An experimental investigation on the two-phase intermittent flow coupling with structural vibration of horizontal pipes

Abstract - Two-phase flow is typically found in several industrial applications, such as in the production and transportation of oil and gas in the petrochemical industry, in the catalytic cracking and microreactors in the chemical industry, and in nuclear reactor cooling pumps. Measurement of two-phase flow features is usually necessary and has been done in several ways, including pressure probes, resistive sensors, gamma-ray, wire-mesh sensor and many others. However, these are either intrusive or invasive techniques, which might be of challenging application in industrial environments, or rely on a hazardous radioactive source. Vibration-based measurement of two-phase flow in pipes stands out as a non-invasive/non-intrusive approach and, consequently, multiphase-flow induced vibration in pipes has receiving increasing attention in recent years. In this work, the dynamic behaviour of a horizontal tube conveying an intermittent two-phase gas-liquid flow is characterised based on indirect approaches. The phenomenon of fluid-structure coupling is investigated using acceleration and pressure measurement. Moreover, the bubble size distribution is estimated from high-speed camera measurements, along with its spectral content and time modulation. Focus is given at frequency bands around the cut-on frequencies of the circumferential wave modes of the pipe. An approach based on the estimation of frequency response function of the pressure and vibration at the liquid piston and Taylor bubble is proposed, such that the coherence function can be used as quantitative measure of the coupling. Some experimental conditions with intermittent flow are investigated as representative cases. It is shown that there is a great vibration amplification at the cut-on frequencies of circumferential wave modes in pipes due to the corresponding structural wave and pressure coupling. Consequently, some features of the two-phase flow can be estimated from the vibration response filtered at the cut-on band. The experimental results pave the way for innovative vibration-based measurement approaches.

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- Seminários de Engenharia Mecânica "Arthur Palmeira Ripper Neto"-

Short Bio: Dr. Adriano Fabro is adjunct professor at the Department of Mechanical Engineering at the University of Brasilia since 2014. He is a CNPq level 2 productivity fellow and an executive member of the ABCM's Uncertainty Quantification and Stochastic Modeling Committee since 2016 and of the Dynamics Committee since 2023. He received ABCM's The Hofer Young Researcher Award for Young Researcher in the field of Dynamics in 2019. His main subjects of interest include structural dynamics, wave propagation, metamaterials, signal processing and uncertainty modeling. He holds a degree in Control and Automation Engineering (2007) and Master's Degree in Mechanical Engineering (2010) from the University of Campinas, in Brazil, and a PhD in Sound and Vibration (2014) from the Institute of Sound and Vibration Research (ISVR), University of Southampton, UK, with a The Lord Rayleigh scholarship during which time he was EU FP7 Marie Curie fellow. He published 34 articles in international journals and more than 70 papers in national and international conferences and patent applications as a result of research in collaboration with the industry. PI and co-PI in research projects funded by CNPq, FAPDF, FAPESP, the Royal Society and PETROBRAS.