Proceedings of the 1st international Symposium on AI and Fluid Mechanics
Abstract No S11 A1

Modeling Flow Dynamics in Rotor-Stator Mixers using Data-Free Physics-Informed Neural Networks

[1]Amin Zargaran*; [1]Uwe Janoske

[1]School of Mechanical and Safety Engineering, University of Wuppertal, Wuppertal, Germany

Abstract

In-line multi-stage rotor-stator mixer (RSMs) have emerged as a state-of-the-art industrial solution for rapidly and efficiently mixing highly viscous liquids while minimizing temperature increases throughout the process. Unlike traditional batch mixers, which operate in discrete batches, RSMs facilitate continuous operation, leading to improved production rates and mixing efficiencies. The challenge of mixing highly viscous fluids lies in their tendency to maintain laminar flow regimes, which further limits the mixing rate. A majority of existing studies have employed Eulerian approaches for modeling phase distribution and the mixing process, which are prone to numerical diffusion. This can lead to an overestimation of mixing efficiency. In this talk, a model based on Physics-Informed Neural Networks (PINNs) is proposed as an alternative solution approach to conventional Computational Fluid Dynamics (CFD) methods. The unique feature of PINNs comparing to other machine learning approaches lies in their capability to directly incorporate physical equations, such as the Navier-Stokes equation, into their loss functions, thereby ensuring an accurate approximation which adheres to the governing equations. Comparing to the conventional CFD, such as finite volume method, PINNs employ meshless approximations using continuous functions, avoiding the need for iterative solutions on discretized grids and thus not prone to numerical diffusion. A trained PINN model is used to simulate the fluid flow through a standard rotor-stator mixer. The PINN predictions show good agreement with literature data and are discussed in detail.

Keywords: physics-informed neural network, rotor-stator mixer, highly viscous, mesh-less method