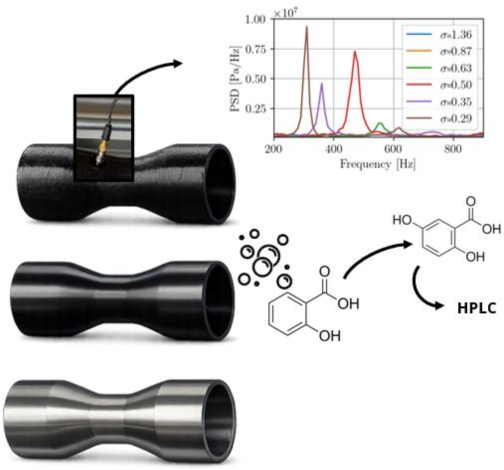
Fakultät Maschinenwesen | Institut für Verfahrenstechnik und Umwelttechnik | Professur für Chemische Verfahrenstechnik

Student Thesis:

Surface Roughness Effects in 3D-Printed Hydrodynamic Cavitation Reactors

Hydrodynamic cavitation (HC), the formation and violent collapse of vapor bubbles in a liquid due to local pressure drops, is a powerful phenomenon harnessed in chemical processing, water treatment, and process intensification [1]. The intensity and efficiency of cavitation are highly sensitive to reactor geometry and surface properties, particularly wall roughness, which influences bubble nucleation, pressure fluctuations, and radical generation [2], [3].



Additive manufacturing, specifically Fused Deposition Modeling (FDM) of ABS, enables rapid prototyping and easy customizability of reactors with complex geometries. However, FDM-printed surfaces exhibit high roughness (Ra 8.8–22.0 μm), in stark contrast to precision-machined venturis (Ra < 1 μm) [4].

While surface roughness is known to affect cavitation inception and intensity, the systematic relationship between 3D-printed surface parameters and cavitation performance remains underexplored, especially when compared to traditional machined reactors.

Thesis Objectives

- Quantitatively assess how surface roughness, which is modulated by acetone smoothing of FDM-printed ABS venturi reactors, affects cavitation.
- Measure dynamics and pressure-collapse signatures of different venturis using high-speed pressure measurements [5].
- Measure chemical intensification performance with salicylic acid dosimetry [6].
- Benchmark the findings against a machined venturi reference.

Requirements

- Currently enrolled in a Bachelor/Master's program in Engineering or Chemistry field.
- A solid understanding of fluid mechanics and interest in experimental techniques.

Literature

[1] V. V. Ranade, V. M. Bhandari, and S. Nagarajan, *Hydrodynamic Cavitation: Devices, Design and Applications*, 1st edn. Wiley, 2022. doi: 10.1002/9783527346448.
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[3] M. Ghorbani, A. K. Sadaghiani, L. G. Villanueva, and A. Koşar, 'Hydrodynamic cavitation in microfluidic devices with roughened surfaces', *J. Micromechanics Microengineering*, vol. 28, no. 7, p. 075016, Jul. 2018, doi: 10.1088/1361-6439/aab9d0.
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[5] U. U. Gawandalkar and C. Poelma, 'The characteristics of bubbly shock waves in a cavitating axisymmetric venturi via time-resolved X-ray densitometry', *J. Fluid Mech.*, vol. 988, p. A34, Jun. 2024, doi: 10.1017/jfm.2024.435.
[6] S. J. De-Nasri, V. P. Sarvothaman, S. Nagarajan, P. Manesiotis, P. K. J. Robertson, and V. V. Ranade, 'Quantifying OH radical generation in hydrodynamic cavitation via coumarin dosimetry: Influence of operating parameters and cavitation devices', *Ultrason. Sonochem.*, vol. 90, p. 106207, Nov. 2022, doi: 10.1016/j.ultsonch.2022.106207.

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Scope
Thesis

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