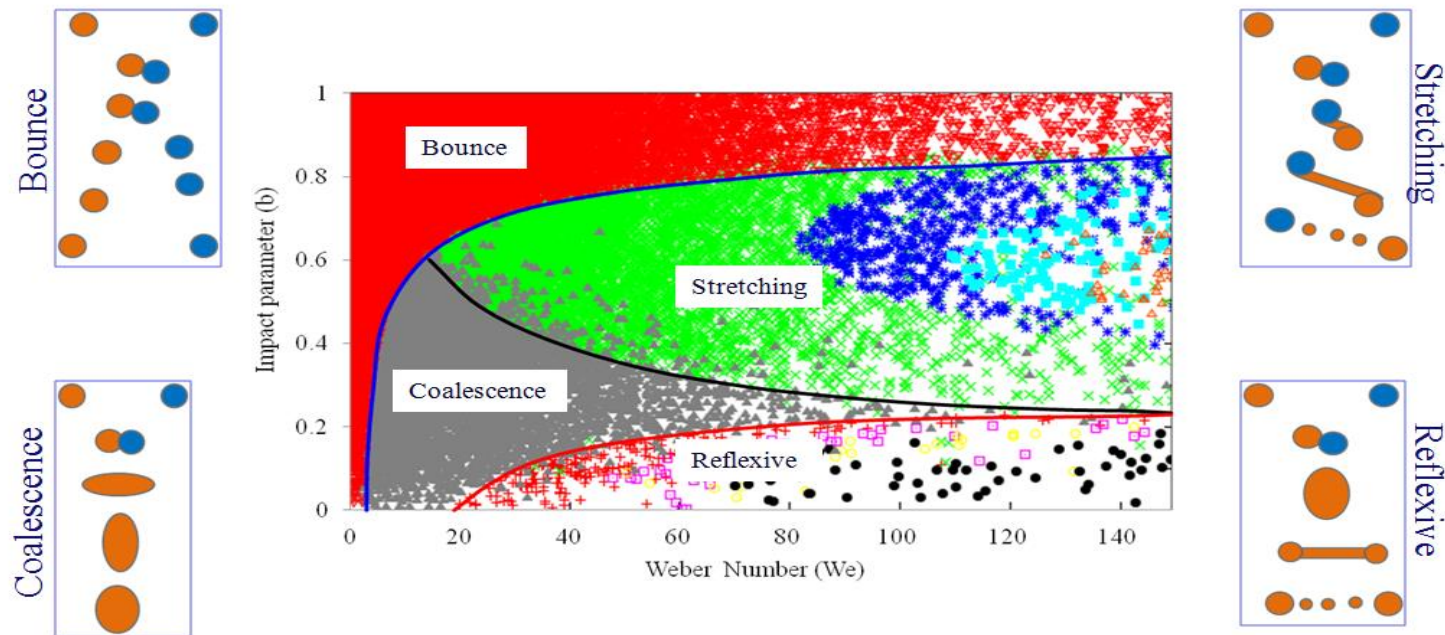


Lance on swivel
Swivel adjustment

Agglomeration

Agglomeration principles

