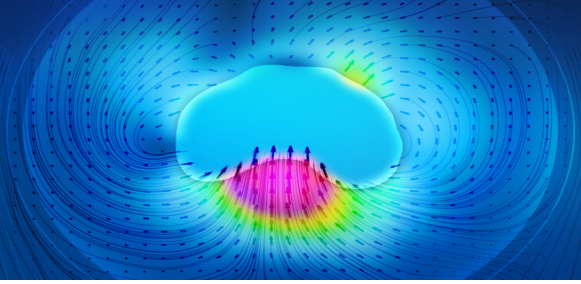
TUHH Hamburg University of Technology

Institute of Process Imaging



08.01.2025

Project work / Bachelor's thesis / Master's thesis

Dynamically structured bubbling in gas-solid vibrated fluidized beds

Motivation:

Gas-solid fluidized beds are widely utilized in various process engineering applications, including chemical reactions, mixing, drying, energy conversion, and material processing due to enhanced gas-solid contact. Vibrated fluidized beds, where mechanical vibration is applied either horizontally or vertically, can further improve the performance of fluidized beds. Previous studies have demonstrated that mechanical vibration reduces the minimum fluidization velocity and minimum bubbling velocity [1], prevents agglomeration and channeling in Geldart Group A and C type particles while initiating fluidization [2], and enhances heat transfer during drying process [3]. Additionally, mechanical vibration induces complex phenomena within fluidized beds such as dynamically structured bubbling.

Fluidized beds are inherently chaotic, with bubbles forming in varying sizes and shapes. Normally chaotic motion of bubbles in fluidized beds could be turned into a more structured, predictable pattern via mechanical vibration, oscillating gas flow and internals (Fig. 1a) [4]. In structured bubbling , the bubbles become smaller, distributing more uniformly throughout the bed and following a specific arrangement (Fig. 1b). This phenomenon offers uniform mixing and improves the predictability of the operation and would ease scale-up processes [5].

Tasks:

- Literature review on structured bubbling in granular media.
- Investigation of dynamically structured bubbling in a mechanically vibrated pseudo-two-dimensional and three-dimensional gas-solid fluidized beds.
- Investigation of the impact of particle properties and gas distributors.
- Investigation of bed hydrodynamics with real-time Magnetic Resonance Imaging for three-dimensional beds and and high-speed camera for pseudo-two-dimensional bed.
- Performing digital image analysis with Python.

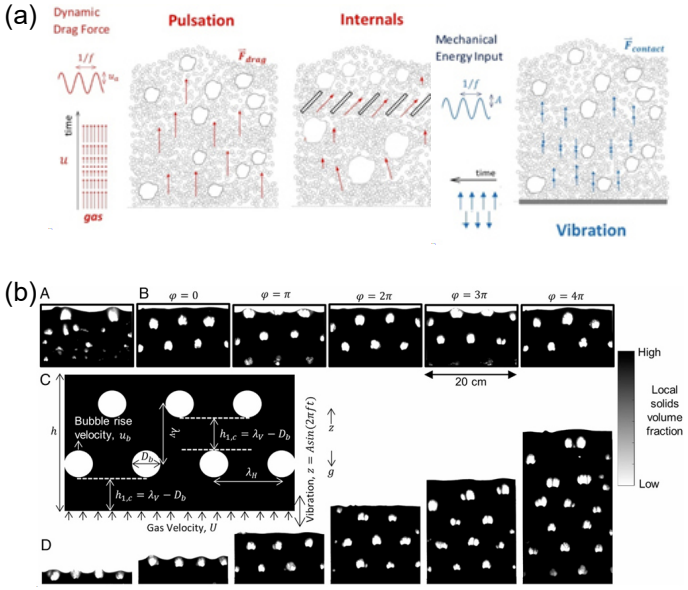


Figure 1: (a) Methods for achieving structured bubbling in gas-solid fluidized beds. [4] (b) Dynamically structured bubbling induced by mechanical vibration. Figure A illustrates bubbling without vibration, while Figure B demonstrates bubbles rising in a regularly spaced triangular arrangement without coalescing or splitting under vibration. This arrangement repeats itself every two vibration cycles. Figure C shows the key parameters for image analysis, and Figure D shows that the structuring persists as the bed height increases until a critical height. [5]

Your profile:

Ideally, experimental work experience, basic knowledge of image processing and programming with Python.

Starting date: February 2025

Contact person: Melis Özdemir, melis.oezdemir@tuhh.de, Tel: +49 40 42878 3124, Building L, Room 3.014

Other projects involving vibrated fluidized beds are available for Master's theses, Bachelor's theses, and project work. Feel free to contact for further information.

[1] McLaren, C. P.; Metzger, J. P.; Boyce, C. M.; Müller, C. R. Reduction in Minimum Fluidization Velocity and Minimum Bubbling Velocity in Gas-Solid Fluidized Beds Due to Vibration. Powder Technology 2021, 382, 566–572. https://doi.org/10.1016/j.powtec.2021.01.023. [2] Xu, C.; Zhu, J. Experimental and Theoretical Study on the Agglomeration Arising from Fluidization of Cohesive Particles—Effects of Mechanical Vibration. Chemical Engineering Science 2005, 60 (23), 6529–6541. https://doi.org/10.1016/j.ces.2005.05.062. [3] Guo, Q.; Spitler, C.; Sanghishetty, J. M.; Boyce, C. M. Advances in Vibrated Gas-Fluidized Beds. Current Opinion in Chemical Engineering 2023, 42, 100977. https://doi.org/10.1016/j.coche.2023.100977. [4] Francia, V.; Wu, K.; Coppens, M.-O. Dynamically Structured Fluidization: Oscillating the Gas Flow and Other Opportunities to Intensify Gas-Solid Fluidized Bed Operation. Chemical Engineering and Processing - Process Intensification 2021, 159, 108143. https://doi.org/10.1016/j.cep.2020.108143. [5] Guo, Q.; Zhang, Y.; Padash, A.; Xi, K.; Kovar, T. M.; Boyce, C. M. Dynamically Structured Bubbling in Vibrated Gas-Fluidized Granular Materials. Proc. Natl. Acad. Sci. U.S.A. 2021, 118 (35), e2108647118. https://doi.org/10.1073/pnas.2108647118.

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