PRESSURE AND X-RAY TOMOGRAPHY CHARACTERIZATION OF THE FLUIDIZATION BEHAVIOR OF TIO_2NANOPARTICLES

Jesús Gómez-Hernández , Carlos III University of Madrid; Avda. de la Universidad 30, Spain
jegomez@ing.uc3m
Evert Wagner, Robert F. Mudde, J. Ruud van Ommen, Delft University of Technology; The Netherlands

During recent years the fluidization of nanoparticles has been attracting the interest of the scientific community as the number of industrial applications has increased [1]. In these systems, the powder tends to agglomerate during the fluidization showing either bubble-less and smooth behavior for agglomerate particulate fluidization (APF), and bubbling behavior with little bed expansion for agglomerate bubbling fluidization (ABF) [2]. Regarding the ABF regime, relatively high gas velocities are required to fluidize these nanoparticles, which causes a large powder elutriation and the reduction of the fluidization quality. In this sense, it would be interesting to detect the changes in the fluidization behavior using an easy and reliable measurement technique. However, the literature commonly uses of the bed expansion ratio or the bed pressure drop [1], which are not able to detect maldistributions inside the fluidized bed.

Therefore, in this work is proposed the use of the pressure fluctuation signals as a tool to describe the state of a fluidized bed of nanoparticles. The differential pressure signals will be analyzed in the time and frequency domain following earlier work for micron-sized particles [3, 4]. TiO_2 nanoparticles (d_p= 21nm) were fluidized in a Perpex column of 5 cm inner diameter at different gas velocities. The particles were sieved with a 350μm mesh to remove the large agglomerates and dry nitrogen was used during all experiments.
To validate the pressure results, an X-ray tomography system is employed. This technique measures the attenuation of the X-rays through the fluidized bed, which is placed between the X-ray source and the detector. A square detector of 30 cm x 30 cm with a pixel resolution of 1524x1548 is employed. In this way, it is possible to obtain 2D pictures of the fluidization regime at a frame rate of 22 Hz (see Fig. 1). The results show that the main frequencies of the power spectrum are moved towards to higher frequencies as the gas velocity is increased (see Fig. 2). We will demonstrate that the pressure fluctuation data can indicate whether or not the nanoparticle bed is properly fluidized .

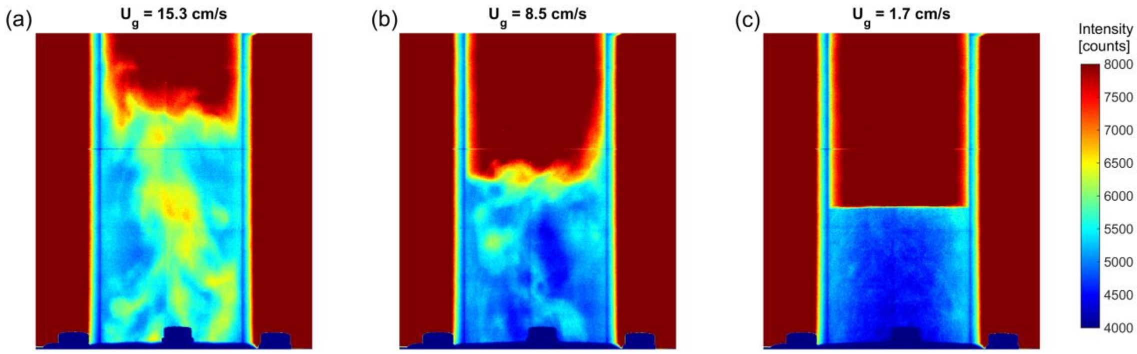

Figure 1. Snapshots obtained with the X-ray tomography system at different gas velocities. The color bar identifies the changes in density within the bed, showing cold colors for denser materials (dense phase) and hot colors for lighter materials (gas phase). The pictures clearly see the transition from high gas velocities, (a) and (b), to low gas velocity, (c) which is near the minimum fluidization velocity.

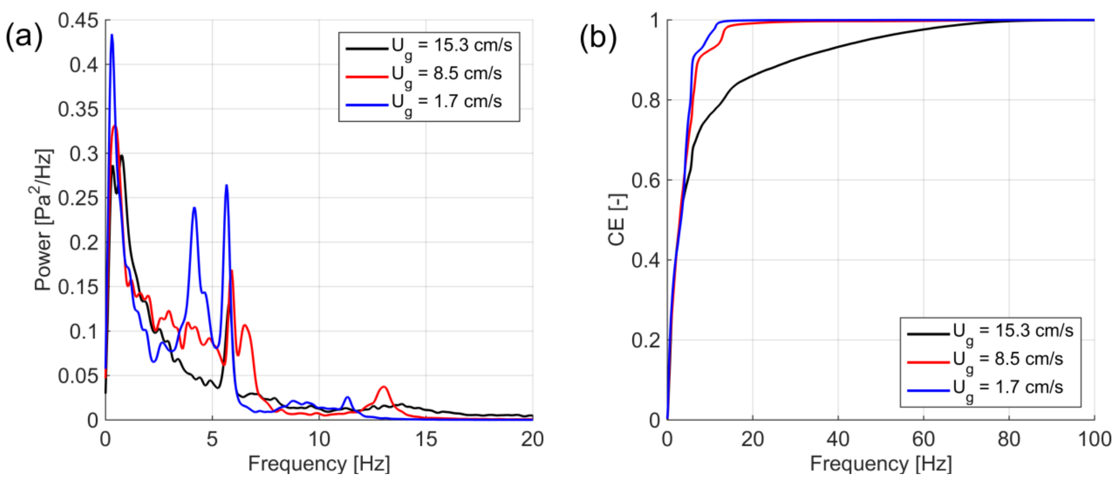

Figure 2.Frequency domain analysis of the differential pressure fluctuations measured in the plenum. The correspondence between X-ray pictures and pressure results is clear. The power spectrum of the pressure signals (a) shows the influence of the superficial gas velocity on the bed dynamics. Similarly, the cumulative energy of the power spectrum (b) is able to clearly differentiate the bed dynamics and shows that the frequencies of interest range from 0 to 20 Hz.

REFERENCES

1. van Ommen, J.R., J.M. Valverde, and R. Pfeffer, Fluidization of nanopowders: a review. J Nanopart Res, 2012. 14(3): p. 737.
2. Yao, W., et al., Fluidization and agglomerate structure of SiO_2 nanoparticles. Powder Technology, 2002. 124: p. 152-159.
3. Johnsson, F., B. Leckner, and C.M. Van den Bleek, Characterization of fluidization regimes by time-series analysis of pressure fluctuations. International Journal of Multiphase Flow, 2000. 26(4): p. 663-715.
4. van Ommen, J.R., et al., Time-series analysis of pressure fluctuations in gas-solid fluidized beds - A review. International Journal of Multiphase Flow, 2010. 37(5): p. 403-428.