Viscosity will have an impact on collision outcomes

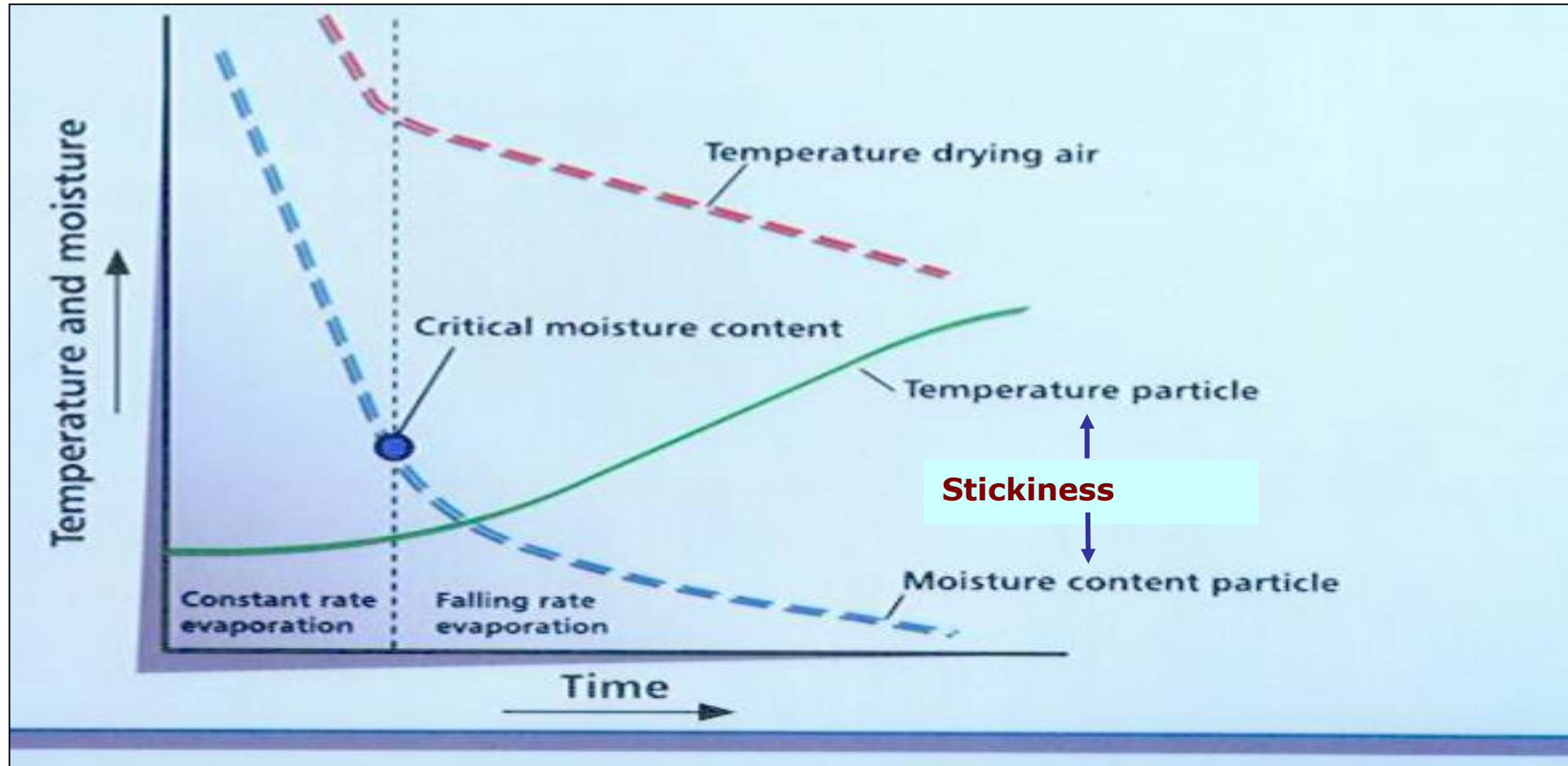


- Above example = water
- Viscosity changes regime bounds



