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CFD simulation for predicting the impact of bed-height alteration on the performance of a pilot-scale fluidized bed polymerization reactor

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Abstract: In this study, a novel initiative for examining the impact of bed-height control inside a fluidized bed reactor has been deliberated. The CFD (Computational Fluid Dynamics) simulation has been built, adopted and compared with literature data employed for the important process parameters, such as minimum pressure, initiation temperature and on the dynamics of gas-solid distribution in a catalytic Fluidized Bed Reactor (FBR). The developed multiphase fluid dynamics modelling is one of the first of its kind to study and designate the 2D simulation that revealed that bed-height is one of the vital process parameters in larger scale olefin polymerization. The outcomes showed diverse heterogeneous flow shapes being shaped when bed-height altered, because of more bubbling and emulsion phase dominance in the reaction zone. The information attained from this simulation could be significant for designing the pilot and industrial-scale petrochemical reactors to guarantee effective process operations by using FBRs.

Keywords: process modeling, Computational Fluid Dynamics, Fluidized Bed Reactor (FBR).

Recurrent Neural Network – Auto Regressive Exogenous Based Modelling and Control of a Bioreactor for Ethanol Production

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Abstract: A bioreactor is a highly nonlinear system for which obtaining an accurate mathematical model and superior control performance is still a challenging task. Deep learning techniques such as Recurrent Neural Networks (RNN) and data-driven modelling effectively capture the temporal characteristics of nonlinear systems, which can change over time and exhibit linearization. Hence in this present study, a Gated Recurrent Unit (GRU), a type of RNN is designed for the control of temperature in bioreactor system based on a model-based control framework. Random sequences of Input data (F_{in}) are generated and given to First Principles Model Equations (FPME) of bioreactor and the sequences of output data (T_r) are obtained. The generated input-output data is provided for the training of GRU network model. The GRU model is tuned by adjusting hyperparameters such as number of hidden layers, hidden units, and epochs for the minimization of the prediction error. Once

a reasonably reliable model is obtained, by approximating the function coefficient of the model with GRU, Gated Recurrent Unit-Auto Regressive eXogenous (GRU-ARX) model is developed. Similarly, another GRU network is trained for use as a controller. To track the test setpoints with minimum error, the controller network architecture is tuned. This procedure is repeated with another popular RNN known as Long Short-Term Memory (LSTM) network also. The servo and regulatory response of both the network models and controllers are evaluated in terms of standard performance measures as Root Mean Square Error (RMSE). The controller which is designed based on the RNN performs better when compared with Internal Model Control-Proportional Integral (IMC-PI) controller.

Keywords: RNN, ARX model, LSTM, GRU, Bioreactor, Ethanol, PI Control.

Analysis of zero dynamics of non-minimum phase reaction systems using the concepts of vessel extents

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Abstract: In this work, the reactor model, expressed in terms of vessel extent states, is exploited to analyze a typical non-minimum phase reaction system from the viewpoint of system theory. More precisely, it is shown that the dynamics of vessel extents of reactions that are independent of manipulated inputs, namely mass flowrates of inlet streams, can be considered as the zero dynamics of the system. And, by analyzing the dynamics of vessel extents of reactions when other vessel extents reach their steady states, instability of the zero dynamics under an operating condition that implies an inverse response behavior can be predicted. It should be noted that, instead of a complex diffeomorphism, only a linear time-invariant transformation is utilized for system analysis, thereby easing the applicability of the proposed method. Simulations for the Van de Vusse reaction system illustrate its effectiveness.

Keywords: Isothermal reactors, Van de Vusse reaction system, nonlinear system, system analysis