Particle Motion in the Wurster Coating Process

by Samira El Mafadi, ENITIAA, BP 82225, F-44322 Nantes cedex 3

Introduction

The Wurster system known as the bottom spray process is commonly used for coating of small particles in food and pharmaceutical industries for stability, taste masking or controlled release. The process is complex but its control is essential to insure a good coating quality. Our objective is to increase the understanding level of the process by determining the particle trajectories and residence times in different parts of the reactor.

Materials & Methods

Microcrystalline cellulose particles (Glatt Systemtechnik GmbH), with volume weighed average size of 1 mm and a density of 1350 kg · m^{-3} (Fig 1), are fluidized in the Uni Glatt pilot (Glatt GmbH, Binzen, D) with a cylindrical insert of 0.074 m diameter and 0.15 m height (Fig 2).

Fig 1: Micrograph of micro-crystalline cellulose particles

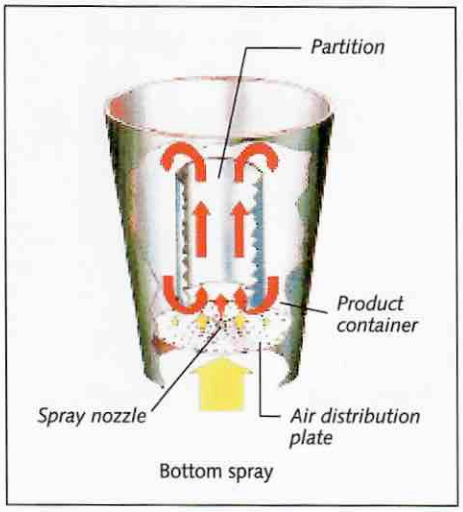

Fig 2: Scheme of the Wurster coating process

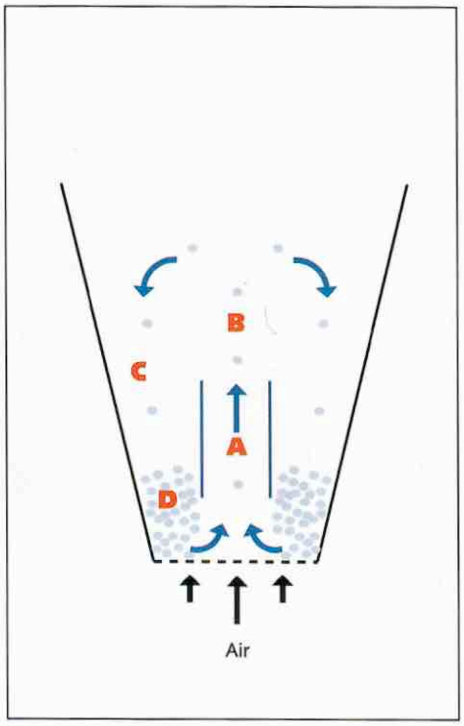

Fig 3: The 4-steps Wurster process

Observation of particle motions

The Wurster process can be divided in four regions (Fig 3)

- The upbed region (A): The approach air velocity is much greater than the particle terminal velocity. So, particles are transported vertically by pneumatic conveying with a very high porosity (of 0.9 in our case). In this region, particles are wetted by the sprayed coating liquid and they begin to dry before attending the second region.
- The deceleration region (B): Particles leave the upbed to enter in the expansion region, where they are in deceleration. They travel a certain distance upwards in a parabolic direction before they loose their momentum and start to fall down in the annulus. The particle's drying continues in this region.
- The downbed region (C): Particles flow downwards in the annulus in a plug flow manner before they re-enter the upbed region. In this region, particles must be completely dried to avoid the sticking of particles and their agglomeration.
- The compact bed region (D): It consists of an expanded bed where particles are moving slowly towards the upbed region.

