

# **POLLUTION PREVENTION THROUGH PROCESS INTEGRATION**

*Systematic Design Tools*



**Mahmoud M. El-Halwagi**

# Pollution Prevention Through Process Integration Systematic Design Tools

**Jirí Jaromír Klemeš, Petar Sabev  
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### **Pollution Prevention Through Process Integration Systematic Design Tools:**

Pollution Prevention through Process Integration Mahmoud M. El-Halwagi, 1997-08-19 The environmental impact of industrial waste is one of the most serious challenges facing the chemical process industries From a focus on end of pipe treatment in the 1970s chemical manufacturers have increasingly implemented pollution prevention policies in which pollutants are mitigated at the source or separated and recovered and then reused or sold This book is the first to present systematic techniques for cost effective pollution prevention altering what has been an art that depends on experience and subjective opinion into a science rooted in fundamental engineering principles and process integration Step by step procedures are presented that are widely applicable to the chemical petrochemical petroleum pharmaceutical food and metals industries Various levels of sophistication ranging from graphical methods to algebraic procedures and mathematical optimization numerous applications and case studies and integrated software for optimizing waste recovery systems make Pollution Prevention through Process Integration Systematic Design Tools a must read for a wide spectrum of practicing engineers environmental scientists plant managers advanced undergraduate and graduate students and researchers in the areas of pollution prevention and process integration Allows the reader to establish pollution prevention targets for a process and then develop implementable cost effective solutions Contains step by step procedures that can be applied to environmental problems in a wide variety of process industries Integrates pollution prevention with other process objectives Author is internationally recognized for pioneering work in developing mass integration science and technology

**Sustainable Design Through Process Integration** Mahmoud M. El-Halwagi, 2011-09-19 This timely book provides authoritative comprehensive and easy to follow coverage of the fundamental concepts and practical techniques on the use of process integration to maximize the efficiency and sustainability of industrial processes Over the past three decades significant advances have been made in treating designing and operating chemical processes as integrated systems Whether you are a process engineer an industrial decision maker or a researcher this book will be an indispensable resource tool for systematically enhancing process performance and developing novel and sustainable process designs The book is also ideal for use as a text in an upper level undergraduate or an introductory graduate course on process design and sustainability This ground breaking reference enhances and reconciles various process and sustainability objectives such as cost effectiveness yield improvement energy efficiency and pollution prevention The detailed tools and applications within are written by one of the world's foremost process integration and design experts and will save you time and money Contains state of the art process integration approaches and applications including graphical algebraic and mathematical techniques Covers applications that include process economics targeting for conservation of mass and energy synthesis of innovative processes retrofitting of existing systems design and assessment of renewable energy systems and in process pollution prevention Presents fundamentals and step by step procedures that can be applied to the design and optimization of new

processes as well the retrofitting and operation of existing processes as well as including numerous examples and case studies for a broad array of industrial systems and processes      **Process Integration for Resource Conservation** Dominic C.Y. Foo,2016-04-05 To achieve environmental sustainability in industrial plants resource conservation activities such as material recovery have begun incorporating process integration techniques for reusing and recycling water utility gases solvents and solid waste Process Integration for Resource Conservation presents state of the art cost effective techniques

**Process Design Tools for the Environment** Subhas Sikdar,2001-05-07 Much of the pollution in the air water or soil results from discharges from industrial activities Industrial practice can be significantly altered to reduce or eliminate the pollution if processes and products are so designed that either toxic materials are not used or processes are inherently less polluting This book is a collection of methods written by experts that would enable industry to design benign processes at the outset to achieve this purpose      Process Integration Mahmoud El-Halwagi,2006-02-28 With growing global competition the process industries must spare no effort in insuring continuous process improvement in terms of Increasing profitability Conservation of resources and Prevention of pollution The question is how can engineers achieve these goals for a given process with numerous units and streams Until recently conventional approaches to process design and operation put emphasis only on individual units and parts of the process A more powerful integrated approach was lacking The new field of Process Integration looks towards the processing plant as a whole in its attempt to find solutions and improvements Research over the past two decades has resulted in many techniques that allow engineers to better understand complex facilities and significantly enhance their performance This textbook presents a comprehensive and authoritative treatment of the concepts tools and applications of Process Integration Emphasis is given to systematic ways of analyzing process performance Graphical algebraic and mathematical procedures are presented in detail In addition to covering the fundamentals of the subject the book also includes numerous case studies and examples that illustrate how Process Integration is solving actual industrial problems Systematic methodology for analyzing the process as an integrated system identifying global insights of the process and generating optimum strategies and solutions Proper mix of fundamental principles insightful tools and industrial applications Generic techniques that are applicable to a wide variety of processing facilities Packed with case studies practical tools charts tables and performance criteria Extensive bibliography to provide ready access to process integration literature Excellent review of state of the art technology development trends and future research directions

