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# JETTING VISUALIZATION IN AN ACOUSTIC FLUIDIZED BED USING X-RAY COMPUTED TOMOGRAPHY

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**Research Program: Experimental Multiphase Flow.**

## Introduction

Understanding the jetting phenomena near the gas distributor plate in a fluidized bed is important to gas-solids mixing, heat and mass transfer, and erosion on any bed internals, which can all affect the performance of the bed. Moreover, acoustic vibration in a fluidized bed can be used to enhance the fluidization quality of particulate matter. Visualizing the jetting structure using X-ray computed tomography in a 3D fluidized bed, with and without acoustic intervention, is completed in this study. A 10.2 cm ID fluidized bed filled with glass beads, with material density of 2500 kg/m$^3$ and particles sizes ranging between 212-600 μm, is used in these experiments. X-ray computed tomography (CT) imaging is used to determine local time-average gas holdup. From this information, qualitative characteristics of the hydrodynamic structure of the multiphase flow system are visualized.

Jetting has been studied extensively in the gas-solid fluidized bed literature [1-3]. However, most of the studies focused on jetting produced by using a central vertical nozzle or focused on jetting produced by a horizontal nozzle penetrating a lightly fluidized bed.

Sound assisted fluidized beds have been studied in the literature because it has been shown that the inclusion of sound vibrations can help overcome fluidization problems in certain material types. Different behaviors under sound vibrations have been observed [4, 5].

Noninvasive techniques have also been used to investigate the effects of acoustic waves on the void fraction distribution in fluidized beds. Escudero and Heindel [6] used X-ray computed tomography imaging to characterize the gas distribution in an acoustic gas-solid fluidized bed.

The goal of this study is to visualize the jetting phenomena created by the distributor plate of an acoustic fluidized bed using images obtained from X-ray computed tomography.

## Experimental Setup

The material used in these experiments is glass beads ($\rho_{glass}$ = 2500 kg/m$^3$), with particles sizes that range from 212 – 600 µm. The material is sifted several times using a mechanical shaker and sieves with different mesh sizes, to assure the material falls in the desired particle size range. The bed bulk density was determined using the material mass and the static bed volume.

X-ray computed tomography (CT) scans are captured with and without acoustic intervention at different H/D ratios (0.5, 1, 1.5) and different superficial gas velocities $U_g$ = 1.5 $U_{mf}$ and 3 $U_{mf}$, where $U_{mf}$ is the minimum fluidization velocity previously determined [5]. The minimum fluidization velocity differs between the acoustic and the no acoustic fluidized bed. Table 1 summarizes the general bed characteristics.

**TABLE 1: SUMMARY OF MATERIAL PROPERTIES.**

| Glass Beads | | | |
|---|---|---|---|
| **H/D** | **0.5** | **1** | **1.5** |
| **Bed Mass (g)** | 620 | 1240 | 1860 |
| **Bulk density (kg/m$^3$)** | 1505 | 1505 | 1505 |
| **Diameter (µm)** | 212-425, 425-500, 500-600 | | |
| **Particle Density (kg/m$^3$)** | 2500 | | |
| **$U_{mf}$ no acoustic bed (cm/s)** | 8.8,11,15 | | |
| **$U_{mf}$ acoustic bed (cm/s)** | | | |
| **212-425 µm** | 8..1 | 8 | 8.3 |
| **425-500 µm** | 9.1 | 8.8 | 8.5 |
| **500-600 µm** | 11.5 | 10.1 | 10.3 |

To calculate the local time-average gas holdup information, data obtained from the CT reconstruction volume files are used. Gas holdup is the volumetric gas fraction present in the gas-solid fluidized bed, and is useful to characterize the hydrodynamic behavior of the multiphase flow system. The gas holdup data obtained are used to analyze the jetting phenomena that occur near the distributor plate with and without acoustic intervention.

