

Modelling and model reference adaptive control for fed-batch bakers' yeast fermentation

Citation for published version (APA):

Bögels, P. F., Jager, de, A. G., & Reyman, G. (1990). Modelling and model reference adaptive control for fed-batch bakers' yeast fermentation. In *Systems and control : 9th Benelux meeting, March 14-16, 1990, Veldhoven, The Netherlands* Centrum voor Wiskunde en Informatica.

Document status and date:

Published: 01/01/1990

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Modelling and Model Reference Adaptive Control for Fed-Batch Bakers' Yeast Fermentation

P.F. Bögels
A.G. de Jager
G. Reyman

Eindhoven University of Technology
Eindhoven University of Technology
Unilever Research Laboratorium Vlaardingen

For many years Unilever's research laboratories are active in applied research in the field of biotechnology. A project on the modelling and control of fed-batch fermentation is part of the Unilever development programme in this field.

Fermentation may consist of two phases: growth of the micro-organism on a special fermentation medium followed by a production phase of metabolites eg. enzymes, penicillines, flavorings. The process of interest is bakers' yeast fermentation, regarded as strictly growth associated in an aerobic cultivation medium. The fermentation processes may be classified according to the mode chosen for process operation, eg. batch, fed-batch or continuous. Fed-batch processes are well suited for controlling the growth phase and rate of bakers' yeast. On industrial scale problems often are encountered with insufficient liquid mixing, oxygen transfer and determination of the optimal feed rate. Generally speaking the main objectives for process improvement are the productivity and quality of the yeast. The productivity can be improved through better feeding and oxygen transfer. The quality of the yeast can be improved in various empirical ways. Classical control methods often give unsatisfactory results in achieving these goals. Therefore modern control theories are being investigated for process improvement.

Model reference adaptive control was selected as a new approach in controlling the fed-batch bakers' yeast production. Two problems which appear in control of the biotechnical process are: the most important process state variables are not measurable and the process parameters are strongly time dependent. The knowledge of these state variables and time varying process parameters is essential for state feedback control. An adaptive nonlinear filter or observer based on Kalman filtering techniques was chosen for on-line state reconstruction. The dynamics of the biotechnical process are very complex and until now not completely known. Therefore the filter is based on a relatively simple mathematical reference model. State feedback control is finally achieved using a one step ahead tracking controller. Optimal growth is established by controlling the glucose concentration just above its critical value and the oxygen content of the broth at a constant level.

The model which describes the dynamic behaviour of the bakers' yeast is based on a recently developed hypothesis for the growth in a batch culture. This model is applied for simulation of the fed-batch process. The Kalman filter uses a discrete-time reference model which was derived by reduction of the complex growth model of the yeast.

The model reference adaptive control approach is an attractive way of process control because it leads to a better understanding of the physiology of the yeast cells. This knowledge can be used to improve the modelling of bakers' yeast and the production process through a better supervised controller effort. A negative side effect is that this approach requires intensive tuning and is quite computationally complex. On the other hand process control becomes very flexible and results of controlling the growth process are far better in comparison to classical PID control.