Hydrodynamics Study of a Group of A/B Particles in the Presence of an Acoustic Field

Akash Langde

Department of Mechanical Engineering, Anjuman College of Engg. and Technology, Nagpur, 440025

D. J. Tidke

Department of Mechanical Engineering, Acharya Vinoba Bhave Institute of Technology, Wardha (MH), India, 442001

Ram L. Sonolikar

Department of Chemical Engineering, Laxminarayan Institute of Technology, Nagpur (MH), India, 440033

(Submitted 24 May 2010; provisionally accepted 5 August 2010; accepted 13 September 2010)

The difficulty of putting fine powders in suspension in a fluidized bed is due to cohesiveness and physical forces of attraction among the particles. But the fluidization of a group of A/B particles is not difficult. It fluidized very easily. Motivation of this topic occurred from literature survey in which it was found that study was done for all types of fine powder except for the group A/B boundary particles. In this research work an attempt has been made to improve the flowability of this type of particles through acoustic energy excitation. Beside this, the effect of an acoustic field on the minimum fluidization velocity (U_{mf}) has been determined by varying the frequency and sound pressure level. The micro-fumed silica powder ($d_p = 112$ µm) was used as the fluidizing material. The value of U_{mfs} at 145 dB was found to be 0.44 cm/s, which was much less than U_{mfo} at without sound intensity, that is, 1.1 cm/s for L/D = 0.58. It was also seen that bed expansion (H) was improved with bubble-free fluidization compared to an absence of the acoustic field. An attempt has been made to train the Artificial Neural Network (ANN) with fluidization data using MATLAB software.

LIST OF SYMBOLS

f	frequency of sound(Hz)
H	static bed height (cm)
L	static bed height
D	diameter of fluidized column
ΔP	pressure drop across the bed (cm of water)
Pressure Drop	cm of water
U_{mfs}	minimum fluidization velocity with sound (cm/s)
U_{mfs}, U_{mfo}	minimum fluidization velocity without sound (cm/s)
U_o	superficial gas velocity (cm/s)
W	bed particle loading (kg)
U_{mbs}	minimum bubbling velocity with sound (cm/s)
L/D	aspect ratio

1. INTRODUCTION

In the past, fluidization has progressed through systematic research with various specialized functions such as combustion, chemical reaction, heat and mass transfer, coating, granulation processes, and so on. This research development persuaded the researchers to become interested in the use of fine powders, that is, micronic and nanometric powders. However, fluidization of fine powders is difficult to achieve since they have poor flow characteristics and have very small, loosely packed, bulk densities. Moreover, gas channels and stagnant zones are formed in the bed, which results in restricted particle motion. Once the channels have been created, they tend to enlarge with further increase in gas velocity. The use of additional forces to improve fluidization of fine powders has been attracting more attention in recent years.

Different methods to achieve homogeneous fluidization are vertical vibration by means of mechanical devices;[1,2] fluidization in a stirred vibrating fluidized bed;[3] the effect of agitation on fluidization characteristics of fine particles;[4] pulsating magnetization of magnetizable and non-magnetizable powders;[5,6] and acoustic field concurrent to fluidizing gas.[7–9] The acoustic field on the fluidization of fine powder showed the good effect with homogeneous fluidization, particularly because it is easy to operate and consumes little power.

Morse, who pioneered this work, attempted sonic energy on the fluidized bed from the bottom and noticed that, improved in quality of fluidization at low acoustic frequency.[7] Nowak reported data on the effect of a sound wave on minimum fluidization velocity, bed expansion, and heat transfer rate in a fluidized bed.[8] Chirone et al[10–13] completed extensive work in which they formulated a cluster sub cluster oscillator model. In addition, data were published on the variation of frequency to determine the minimum fluidization velocity and bed expansion. The experiments were performed at 120 Hz with the