Agglomeration

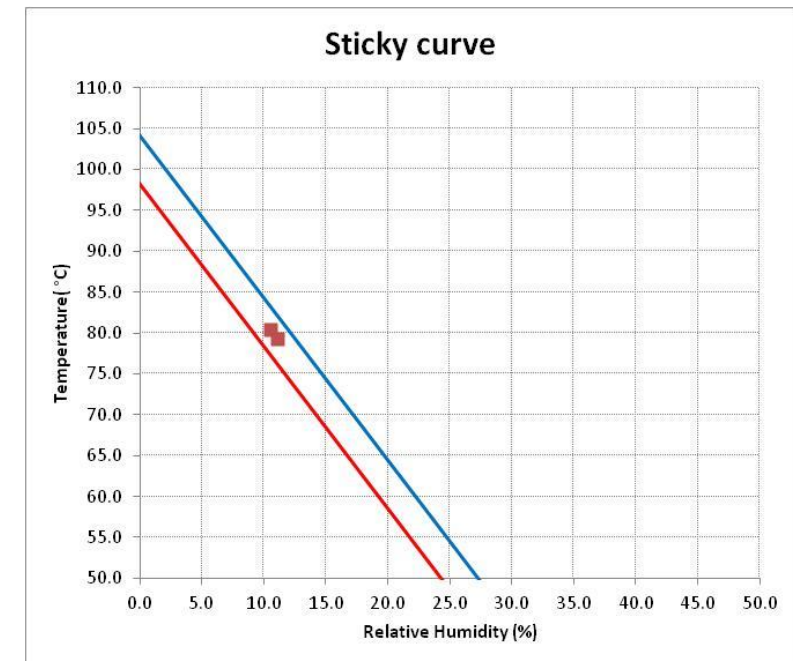
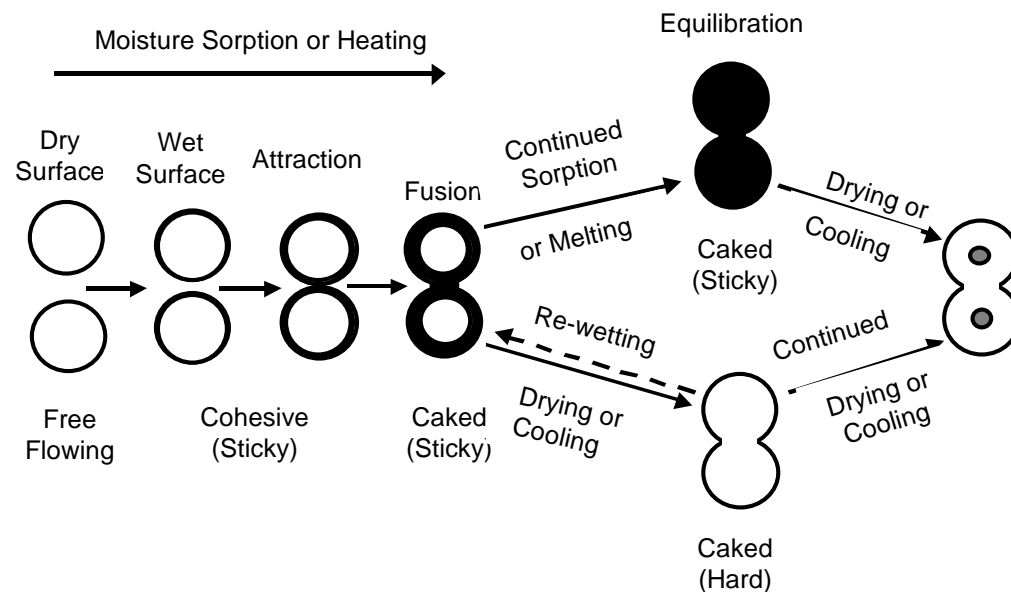
Particle history during drying



