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Monitoring a lab-scale wurster type fluidized bed process by electrical capacitance tomography

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ABSTRACT

In this research, two types of electrical capacitance tomography (ECT) sensors, i.e. 12-4-8 combined electrodes and 8-8 dual planes sensors, were designed and used to monitor the gas-solids flow inside a Wurster type fluidized bed. For the 12-4-8 combined electrodes sensor, the measurement was conducted synchronously both inside and outside of the tube, i.e. coating zone and annulus zone, to achieve a fully understand the gas-solids flow characteristics in the bed. For the dual planes ECT sensor, the flow through the two cross-section areas inside the Wurster tube was measured and solids velocity was calculated based on cross-correlation method. A series of test were carried out by varying the operational parameters including the gap between the Wurster tube and air distributor, fluidization air velocity and materials loading. Different flow regimes as well as the flow stability were evaluated based on the ECT measurement results. To evaluate the flow characteristics inside the bed, power spectra density (PSD) and standard deviation (SD) were applied to investigate the fluctuation characteristics in the coating and annulus zones. Experiment results indicate that ECT technology is a powerful tool to monitor the Wurster type fluidized bed process and analysis the gas-solids flow characteristics inside the bed.

1. Introduction

Fluidized beds are widely used in pharmaceutical, chemical and food industries for particles coating, granulation and drying. In the coating process, particles are fluidized by hot air, while solution or solvent is sprayed into the same zone and contacted with the particles by dual-fluid nozzle. The particles are wetted by the solution or solvent droplets and dried by hot air for a certain time up to form a coating film on the particle's surface. The coating film helps to mask the taste of unpalatable substances and provide sustained or extended release. As a one-step process and enclosed operation, the process can be scale-up to industry scale with low cost. Depending on the desired products and the position of the spray nozzles, several types of technologies are used, including top-spray, bottom-spray and tangential spray [1]. Among them, the bottom-spray was firstly introduced by Wurster [2] and it is one type of fluidized bed with an internal vertical tube named Wurster tube above the air distributor. The air distributor blow Wurster tube was designed to control the airflow with a higher speed in the coating zone and a lower in the annulus zone, resulting in a pressure difference between the two regions. The pressure difference creates a pneumatic mass transport from the annulus zone to the coating zone through the gap between the Wurster tube and air distributor. According to the particles movement, the flow field inside the bed was divided into four different zones, namely coating, drying, annulus and transporting zone. In general, the bottom-spray is the best choice for particle coating as it can produce a superior film compared with other coating strategies [1,3].

In the fluidized bed coating process with Wurster tube, the quality of product is strongly depended on the operation parameters, i.e. fluidization air velocity, inlet air temperature, the gap height between the air distributor and tube, which should be carefully chosen to guarantee the end-point quality of product. Moreover, inappropriate setting of these parameters might lead to particle agglomeration and result in defluidization in the process. Therefore, it is necessary to monitor the complex gas-solids flows inside the bed. However, as a complicated structure, even without coating solution involved, the complex gas-solids flow behaviour is still difficult to monitor and predict [4]. The process is often operated based on "trial-and-error" method and the process is a black box [5]. Therefore, it is necessary to provide efficient measurement tools to investigate the complex flow behaviour inside the Wurster type fluidized bed and improve the process efficiency and product quality.

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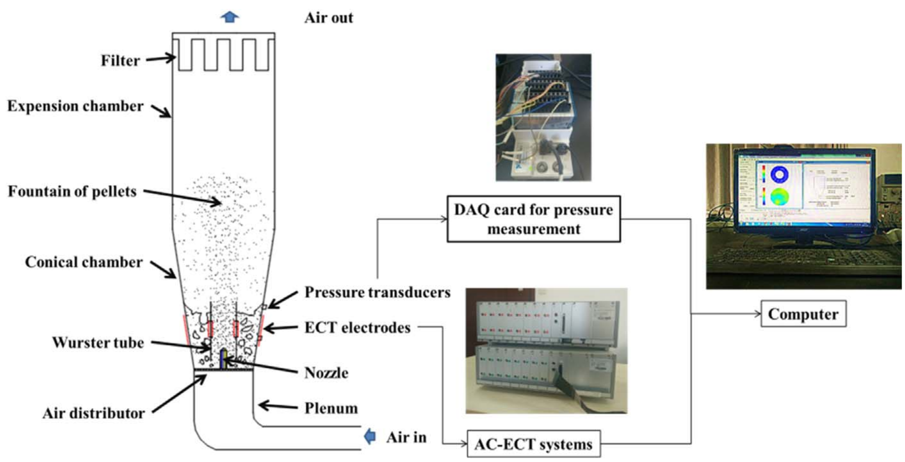

Fig. 1. Schematic of Wurster type fluidized bed and measurement instrumentations.

