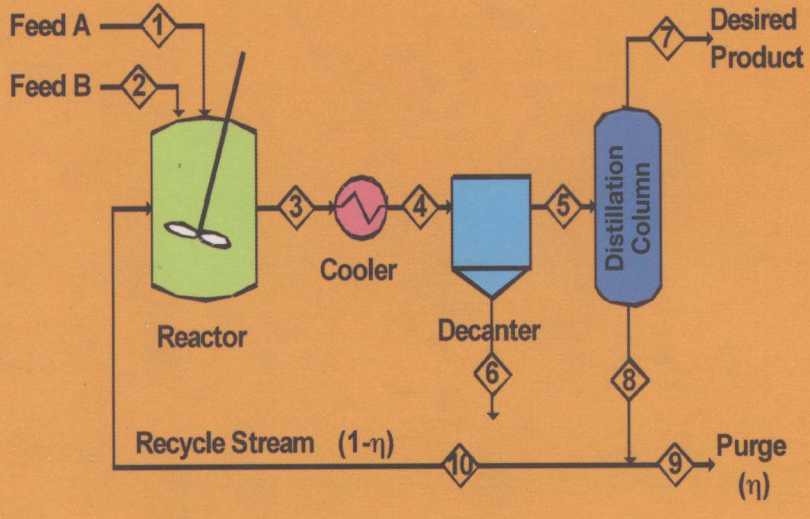
Advances in Process Systems Engineering – Vol. 1

MULTI-OBJECTIVE OPTIMIZATION

Techniques and Applications in Chemical Engineering



Gade Pandu Rangaiah

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Preface

Optimization is essential for reducing material and energy requirements as well as the harmful environmental impact of chemical processes. It leads to better design and operation of chemical processes as well as to sustainable processes. Many applications of optimization involve several objectives, some of which are conflicting. Multi-objective optimization (MOO) is required to solve the resulting problems in these applications. Hence MOO has attracted the attention of several researchers, particularly in the last ten years.

It is my pleasure and honor to edit this first book on MOO with focus on chemical engineering applications. Although process modeling and optimization has been my research interest since my doctoral studies around 1980, my interest and research in MOO began in 1998 when Prof. S.K. Gupta, Prof. A.K. Ray and I initiated collaborative work on the optimization of a steam reformer. Since then, we have studied optimization of many industrial reactors and processes that need to meet multiple objectives. I am thankful to both Prof. S.K. Gupta and Prof. A.K. Ray for the successful collaboration over the years.

The first chapter of the book provides an introduction to MOO with a realistic application, namely, the alkylation process optimization for two objectives. The second chapter reviews nearly 100 chemical engineering applications of MOO since the year 2000 to mid-2007. The next 5 chapters are on the selected MOO techniques; they include (1) review of multi-objective evolutionary algorithms in the context of chemical engineering, (2) multi-objective genetic algorithm and simulated

annealing as well as their jumping gene adaptations, (3) surrogate-assisted multi-objective evolutionary algorithm, (4) interactive MOO in process design, and (5) two methods for ranking the Pareto solutions.

The final 6 chapters present a broad range of MOO applications in chemical engineering including a few in biochemical engineering. They cover gas-phase refrigeration systems for liquefied natural gas, feed optimization to a residue catalytic cracker in a petroleum refinery, process design for multiple economic and/or environmental objectives, emergency response optimization around chemical plants, developing gene networks from gene expression data, and multi-product microbial cell factory. In these applications, the models employed are detailed, and the scenarios and data are realistic.

Each of the chapters in the book was contributed by leading researchers in MOO techniques and/or its applications. Brief resume and photo of each of the contributors to the book, are provided on the enclosed CD-ROM. Each chapter in the book was reviewed anonymously by at least two experts and/or other contributors. Of the submissions received, only those considered to be useful for education and/or research were revised by the respective contributor(s), and the revised submission was finally reviewed for presentation style by the editor or one of the other contributors. I am grateful to my colleague, Dr. S. Lakshminarayanan, who coordinated the anonymous review of chapters co-authored by me and also provided constructive comments on the first chapter.

The book will be useful to researchers in academic and research institutions, to engineers and managers in process industries, and to graduates and senior-level undergraduates. Researchers and engineers can use it for applying MOO to their processes whereas students can utilize it as a supplementary text in optimization courses. Each of the chapters in the book can be read and understood with little reference to other chapters. However, readers are encouraged to go through the introduction chapter first. Many chapters contain several exercises at the end, which can be used for assignments and projects. Some of these and the applications discussed within the chapters can be used as projects in

optimization courses at both undergraduate and postgraduate levels. The book comes with a CD-ROM containing many programs and files, which will be helpful to readers in solving the exercises and/or doing the projects.

I am thankful to all contributors to this book and anonymous reviewers for their collaboration and cooperation. In particular, I am grateful to Prof. S.K. Gupta and Prof. J. Thibault for several suggestions, which enhanced the book. Thanks are also due to Ms. H.L. Gow and Mr. K.W. Tjan from the World Scientific, for their suggestions and cooperation in preparing this book. It is my pleasure to acknowledge the contributions of my research fellow (Dr. A. Tarafder) and postgraduate students (J.K. Rajesh, P.P. Oh, B.S. Mohanakkannan, Y. Li, Y.M. Lee, N. Bhutani, N. Agrawal, F.C. Lee, Masuduzzaman, E.S.Q. Lee and N.M. Shah), to our studies on MOO applications in chemical engineering over the years and thus to this book in some way or other. I thank the Department of Chemical & Biomolecular Engineering and the National University of Singapore for encouraging and supporting my research over the years by providing ample resources including research scholarships.

Finally, and very importantly, I am grateful to my wife (Krishna Kumari) and daughters (Jyotsna and Madhavi) for their loving support, encouragement and understanding not only in preparing this book but in everything I pursue.

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