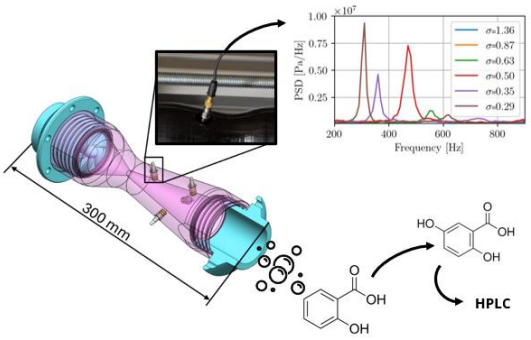
Technische Universität Dresden

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

Student Thesis:

Experimental Analysis of Swirl Impact on Cavitation Behaviour and Performance in 3D-Printed Cavitation Reactors

Hydrodynamic cavitation (HC) reactors, such as Venturi tubes, are widely used in water treatment and chemical processing due to their ability to generate localized high-energy zones that promote hydroxyl radical ·OH formation and molecular breakdown [1]. Swirl-enhanced designs—such as Venturi reactors with swirling internals and vortex diodes—have demonstrated significant advantages over conventional geometries, including reduced wall erosion, improved cavitation control, and enhanced chemical performance [2].



Swirl modifies the flow field, shifting cavitation inception away from solid boundaries and altering bubble collapse dynamics, which can be leveraged to optimize both reactor longevity and process outcomes. Despite these advances, the precise relationship between swirl intensity (quantified by the swirl number), cavitation behaviour, and chemical performance remains insufficiently understood.

Thesis Objectives

- Design and fabricate a series of cavitation reactors (Venturi with swirling internals and vortex diodes) using high-resolution additive manufacturing.
- Measure dynamics and pressure-collapse signatures of different venturis using high-speed pressure measurements [3].
- Measure chemical intensification performance with salicylic acid dosimetry [4].

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.
- Experience with HPLC and other analytical methods (preferred).

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.

[2] A. Simpson and V. V. Ranade, '*110th Anniversary:* Comparison of Cavitation Devices Based on Linear and Swirling Flows: Hydrodynamic Characteristics', *Ind. Eng. Chem. Res.*, vol. 58, no. 31, pp. 14488–14509, Aug. 2019, doi: 10.1021/acs.iecr.9b02757.

[3] 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.

[4] 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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