An Application of Deep Learning to Detect Process Upset during Pharmaceutical Manufacturing using Passive Acoustic Emissions

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Abstract

The multivariate nature of a fluidized bed system creates process complexity that increases the risk of production upset. This research explores the use of passive acoustic emissions monitoring paired with an artificial neural network to detect fluidized bed distributor plate blockage. In many cases, early process failure detection can allow for immediate intervention, thus lowering operation costs. Blockages were simulated by actively covering portions of a top-spray fluidized bed distributor plate. Piezoelectric microphones were placed within the fluidized bed exhaust and attached externally to the vessel wall. Several time and frequency domain feature vectors were extracted from the monitoring data using the open source pyAudioAnalysis library in Python. Through deep learning, the artificial neural network used these feature vectors to train against each distributor plate blockage condition. The deep learning model was then evaluated using k-fold cross validation. The findings were very positive and successfully demonstrated an application of deep learning to detect process upset.

Key words: Pharmaceutical manufacturing, process analytical technology, fluidized bed coating, distributor plate, passive acoustic emissions, deep learning, artificial neural network, signal analysis

1. Introduction

1.1 Fluidized Bed Blockage

Within a fluidized bed, air is introduced through a distributor plate located at the bottom of a conical chamber. The passing air is used to continuously mix and dry material that has been placed inside the chamber. Past studies have related distributor plate design to bubble size and radial gas distribution as an assessment of fluidization quality (Garncarek, et al., 1997; Paiva, et al., 2008)