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Abstract

Analyzing Power Consumption in a Coaxial Bioreactor Using Machine Learning Techniques with Computational Fluid Dynamics †

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Abstract: Agitated bioreactors are the subject of many studies regarding their design and scale-up to enhance the productivity in various chemical and biochemical industries. In this regard, accurately predicting their power consumption is very important, because it influences the mass transfer rate and flow uniformity inside the bioreactor. A literature review revealed that no study has been conducted to investigate the performance of coaxial bioreactors in terms of their power consumption using a machine learning method. In this study, a computational fluid dynamics (CFD) model was developed and validated against experimental data. Subsequently, 500 simulations at different aeration rates (2–6 L/min), anchor impeller speeds (3.5–9.5 rpm), central impeller speeds (60–150 rpm), and rotating modes (co-rotating and counter-rotating) were conducted. The data from these simulations were utilized to train and test various machine learning models. Initially, the *k*-nearest neighbor (KNN) classification model was employed to categorize the coaxial bioreactors into different rotating modes. It was found that with just the torque value and central impeller speed, the model achieved successful classification. In addition, various regression models, including multi-layer perceptron (MLP), KNN, and random forest, were developed to predict the torque that would be produced by the coaxial bioreactor. For all models, the hyperparameter tuning and cross-validations were performed. The mean squared error (MSE) evaluation showed that the random forest model had superior performance compared to its counterparts.

Keywords: machine learning; coaxial bioreactor; power consumption; computational fluid dynamics

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