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Robust observation strategy to estimate the substrate concentration in the influent of a fermentative bioreactor for hydrogen production

Ixbalank Torres Zúñiga [a,c], Alejandro Vargas [a,*], Eric Latrille [b], Germán Buitrón [a]

[a] Laboratory for Research on Advanced Processes for Water Treatment, Unidad Académica Juriquilla, Instituto de Ingeniería, Universidad Nacional Autónoma de México, Blvd. Juriquilla 3001, 76230 Querétaro, Mexico
[b] INRA, UR050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100, France
[c] Facultad de Ingeniería, Universidad Autónoma de Querétaro, Cerro de las Campanas s/n, 76010 Querétaro, Mexico

HIGHLIGHTS

- An observer of the substrate at the input of a hydrogen production reactor is proposed.
- The parameters of the model of the process are first identified.
- Two optimization problems to calculate the gains of the observer are proposed.
- The feasibility of the observer is demonstrated by using experimental data.

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ABSTRACT

The observation strategy developed in this paper consists of an H_∞ Luenberger observer coupled to a classical super-twisting observer. The H_∞ Luenberger observer uses the biohydrogen flow rate measured at the reactor output to estimate the glucose and the biomass concentrations inside the reactor. These estimations are taken by the super-twisting observer to estimate the glucose concentration at the reactor input. First, pseudo-stoichiometric and kinetic parameters of the bioreactor model are identified. Two semi-definite optimization problems are then proposed to compute the observer gains. Results show that the biomass is a sensitive state variable. In spite of this, the glucose estimated at the reactor input correctly follows the experimental data and the estimation error remains close to zero in the complete period of time considered.

1. Introduction

The monitoring of processes is a key subject in biotechnological engineering due to the importance of following the state of a set of critical variables. The information obtained from these variables can help the experts make correct decisions in order to improve the operation of a process of interest. Nevertheless, on-line measurements are not available for some variables because of the lack of reliable and low cost sensors. In such cases, observation strategies can be considered in order to estimate their state as close as possible to their real value.

An accurate knowledge of the a priori unknown inputs is a key issue when dealing with the control of biotechnological systems. This problem has been addressed before in several works. For example, Theilliol et al. (2003) propose an extended Luenberger observer to estimate both the state and the unmeasured input for anaerobic wastewater treatment plants. Rapaport et al. (2008) present the design of an observer for unknown inputs, both constant and periodic (under the assumption of known frequency). Rocha-Cozatl and Vande Wouwer (2011) propose a quasi-unknown input observer to estimate flow rates, concentrations and light intensity in phytoplanktonic cultures. Moreno and Dochain (2013) propose a discontinuous observer able to estimate in finite time both unmeasured states and the unknown input of a SISO nonlinear second order system, and the example that illustrates its application is a bioreactor. Aceves-Lara et al. (2007) address the problem of estimating simultaneously the states and the input concentrations of an acidogenic process used for biohydrogen production. The input and state concentrations were estimated using a state transformation and an asymptotic observer. In this work, we propose an alternative strategy to estimate the unknown input and unmeasured states of a biohydrogen production reactor by coupling a Luenberger observer to a super-twisting observer.

* Corresponding author.
E-mail addresses: ixbalank@gmail.com (I. Torres Zúñiga), avargasc@iingen.unam.mx (A. Vargas), eric.latrille@supagro.inra.fr (E. Latrille), gbuitronm@iingen.unam.mx (G. Buitrón).

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