Proceedings of the 11th International Conference on Fluid Flow, Heat and Mass Transfer (FFHMT 2024)
Chestnut Conference Centre - University of Toronto, Toronto, Canada – June 16-18, 2024
DOI: 10.11159/ffhmt24.004

Investigation of Gas Dispersion in Non-Newtonian Fluids with Coaxial Mixers

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Aerated mixing vessels featuring either a single impeller or multiple impellers mounted on a single shaft have found widespread applications in the chemical and biochemical sectors for gas-liquid contact operations. However, these single-shaft mixing systems exhibit inefficiency in dispersing gas within highly viscous Newtonian and non-Newtonian fluids due to the formation of oxygen and nutrient-segregated regions within the reactor. Additionally, traditional gas-liquid mixers suffer from drawbacks such as high power consumption, uneven shear rate distribution within the vessel, and the existence of dead zones near the vessel walls. To address these limitations and enhance mixing performance, a new approach involves replacing conventional configurations with an aerated coaxial mixing vessel equipped with a central impeller and a wall-scraping anchor rotating at varying speeds and directions. In this coaxial mixing system, the anchor impeller, operating at a low speed, is primarily responsible for clearing the vessel wall and redirecting the bulk fluid towards the central impeller, which rotates at a higher speed to facilitate the shear necessary for gas dispersion. The primary objective of this study was to assess the impact of several parameters—such as speed ratio (central impeller speed relative to anchor speed), rotating mode (co-rotating and counter-rotating modes), central impeller type, fluid rheology, and gas flow rate—on the performance of the aerated coaxial mixing vessel in terms of power consumption, gas holdup, bubble size distribution, and mass transfer coefficient. Various types of non-Newtonian fluids were employed in this investigation. To achieve the objectives of this study, a non-invasive flow visualization technique called electrical resistance tomography and dynamic gassing-in were used to measure gas holdup and mass transfer, respectively. A computational fluid dynamics (CFD) model coupled with the population balance model (PBM) was also developed to simulate the hydrodynamics of gas dispersion in non-Newtonian fluids.