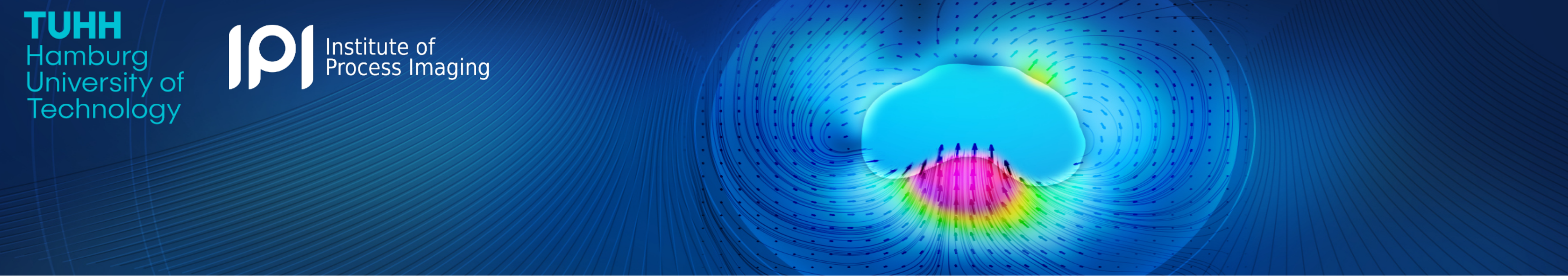


27.02.2025

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

Investigation of bubble properties in vibrated gas-solid pseudo-two-dimensional and three-dimensional fluidized beds

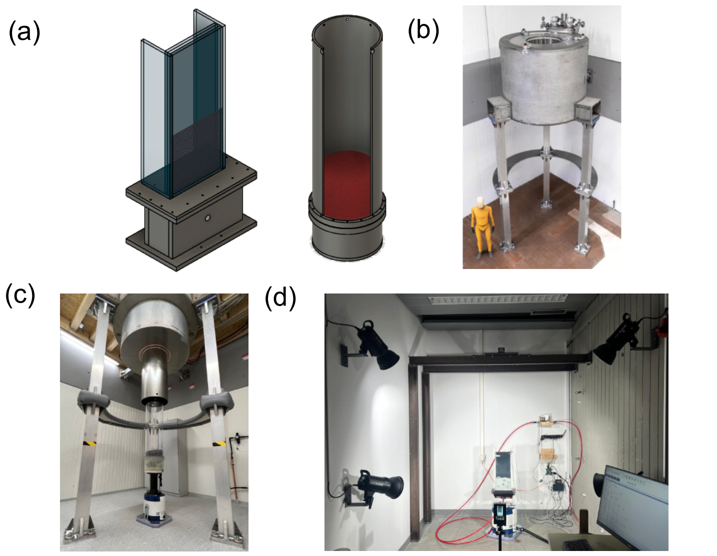
Gas-solid fluidized beds are widely used in various process engineering applications, including pharmaceutical and food production, mixing, and drying. Fluidized beds offer high solid-gas contact, which enhances heat and mass transfer rates. Mechanical vibration can further improve their performance by preventing particle agglomeration and channeling, facilitating fluidization in systems with high cohesive forces [1], and enhancing heat transfer during the drying process, making them a favorable choice in many applications [2]. Studying the hydrodynamics of three-dimensional (3D) fluidized beds is challenging due to their opaque nature. Conventionally, intrusive probes such as pressure and capacitance sensors are used to measure hydrodynamics in 3D beds [3-4]. These measurement techniques provide data on solid concentration, particle velocity, and bubble properties. However, a major drawback of intrusive probes is that they only provide information from specific locations within the bed and can alter the flow. In pseudo-two-dimensional (pseudo-2D) systems - thin, transparent fluidized beds that allow visualization of particle behavior in a quasi-two-dimensional plane while minimizing the influence of the third dimension- high-speed cameras are used to identify bubble properties [5]. However, pseudo-2D beds provide limited insight into the behavior of three-dimensional fluidized beds. To address this limitation, tomographic techniques such as electrical capacitance tomography, X-ray computed tomography, and MRI have been used to characterize fluidized beds. MRI can measure particle concentration and flow, though in the past, it was limited by low temporal resolution. Recent advancements in MRI hardware and the implementation of time-efficient pulse sequences now enable high spatiotemporal resolution imaging of fluidized beds [6]. In this project, 3D vibrated gas-solid fluidized beds will be investigated using MRI. Additionally, identical experiments will be performed in a pseudo-2D system to compare the advantages of both imaging techniques and identify whether pseudo-2D fluidized bed results can predict the behavior in 3D fluidized beds.

<u>Tasks:</u>

- Literature review on vibrated gas-solid fluidized beds.
- Investigation of bubble properties in pseudo-2D beds with high-speed camera and 3D fluidized beds with MRI.
- Performing image segmentation to determine bubble properties such as bubble size and rise velocity.
- Implementing python scripts to detect bubble coalescence and splitting events.
- Integration of back lights for pseudo-2D experiments.
- Comparison of the MRI data with the results of the pseudo-2D bed experiments.
- Comparison of experimental data to literature correlations.

<u>Your profile:</u> Ideally, experimental work experience and programming with Python.

<u>Starting date</u>: March 2025



<u>Figure 1:</u> (a) 3D model of pseudo-2D and 3D fluidized beds. (b) Large-bore vertical MRI scanner, specifically designed for the study of chemical engineering reactors. (c) MRI scanner under which an electrodynamic shaker is placed to vibrate the fluidized bed while being scanned. (d) Experimental setup of vibrated pseudo-2D beds: front lights illuminate the bed, and bubble properties are investigated using a high-speed camera.

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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] 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. [2] 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. [3] Bi, H. T. A Critical Review of the Complex Pressure Fluctuation Phenomenon in Gas–Solids Fluidized Beds. Chemical Engineering Science 2007, 62 (13), 3473–3493. https://doi.org/10.1016/j.ces.2006.12.092.[4] Wiesendorf, V.; Werther, J. Capacitance Probes for Solids Volume Concentration and Velocity Measurements in Industrial Fluidized Bed Reactors. Powder Technology 2000, 110 (1–2), 143–157. https://doi.org/10.1016/S0032-5910(99)00276-4.[5] Zhang, Y.; Zhang, J.; Zhao, Y.; Zhang, X.; Yang, X.; Zhou, E.; Duan, C.; Wang, G.; Dong, L. Investigations on Dynamics of Bubble in a 2D Vibrated Fluidized Bed Using Pressure Drop Signal and High-Speed Image Analysis. Chemical Engineering Journal 2020, 395, 125129. https://doi.org/10.1016/j.cej.2020.125129. [6] Penn, A.; Tsuji, T.; Brunner, D. O.; Boyce, C. M.; Pruessmann, K. P.; Müller, C. R. Real-Time Probing of Granular Dynamics with Magnetic Resonance. Sci. Adv. 2017, 3 (9), e1701879. https://doi.org/10.1126/sciadv.1701879.

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