

Lecture Notes
in Control and Information Sciences 361

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Selected Topics in Dynamics and Control of Chemical and Biological Processes



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To Laura, Valeria, Camila, Beatriz and Cande
H.O. Méndez-Acosta

To cow-eyes lady and my parents
R. Femat

To my lovely family
V. González-Álvarez

Preface

In view of the rapid changes in requirements, it has become necessary to place at the reader's disposal a book dealing with basic and advanced concepts and techniques for the monitoring and control of chemical and biochemical processes, as well as with the aspects of the implementation of these different robust techniques. To make the ideas covered in this book accessible to a larger audience, we have attempted to present a balanced view of the theoretical and practical issues of control systems. Different cases are presented to illustrate the controller and observer design procedures and their dynamic effects in the closed-loop. The book consists of peer-reviewed contributions and aims the integration of recent research by a group of colleagues working on theory and practice of the process control. All authors are members on educative institutions and are the new talent entering the field of process control. The coverage in contributions is from the pure theoretically analysis to the experimental implementation passing through physical interpretation. Thus, process modeling topics, theoretical conditions for controlling and physical interpretations of the controllers are involved in the book. In order to embrace as chemical as control engineering themes, authors have proposed different kind of processes and distinct control scopes. The themes have been chosen by accounting that contributions go beyond the academic custom "give me a model and I can find a controller" and the industry concept "the control is working, do not know why but do not touch it". This book is an effort to incorporate and link both theory-practice and chemical-control engineering.

Concerning the variety of processes, authors have contributed with distillation columns and alkylation, biological and exothermic reactors. In regard distillation columns and alkylation reactors, the control approaches have a physical meaning because the model governing their dynamics is to large to formally study them. Besides, in complementary manner, biological and exothermic reactors are studied in a more formal way; which, in combination with the practical approaches proposed for distillation and alkylation problems, can render to reader a balance on theory-practice. This wide orientation obeys to the diversity of control problems on chemical and biological processes.

In regard dynamics and control scopes, the contributions address analysis of open and closed-loop systems, fault detection and the dynamical behavior of controlled processes. Concerning control design, the contributors have exploited fuzzy and neuro-fuzzy techniques for control design and fault detection. Moreover, robust approaches to dynamical output feedback from geometric control are also included. In addition, the contributors have also enclosed results concerning the dynamics of controlled processes, such as the study of homoclinic orbits in controlled CSTR and the experimental evidence of how feedback interconnection in a recycling bioreactor can induce unpredictable (possibly chaotic) oscillations.

First, we would like to acknowledge the individuals who wrote chapters to this book for taking time out of their busy schedule to contribute to this book. Their hardwork and patience are gratefully appreciated. We also wish to express our gratitude to the international reviewers whose selfless service to the profession is truly appreciated.

The book comprises three parts as follows:

- Part 1 *Control of Chemical Processes*. Some common problems in chemical processes are presented and either classical solutions or physical interpretation of controllers are discussed. Thus, the first chapter includes modeling and local control whereas the second chapter is focussed on nonlinear control design from heat balance on chemical reactors. The three first chapters deal with regulation problems while the last one is devoted to a tracking one.
- Part 2 *Control and Diagnosis of Biological Processes*. This part is oriented on biological wastewater treatment processes. From fuzzy-based designs to geometric control approaches, the wastewater processes are controlled to regulate the concentration of polluting agents, to guarantee the process stability or for fault diagnosis purposes. Control of wastewater treatment plants is a quite active research area and this chapter provides a scope on alternative solutions. Experimental results are included along this part.
- Part 3 *Dynamics of Controlled Reactors*. The first chapter shows how the classical control can induce oscillatory behavior even chaotic in a chemical process. This chapter includes a theoretical treatment whereas the last one shows experimental evidence of how feedback control can induce oscillatory (possibly chaotic) behavior. Thus, this part includes a rarely found topic in control books.

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V. González-Álvarez

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