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Author: Markana Anilkumar Nitin Padhiyar Kannan Moudgalya

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Multi-criterion control of a bioprocess in fed-batch reactor using EKF based economic model predictive control

Markana Anilkumar

Department of Electrical Engineering, Pandit Deendayal Petroleum University, Gandhinagar, India- 382007

Nitin Padhiyar*

Department of Chemical Engineering, Indian Institute of Technology Gandhinagar, Gujarat, India- 382355

Kannan Moudgalya

Department of Chemical Engineering, Indian Institute of Technology Bombay, Mumbai, India- 400076

Abstract

This research paper presents an offline and online user defined priority driven multi-objective optimal control study of a bioprocess in a fed-batch reactor. Productivity and the amount of substrates used in the process are considered as the two control objectives in that order of priority for this purpose. The priorities in the objective functions are realized using the lexicographic approach by sequentially solving multiple objectives to arrive at a Pareto solution point. This approach is not sensitive to the tuning of weighting parameters as compared to the scalarized objective, practiced conventionally. The weighting factors tuning issue is demonstrated with an offline optimal control. The lexicographic optimization approach is then implemented to overcome this thing issue. Subsequently, the online optimal control problem is solved using economic model predictive control (EMPC) owing to the economic nature of the control objectives. Often, the Pareto curve is such that marginally relaxing one objective results into a significant improvement in the other objective. This can easily be implemented with the lexicographic approach and is demonstrated using EMPC. Moreover, unlike the continuous processes, the batch processes operate for a specific batch time. Hence, the shrinking horizon approach along with the EMPC framework is employed in the fed-batch bioreactor for online control with extended Kalman filter (EKF).

Keywords: Lexicographic optimization, model predictive control, multi-criterion control, bioprocess

1. Introduction

The bioprocess industry has considerably changed in the last one decade owing to mainly two reasons, (1) ever-increasing research emphasis to develop therapeutic candidates and (2) an increased regulatory pressure to develop better control on the product quality. However, the control of bioprocesses is yet to mature as compared to the rest of chemical processes. Insufficient bioprocess understanding, the lack of key process measurements and complex nonlinear process dynamics are few critical challenges during the bioreactor control and optimization. The control of bioreactors is aimed to influence the intracellular reactions of numerous cells by controlling the extracellular conditions [1]. There have been noteworthy work reported on the off-line optimal control of bioreactors using the dynamic optimization [2, 3, 4, 5, 6, 7].

*Corresponding Author

Email addresses: anil.markana@spt.pdpu.ac.in (Markana Anilkumar), nitin@iitgn.ac.in (Nitin Padhiyar), kannan@iitb.ac.in (Kannan Moudgalya)

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