Particle trajectories

Particles position (z) and particles velocity (U) are computed as functions of time from the equation of motion. Regions (A), (B) and (C) are characterized by a diluted transport (high porosity). It means that particles move in an isolated way so that the inter-particle forces are negligible.

$$\frac{dU}{dt} = -g + \frac{C_D \cdot \pi \cdot d_p^2 \cdot \rho_g}{8} \cdot (U_{air} - U)^2$$

C_D : Drag coefficient
d_p : Average diameter of particle (mm)
U : Particle velocity (m/s)
U_{air} : Air velocity (m/s)
t : Time (s)
ρ_g : Air density (kg/m^3)

In each region, the residence time is deducted from particles trajectory in the reactor (Fig 4). For the compact bed region (D), an important contact exists between particles (low porosity = 0.1) and the residence time ($t_{r(D)}$) is deducted from this equation:

$$t_{r(D)} = t_{cycle} - \sum t_{r(A,B,C)}$$

where $t_{cycle} = \dfrac{M_p}{Q_p}$

$t_{r(x)}$: Residence time in the region x (s)
t_{cycle} : Mean time of the whole cycle of particle (s)
M_p : Bed mass (kg)
Q_p : Particle circulation rate (kg/s)

Equations have been solved by Lagrange numerical method (Matlab) for several total air flows.

This table summarizes the 4 residence times which depend strongly on air flow.

Region	A	B	C	D
Tr (s)	0.62	0.52	1.48	5

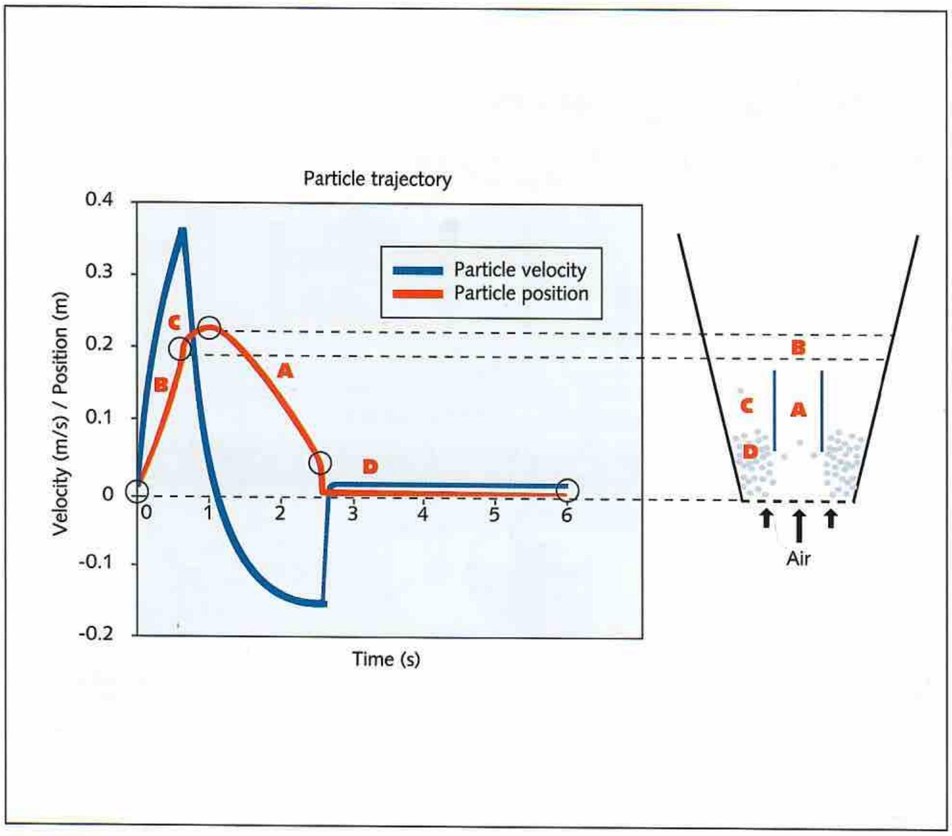

Fig 4: Particles trajectory in the Wurster process for total air flow of 115 $m^3 \cdot h^{-1}$

Conclusions

Using numerical method, the mean particles trajectory in the Wurster process can be predicted depending to the air fluidization velocity. It allows to calculate the residence time which can be controlled and optimized relating to the drying of droplets deposited on particles. We can conclude that:

- Particles spend little time in zones A,B and C, this time must be sufficient to dry the layer of deposited coating. If not, agglomeration of particles may occur in the zone D where there is a strong accumulation of the particles (an expanded bed).
- Particles remain longer in the zone D. This residence time depends strongly on the load of the particles and fluidization conditions. It has to be controlled in order to avoid an overheating for particles sensitive to high temperature.
- The knowledge of the residence times may help us to define the operational parameters necessary to lead to a uniform coating and low degradation of fragile materials to be coated.

Forthcoming Events

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