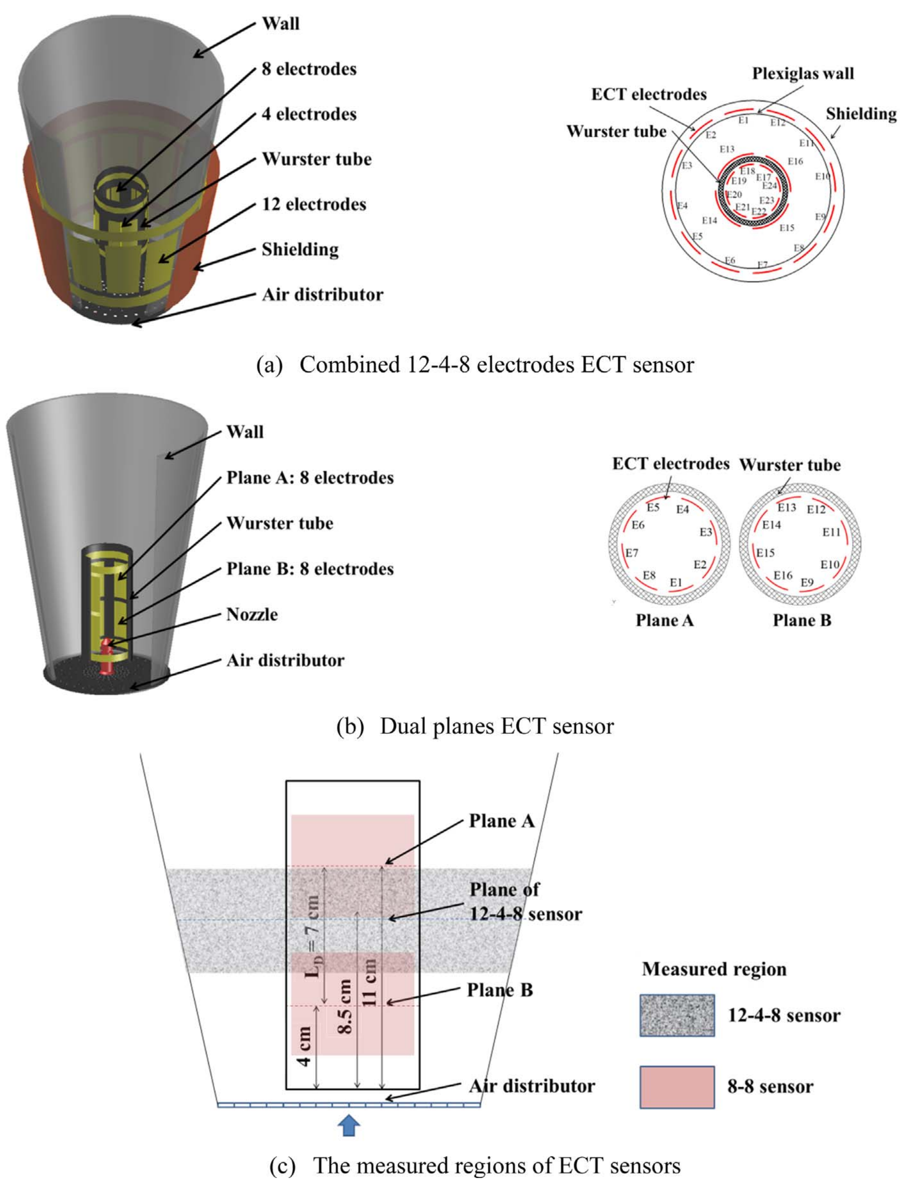

Fig. 2. Structure of ECT sensors.

Currently, two methods are commonly used to monitor the coating process, i.e. single point based measurement and tomography based measurement. In the single point measurement, pressure transducer or optical probes are used to investigate the solids concentration and fluctuations. The pressure signals carry the information such as turbulence intensity, particle movement and eruption of bubbles and such information can be retrieved by signal processing both in time domain and frequency domain analysis [6]. However, pressure signals can only