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Fluidization of Fine particles : Acoustics Field Approach

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ABSTRACT

Fluidization technology has been a very important process in chemical, environmental, and energy industries. Fluid dynamic characteristics in a fluidized bed has a direct binding on solid mixing and heat and mass transfers between gas and solid phases. Suspensions of fine particles in either Newtonian or non-Newtonian fluids finds its presence in physical, engineering and biological sciences. Reinforced composites, paints, paper, slurries, cements etc which are particle laden products need the processing of fine particles. Forces like the Van Der Waals force capillary and cohesive forces leads to aggregate formation in liquids which prevents the fine particles from suspending properly. Way out from this problem is to use forces like magnetic field, electrical field, acoustic field and mechanical. This process is termed as homogeneous fluidization. In this work we try to explore the effects of acoustic field in homogenous fluidization document.

Keywords: Newtonian or non-Newtonian fluids, Van Der Waals force, acoustic field, homogeneous fluidization

I. INTRODUCTION

Over the years many approaches have been followed to improve the fluidization behavior of particles, such as , adding another kind of particle to the bed and introducing a magnetic field, acoustic field, or vibrating field. Sound based fluidization turns out to be quite productive as no internals are needed and there is no limitation in terms of particle type. The application of an acoustic field can improve the fluidization quality of fine powders. Morse(2) investigated the fluidization behaviors of fine particles in an acoustic field and found that channeling and slugging in fine-particle fluidization can be suppressed significantly in the sound frequency range of 50-400 Hz and at sound pressure levels higher than 110 dB. At the natural frequency of a bed of micron-sized particles, high intensity sound waves lead to reductions in both the minimum bubbling velocity and the minimum fluidization velocity.3,4 The results of Chirone et al.5 showed that a high-intensity sound can significantly suppress the elutriation of fine particles. Zhu et al.6 found that, for a given sound pressure level and bed weight, the minimum fluidization velocity was significantly reduced and elutriation of nano particles agglomerates was much weakened. An acoustic fluidized bed with nano particles as the bed material was employed by Guo et al.,7-11 who found that increasing sound pressure levels result in a decrease in minimum fluidization velocity and an increase in bubble frequency. In addition, Xu et al.12 reported the influence of sound waves on fluidization of fluid catalytic cracking particles. Their observations showed that the fluidization quality of Geldart A particles Recent interest in processing of fine particles raises the practical question of the fluidizability of non-fluent solids. For number of applications, particularly in ceramic processing, it is often de sired to obtain powder flowability without agglomerates. However, fluidization of very fine, cohesive powders (less than 75 mm) is difficult to fluidize, since they have very poor flow character is tics. Moreover, gas channels and stagnant zones are formed in the bed resulting in restricted particle motion. Once the channels have been created, they tend to enlarge with further increase in gas velocity. In recent years, the use of other extern al forces such as mechanical vibration, stir ring elements, etc. has been tested to improve the quality of fluidization of cohesive powders. However; the basic focus has been directed towards vibrated bed. The layout of the paper is as below

Section II discusses the literature review ,Section III discusses the proposed methodology followed by the conclusion in section IV.