Agglomeration

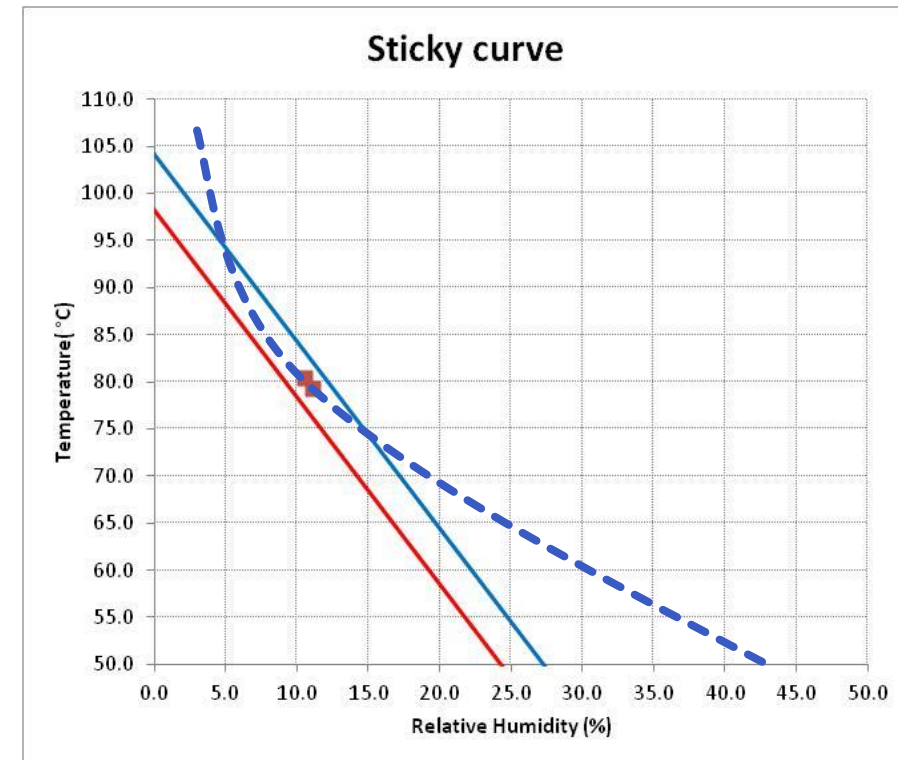
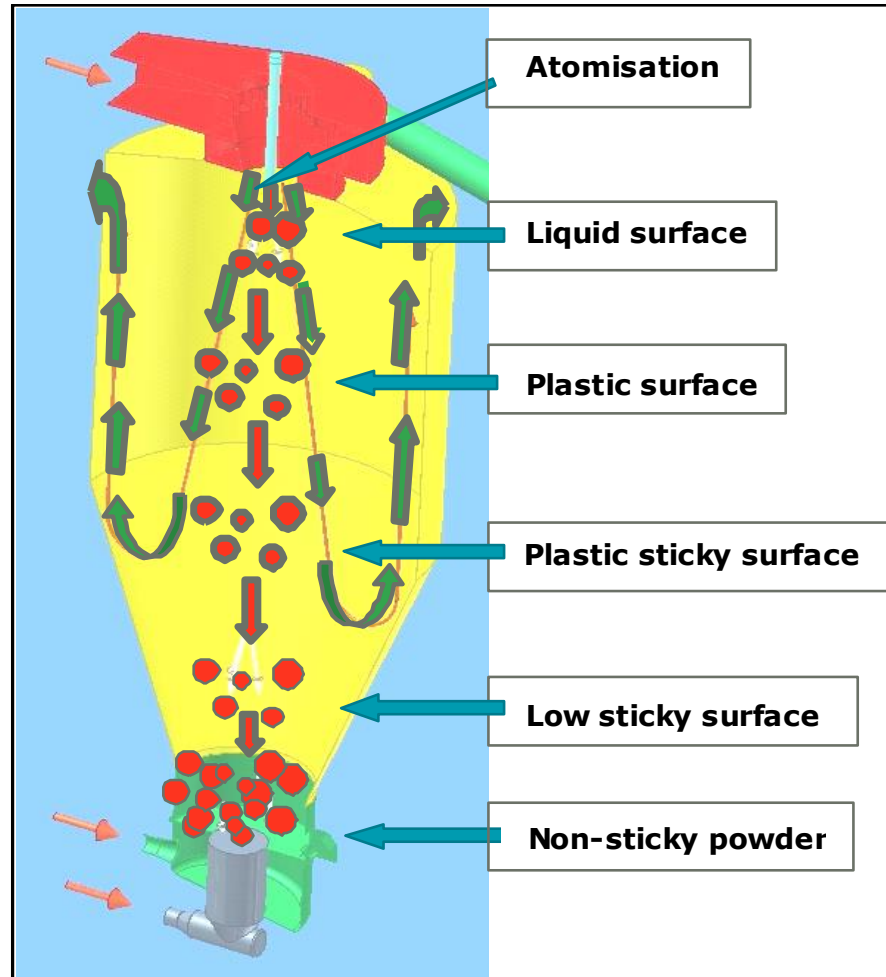
Importance of glass transition

- ▶ Glass transition is a phenomenon, of powders that at specific combinations of moisture and temperature, at the surface of the particles allows viscous flows during particle contact.



