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# ASSESSING TURBULENCE MODELS FOR MULTIPHASE MIXTURE MODEL SIMULATIONS OF HYDROCYCLONES USING OPENFOAM.

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## ABSTRACT

Hydrocyclones are critical devices in various industrial applications, including mineral processing, chemical engineering, and wastewater treatment, due to their ability to efficiently separate particles based on size and density. Their compact design, lack of moving parts, and high separation efficiency make them indispensable in industries requiring solid-liquid or liquid-liquid separation. Despite their widespread use, accurately simulating the complex multiphase flow dynamics within hydrocyclones remains a significant challenge. The solid-liquid flow inside a hydrocyclone is characterized by intense swirling motion, strong velocity gradients, and complex interactions between the fluid and solid phases. Among various CFD approaches, the multiphase mixture model—a simplified Eulerian approach that solves the equations of motion only for the mixture—is commonly employed to reduce computational costs while maintaining accuracy. However, the model's performance heavily depends on the selection of the turbulence model, as hydrocyclone flows (with their swirling motion, strong velocity gradients, and phase interactions) are highly sensitive to turbulence modeling.

Selecting an appropriate turbulence model that complements the multiphase mixture model is therefore crucial for achieving accurate flow predictions and ensuring computational efficiency. This study comprehensively assesses the impact of various turbulence models on the simulation of hydrocyclone flow patterns. OpenFOAM categorizes the turbulence models into two categories: (a) Reynolds-Averaged Simulation (RAS) models and (b) Large Eddy Simulation (LES) models. The RAS models considered in this study include the one-equation model: Spalart-Allmaras, two-equation models: Standard k-ε, k-ω, and their variants, three-equation model: k-kl-ω and seven-equation model: LRR-Reynolds Stress Model (RSM). (LES) Models include the Smagorinsky model, the WALE model, the dynamic kinetic energy model, and Detached Eddy Simulation (DES) approaches, such as Spalart-Allmaras-DES and k-ω SST-DES. These models are systematically assessed for their effectiveness in predicting hydrocyclone flow characteristics when simulated with the multiphase-mixture model in OpenFOAM.

A review of existing literature suggests that higher-order turbulence models, when combined with advanced computational capabilities, significantly improve predictions of hydrocyclone performance. However, these models often require greater computational resources. This study therefore compares available turbulence models compatible with the mixture approach to enable precise predictions of flow velocity and solids separation with optimal computational efficiency. The results will highlight the strengths and limitations of each model in capturing the anisotropic turbulence and swirling flow characteristics of hydrocyclones. Additionally, the study provides insights into accuracy-computational cost trade-offs, offering practical recommendations for industrial applications.