J Pharm Innov (2013) 8:99–110
DOI 10.1007/s12247-013-9152-3

RESEARCH ARTICLE

Improving Continuous Powder Blending Performance Using Projection to Latent Structures Regression

Yijie Gao · Fani Boukouvala · William Engisch · Wei Meng · Fernando J. Muzzio · Marianthi G. Ierapetritou

Published online: 16 April 2013

Abstract
Purpose There has been increasing interest in the last few years especially within the pharmaceutical industry towards continuous powder blending. In this paper, the effects of different design and operating parameters are investigated, which include blade speed, shaft angle, weir height, fill level, blade angle, and blade width.
Method The projection to latent structures regression is introduced to elucidate the significance of these factors on the two key indices of continuous blending performance, the local blending rate and the mean axial velocity.
Results Shaft angle and blade speed are the two most influential factors pointing to a blending improvement strategy. The proposed strategy is examined using an experimental setup for the production of pharmaceutical powder mixtures.

Keywords PLS · Continuous powder blending · DEM · Variance decay · Residence time

Introduction

Powder blending is crucial for the manufacturing of many industrial products including food, cement, catalysts, and pharmaceutical tablets. In the pharmaceutical industry, continuous powder blending has been the focus of research during the last 10 years due to the advantages of better control and of the lack of production scale-up when compared to the traditional batch mode. Past work in the area of continuous powder blending has pointed to two main blending influential factors [1], the axial blending factor and the cross-sectional blending factor. Studies have illustrated the effects of axial dispersion and the low-pass filter effect of the residence time distribution (RTD) in this blending component [1–4]: fluctuations from feeder could be attenuated by the RTD of the blender. As high-frequency fluctuations can be easier to be filtered out, the blender is considered as a low-pass filter in this axial blending factor. Boarder RTD leads to better filtering of these fluctuations. Due to recent developments in powder feeding systems, the variability of material flow has been significantly reduced, and this component is less important for the blending performance of pharmaceutical products [5]. The other factor, the cross-sectional blending, is one of the main challenges for solids systems. It describes segregation observed at the output of blending systems with ideal feeding conditions especially for cohesive cases [6]. A recent review by Pernenkil and Cooney [7] suggested a similar mechanism between this blending component and batch blending, where the overlay of a net axial flow converts an existing batch to a continuous system. This consideration was theoretically developed in a recent study about periodic section modeling [8]. This approach used the blending information in a batch-like periodic section and the residence time information of a corresponding continuous system to predict continuous blending performance. Two key blending parameters were extracted from this method: the variance decay rate in the periodic section and the mean axial powder velocity of continuous blending.

Besides the theoretical developments, a number of experimental studies on continuous blending have

Y. Gao · F. Boukouvala · W. Engisch · W. Meng · F. J. Muzzio · M. G. Ierapetritou (✉)
Department of Chemical and Biochemical Engineering, Rutgers, The State University of New Jersey, 98 Brett Road, Piscataway, NJ 08854, USA
e-mail: marianth@soemail.rutgers.edu