Agglomeration

Particle phases in a spray dryer



Agglomeration

Temperature Effects during Spray Drying

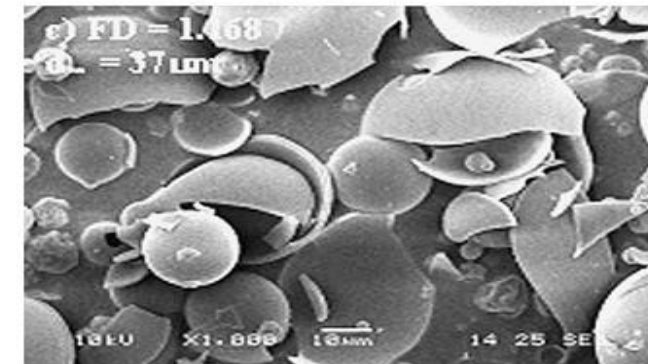
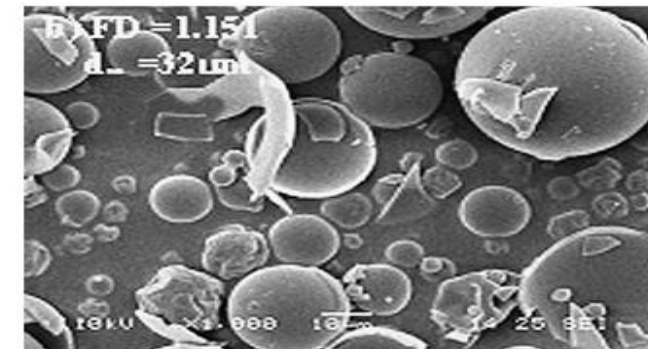
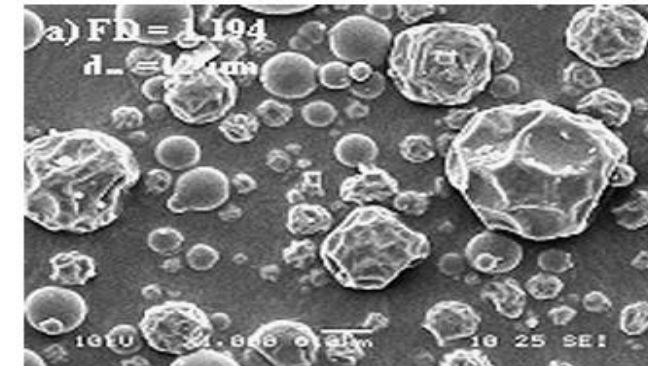
▶ Example, Drying of Malto Dextrin 20

▶ TS = 40%

▶ A: $T_{in} / T_{out} = 110/74^{\circ}\text{C}$

▶ B: $T_{in} / T_{out} = 170/145^{\circ}\text{C}$

▶ C: $T_{in} / T_{out} = 200/173^{\circ}\text{C}$





Relation between dryer, feed and powder properties

Processing parameters

Physical configuration of drier

- Configuration (e.g. co-current, 2-stage)
- Secondary feeds (e.g. fines return)
- Air pattern and mixing
- Atomizer type

Feed characteristics

- Chemical Composition
- Solids content
- Temperature
- Degree of homogenization
- Viscosity
- Foam-ability
- Pre-treatment
- pH

Operation conditions

- Feed rate
- Gas flow rate
- Gas composition
- Drying temperature

Primary powder properties

- Moisture content
- Particle Size distribution
- Particle density
- Particle morphology
- Color
- Component distribution
- Surface composition

Secondary powder properties

- Reconstitution properties
- Protein Stability
- Oxidative Stability
- Hygroscopicity
- Stickiness
- Flowability
- Dustiness
- Volatile retention
- (Surface) Free Fat



Q&A

