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Measurement of the particle movement in the fountain region of a Wurster type bed

Stina Karlsson [a], Ingela Niklasson Björn [b], Staffan Folestad [b], Anders Rasmuson [a,*]

[a] Department of Chemical and Biological Engineering, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden
[b] AstraZeneca Centre of Excellence for Process Analytical Technology, R and D Mölndal, SE-431 83 Mölndal, Sweden

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Abstract

A non-intrusive technique to follow single particles in the fountain region of a spouted bed with draft tube, the Wurster coater, is developed and tested. Compared to other techniques found in literature, the measurement technique presented here is easy to handle, inexpensive and suitable for particles with a diameter down to 500 μm. The measurements are performed in a laboratory scale Wurster bed constructed of Plexiglas to allow optical access to the flow. A small quantity of the particles in the bed are marked with fluorescence. A UV lamp is used to excite the fluorescence and the marked particles are followed with a high-speed video camera equipped with an optical filter. A single marked particle in the fountain can be followed in 5–30 images in sequence at a frame rate of 125 fps. The particle position and velocity are calculated. The distribution of the particle trajectories maximum height is studied for different particle loading, jet air velocity and position of the Wurster tube. The technique can be used for the characterization of differences in process dynamics due to different operating conditions.

Keywords: Single particle; Trajectory; Wurster; Tracking technique

1. Introduction

1.1. The Wurster process

The Wurster type bed [1] is frequently used for coating particles and pellets. In Teunou and Poncelet [2], a review of fluid bed coating is presented and the Wurster bed is described as the most efficient batch fluid bed coating equipment. Within the pharmaceutical industry, pellets and particles are coated to modify the release of an active substance. Particle coating can also improve appearance, mask taste and odour, and protect substances from oxygen and humidity and giving easier product handling. The Wurster bed is a combination of a spouted bed and a fluidized bed [3]. To support a more defined particle motion than the traditional spouted bed a tube is placed around the spout. The Wurster equipment consists of an expansion chamber, an annulus, a Wurster tube, a distributor plate and a spray nozzle located at the centre of the distribution plate. Christensen [4] describes the Wurster process and divides it into four regions according to particle motion: the up bed region, the deacceleration region, the down bed region and the horizontal transport region. A schematic diagram of the Wurster bed showing its components and the different regions is presented in Fig. 1.

The process can be described by following the cycle of a particle in the bed. In the Wurster tube, the particle accelerates and the droplets of coating liquid hit the particle surface and are spread out forming a liquid film. After leaving the Wurster tube, the particle enters the expansion chamber where it deaccelerates and falls down into the annulus. It is important that the surface of the particle is dry before entering the annulus with a high concentration of particles. If a wet particle enters, the dense region particle agglomeration may occur, which is undesirable in terms of coating quality. In the annulus, particles move towards the bottom and when the particle is level with the opening between the bottom plate and the Wurster tube it moves

* Corresponding author. Tel.: +46 31 772 29 36; fax: +46 31 814620.
E-mail address: rasmuson@chemeng.chalmers.se (A. Rasmuson).

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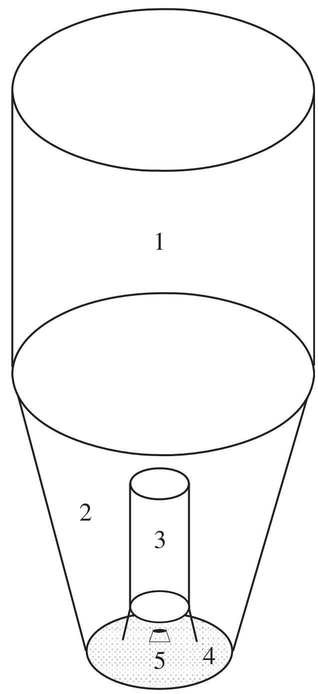

Fig. 1. Schematic drawing of the Wurster bed, (1) expansion chamber (deacceleration region; fountain region), (2) annulus (down bed region), (3) Wurster tube (up bed region), (4) distributor plate and (5) spray nozzle.

horizontally and will be drawn into the Wurster tube by the jet. This cycle is repeated until the intended amount of coating liquid has been sprayed onto the particle.

As described above, the process involves wetting and drying in combination with particle movement. These elements of the process are directly coupled and influence coating quality. A large number of operating and design variables affect coating quality; however, a theory of how combinations of these variables influence the process has not been fully developed. One way to obtain better knowledge of the process is to divide it into simplified systems describing part of the coating phenomena. These simplified systems can be used to understand separate mechanisms in the process that can be combined to describe the whole process.

Table 2
Dimensions of the bed (in mm)

Bottom diameter cone	Du	37.6
Top diameter cone	Do	94
Height cone	Hc	105.2
Height expansion chamber	He	320.5
Height Wurster tube	Hw	74
Diameter Wurster tube	Dw	19
Gap between Wurster tube and distributor plate	Hg	5–15

In Ström et al. [5], a new device for coating a single particle is presented. This device is a simplified system for studying the wetting and drying mechanism in the Wurster process. To couple the coating on a single particle level to the Wurster process, the trajectory for a single particle is essential. Particle velocity influences the mass and heat transfer conditions that control drying. Each time the particle passes the spray zone, the amount of droplets deposited on the particle increase; hence, the droplets deposited on the particle are directly coupled to particle motion.

In the study presented here, a technique for following a single particle trajectory in the regions with low particle concentration is described. To investigate the particle trajectory, a laboratory scale Wurster equipment in Plexiglas without spraying is used.

1.2. Measurement techniques for particle tracking

In literature, there are several techniques for measuring particle movement in systems similar to the Wurster bed. A summary of these techniques is given in Table 1.

In several studies, a magnetic particle is used [6–9]. The magnetic particle is placed in a spouted, or Wurster bed equipped with a coil around the spout to measure the circulation time in the bed. When the magnetic particle moves into the coil, an electromotive force (emf) is induced. The magnitude of the emf depends on particle velocity, coil diameter, number of coil turns and the magnetic strength of the particle. A major disadvantage of this technique is that the magnetic particle has to be relatively large to obtain an emf that can be separated from background electronic noise. Mann and Crosby[6] reports that the smallest

Table 1
Particle tracking methods

Method	Data	Measurement equipment	System	References
Magnetic particle	Circulation time	Coil, magnetic particle	Spouted bed, Wurster	[6–9]
Phosphorescent	Average velocity residence time	phosphorescence photo-multiplier light source	Circulating fluidized bed	[10,11]
γ-radiation RPT CARPT	Particle position	γ-radiated particle, scintillation detectors	Circulating fluidised bed polymerisations reactor multiphase reactor	[12,13]
Positron emission particle tracking, PEPT	Particle trajectory	Positron-emitted particle, positron camera	Gas fluidised bed	[14,15]
Cinematography	Local velocity average velocity	Colour particle video camera	Semicircular "spouted" bed	[16–19]
Fluorescent particles	Circulation time	Fluorescence	Wurster pneumatic transport	[20]