Synopsis

Atharva Dhore
Department of Mechanical Engineering, VIIT Pune
Dr. Dhiraj Kumar Garg
Department of Chemical Engineering, SNU Delhi NCR

Steady State CFD Method For Residence Time Distribution In Different Tubular Geometries To Evaluate The Mixing

Radial mixing is crucial for evaluating and comparing different tubular flow geometries under different operating conditions. Mixing occurs through diffusion and convection, with diffusion playing a significant role in mixing at the molecular level and over short distances. For micromixers with small radial distances, diffusion increases radial mixing for diffusing chemical species, even under laminar flow conditions. However, for non-diffusing chemical species, convection is the only way to improve radial mixing. Convection in the radial direction can be caused by turbulent flow or laminar flow methods. Active methods require external energy and moving equipment, while passive methods use curvature to increase radial mixing. The project currently includes straight tube reactors (STR), helical coil reactors (CTR), and helical coil with regular bends (CFI). The project aims to increase radial mixing by introducing regular bends in the same coil. To measure radial mixing in non-diffusing massless tracer, two methods are proposed: RTD calculations and an unmixed feed case. RTD calculations typically involve a step input of a uniform concentration of non-diffusing massless tracer simulated at the inlet with fully developed flow at the inlet. However, this method has several disadvantages, such as requiring many simulations in terms of each time step and requiring computational resources in terms of computational power, storage, and time requirements. A new method of measuring RTD is proposed, which injects a parabolic concentration profile of massless non-diffusing tracer at the inlet in a step-input manner. The dimensionless time of first appearance for laminar flow is 0.5, while for plug flow, it is 1.0. For plug flow, the theoretical value of C_avg/C_max is 0.667, and for plug flow with a flat velocity profile, it is 0.5.

References

[1] Garg, D. K., Serra, C. A., Hoarau, Y., Parida, D., Bouquey, M., & Muller, R. (2020, June 2). Numerical Investigations of Different Tubular Microreactor Geometries for the Synthesis of Polymers under Unmixed Feed Condition. Macromolecular Theory and Simulations, 29(4), 2000008. https://doi.org/10.1002/mats.202000008