Optimization of Selected Biochemical Processes Production Using Evolutionary Algorithms

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Abstract

This study presents the use of differential evolution algorithm for single and multi-objective optimization of the fermentation production processes of three industrial important bio-products, namely Astaxanthin, Lactic acid and Lysine. Differential evolution (DE) algorithm is used in validating the kinetic models, estimating the kinetic parameters and obtaining the optimal control of batch and fed batch fermentations of such production processes. In Astaxanthin production study, two different specific growth rates, substrate and product inhibition, and substrate saturation and product inhibition, are evaluated in order to determine the biochemical reaction kinetics corresponding to the optimum kinetic parameters using batch models. Coefficient of determination (R2) is used to check the model fitting with the obtained optimization data and experimental data in batch mode. Improved kinetic parameters are obtained and are reported. In Lactic acid production study, DE algorithm is used in the validation of the kinetic models of batch and fed batch fermentations of Lactic acid production. In fed batch fermentations, different feeding strategies such as exponential, modified exponential and feed forward controlled are tested. Improved kinetic constants for both fermentations are found by minimizing the least square error between the experimental data and the results of the simulated model. DE successfully improves the optimization results of batch fermentation bioreactor. DE strategies comparative analysis is studied for exponential feeding fed batch to check the robustness of the optimization algorithm. The DE/best/1/bin and DE/current to best/1/bin are the best strategies suitable for such problems. These strategies along with their associated control parameters are used to estimate the kinetic parameters of fed batch fermentation studies with different feeding strategies. In Lysine production, three multi-objective differential evolution algorithms; MODE-III, Harmonic MODE and improved selection scheme MODE-III-IMS; are used to obtain the optimal control of Lysine fed batch bioreactor. Two conflicting objectives (namely the yield and the productivity) are used. Detailed algorithmic specific studies are reported using test problems and the fed batch bioreactor problem. Singular and constant feeding policies are studied using all algorithms and the Pareto fronts are reported. The Pareto fronts of different feeding rates in a given range are also reported. The Pareto front of the higher bound of feeding rate (2.0 L/s) approaches the true non-dominated region on the search space. Tournament selection and penalty constraint handling methods are used in all algorithms and performance is compared. Two different forms of yield expressions are analyzed for MOO study. Harmonic MODE algorithm results in well diverse set

of solutions. MODE-III-IMS converges to the true Pareto front in a faster rate than MODE-III and showed better yield-productivity results.