II. LITERATURE REVIEW

The work was started by Morse(1) to improve the quality of fluidization with the help of acoustic field. It was seen that, low-frequency, high-intensity sound above 110dB could improve the fluidization of fine particles2 used sound intensity to speed up the fluidization for various materials ranging from 7μm to 97μm. A loudspeaker was located above and at the bottom of the bed. Fluidization of fine particle in presence of sound intensity was also studied in 2-D column. Chirone3 studied the effect of acoustic field on five cohesive solids, ranging from 0.3 to 11μm up to SPL of 150dB. Sound-assisted aeration gives rise to bubble free fluidization. Afterward, Leu and Haung4 presented a theoretical model of transition from Geldart group C to A powders. The interparticle forces and the group C/A boundary of lower density powders were estimated. The behavior of eight types of Geldart C particles was studied in the sound wave vibrated fluidized beds. Russo et al.5 studied the influence of frequency by using nonfluent 0.5-45μm catalyst particle with a 145mm ID column. A loudspeaker generated acoustic field varying from 110 to 140dB and frequency from 30 to 1000Hz has been used with different L/D ratio. Levy et al.6 studied the effect of acoustic field on very fine particles in the Geldart group C range. It was seen that, the homogeneous fluidization and bed expansion observed was occurred in presence of acoustic field due to external force on the bed particles. Guo et al.7 investigated the fluidization behaviors of ultrafine particles in an acoustic fluidized bed with one type of micron particles and two types of nanoparticles (dp = 500nm – 10.69μm). It was stated that, with the assistance of sound wave with low sound frequency and high sound pressure level, the micron and nanoparticles can be fluidized smoothly with fluidization behaviors similar to those of Geldart group A particles. Also, Roy and Kytomaa8,9 published the model on speed of sound in fine powder. Guo et al.10 studied the fluidization behavior of three types of SiO2 ultrafine particles (dp = 5-500nm) in a fluidized bed with sound excitation. It has been shown that agglomerate size tends to reduce with an increase in sound pressure level. Recently, Langde et.al11 worked on two different particles, 112 μm micro fumed silica and 180 μm glass bead powders, and reported that these two particle types gave good quality of fluidization in presence of acoustic field when compared with the performance without any sound field.

III. PROPOSED METHODOLOGY

For our study we have use micro material such as marble and silica sand for our study. The core area of the work revolves around the pressure drop and minimum fluidization velocity. To achieve this we have developed an experimental setup which consist of an oscilloscope, signal generator ,microphone , ,speakers and rotameter.

The experimental set up is shown in figure 1. It consists of cylindrical fluidization column and sound generation system. A porous distributor was located at the bottom of the column. Experiments will perform with air at atmospheric pressure and room temperature. The air flow rate will measured by using rotameter. A digital signal generator was used to obtain different wave of specified frequency. The signal was amplified by means of a power audio amplifier and sent to a speaker. The speaker was placed at the top of the column.

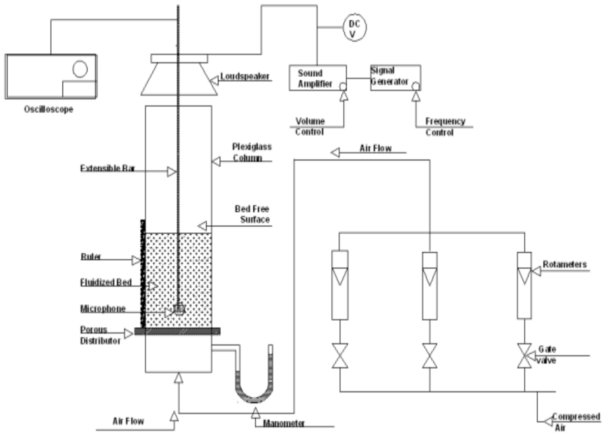

Figure 1. The Experimental setup

IV. CONCLUSION

On the basis of the work carried out we have the following conclusions

1. Fluidization of binary mixture:

Experiments were conducted by increasing and decreasing gas velocity by measuring pressure drop. It was observed that, marble powder was unable to fluidize even with presence of high sound intensity. It gets fluidize at high gas velocity with addition of promoters. For first combination, i.e. 25% of mass fraction of total bed mass gave some channeling but at 50% of mass fraction, channeling were disappeared and bubbling took place in absence of sound pressure level. It was noted that, minimum fluidization velocity decreases with increase in mass fraction and pressure drop increases, in absence of sound intensity.

2. Effect of sound pressure level on minimum fluidization velocity:

Minimum fluidization velocity decreases as sound intensity increases upto 145dB. The results were quite different compared to sound intensity used in mono group powder .

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