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## Results and Discussion

Figures 1 and 2 show the 3D representation of the jets for 500-600 µm glass beads. As Figure 1 shows, when the fluidized bed has acoustic intervention, the length of the jets appear to be longer than the same jets shown in Figure 2 without acoustic intervention, particularly the jets that are located near the walls of the fluidized bed. Moreover, Figure 2 shows more jet-jet interactions, where jet merging is more prevalent.

These images show than for the acoustic case, there are less active jets present in the fluidized bed, some of the holes from the distributor show little jet formation compared to the same holes in the no acoustic case, this difference is attributed to the different superficial gas velocity that is applied to the fluidized bed.

## Conclusions

Local time-average gas holdup images of the fluidized bed under acoustic intervention at a high superficial gas velocity show that jets produced near the aeration plate are larger and merge with other jets at a higher axial position of the bed compared to the no acoustic condition.

Acoustic fluidized beds also have a fewer number of active jets than the no acoustic fluidized bed, which allowed for a more homogeneous gas holdup region deep into the bed.

## References


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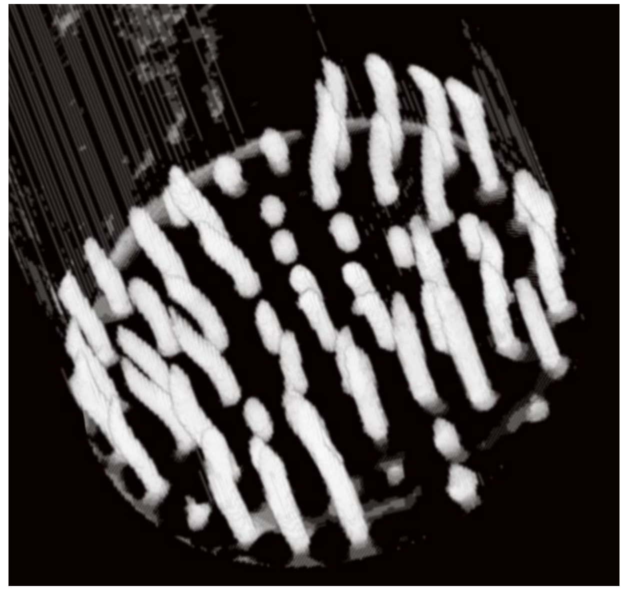

**Fig. 1:** 3D Image of the jets for a fluidized bed of 500-600 µm glass beads at a $U_g = 3U_{mf}$ with acoustic intervention.

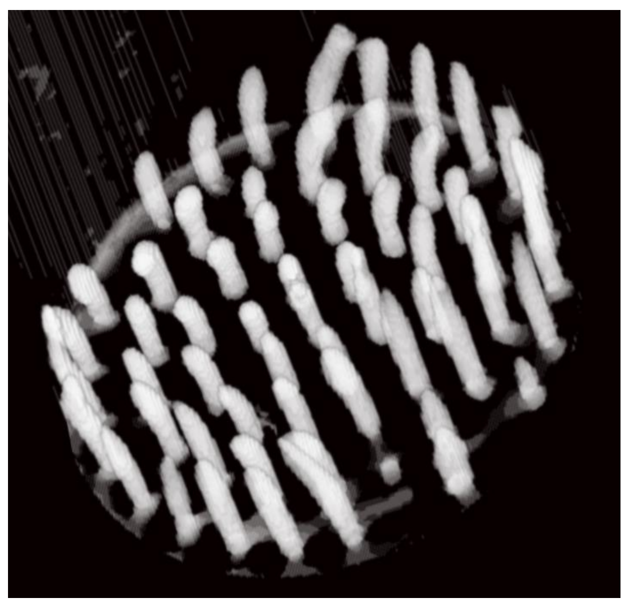

**Fig. 2:** 3D Image of the jets for a fluidized bed of 500-600 µm glass beads at a $U_g = 3U_{mf}$ without acoustic intervention.

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