**Encyclopedia of Sustainable Technologies** Martin Abraham,2017-07-04 Encyclopedia of Sustainable Technologies Eight Volume Set provides an authoritative assessment of the sustainable technologies that are currently available or in development Sustainable technology includes the scientific understanding development and application of a wide range of technologies and processes and their environmental implications Systems and lifecycle analyses of energy systems environmental management agriculture manufacturing and digital technologies provide a comprehensive method for

understanding the full sustainability of processes In addition the development of clean processes through green chemistry and engineering techniques are also described The book is the first multi volume reference work to employ both Life Cycle Analysis LCA and Triple Bottom Line TBL approaches to assessing the wide range of technologies available and their impact upon the world Both approaches are long established and widely recognized playing a key role in the organizing principles of this valuable work Provides readers with a one stop guide to the most current research in the field Presents a grounding of the fundamentals of the field of sustainable technologies Written by international leaders in the field offering comprehensive coverage of the field and a consistent high quality scientific standard Includes the Life Cycle Analysis and Triple Bottom Line approaches to help users understand and assess sustainable technologies     *Sustainable Process Integration and Intensification* Jiří Jaromír Klemeš, Petar Sabevar Varbanov, Sharifah Rafidah Wan Alwi, Zainuddin Abdul Manan, Yee Van Fan, Hon Huin Chin, 2018-04-23 In its second edition Sustainable Process Integration and Intensification continues the presentation of fundamentals of key areas of both fields Thoroughly updated and extended to include the latest developments the reader also finds illustrated working sessions for deeper understanding of the taught materials The book is addressed to graduate students as well as professionals to help the effectively application in plant design and operation     Handbook of Process Integration (PI) Jiří Jaromír Klemeš, 2022-11-09 Handbook of Process Integration PI Minimisation of Energy and Water Use Waste and Emissions Second Edition provides an up to date guide on the latest PI research and applications Since the first edition published methodologies and sustainability targets have developed considerably Each chapter has been fully updated with six new chapters added in this release covering emissions transport water scarcity reliability and maintenance environmental impact and circular economy This version also now includes worked examples and simulations to deepen the reader s understanding With its distinguished editor and international team of expert contributors this book is an important reference work for managers and researchers in all energy and sustainability industries as well as academics and students in Energy Chemical Process and Environmental Engineering Provides a fully updated handbook with six new chapters that reflect the latest research and applications on process integration Reviews a wide range of process design and integration topics ranging from heat and utility systems to water recycling waste and hydrogen systems Covers equipment design and operability issues with a strong extension to environmental engineering and suitability issues     Process Integration for Resource Conservation Dominic C.Y. Foo, 2025-01-31 To achieve environmental sustainability in industrial plants resource conservation activities such as material recovery have begun incorporating process integration techniques for reusing and recycling water utility gases solvents and solid waste Process Integration for Resource Conservation presents state of the art cost effective techniques including pinch analysis and mathematical optimization for numerous conservation problems The second edition of this best seller adds new chapters on heat integration and retrofitting of resource conservation networks and features multiple optimization examples via downloadable MS Excel spreadsheets Emphasizes the goal of setting

performance targets ahead of detailed design following the holistic philosophy of process integration Explains various industrial examples step by step and offers demo software and other materials online Features a wealth of industrial case studies Adds chapters on heat integration combined heat and power heat integrated water network and retrofit of resource conservation network Adds new optimization examples and downloadable MS Excel files on superstructural approaches and automated targeting models for direct reuse recycle and regeneration Ideal for students preparing for real world work as well as industrial practitioners in chemical processing the text provides a systematic guide to the latest process integration techniques for performing material recovery in process plants The book features a solutions manual lecture slides and figure slides for adopting professors to use in their courses      Decontamination of Heavy Metals Jiaping Paul Chen,2012-12-18 Heavy metals such as lead chromium cadmium zinc copper and nickel are important constituents of most living organisms as well as many nonliving substances Some heavy metals are essential for growth of biological and microbiological lives yet their presence in excessive quantities is harmful to humans and interferes with many environmental      *Kirk-Othmer Chemical Technology and the Environment, 2 Volume Set* Wiley,2007-05-21 The two volume reference work Chemical Technology and the Environment provides readers with knowledge on contemporary issues in environmental pollution prevention and control as well as regulatory health and safety issues as related to chemical technology It introduces and expands the knowledge on emerging green materials and processes and greener energy technology as well as more general concepts and methodology including sustainable development and chemistry and green chemistry Based on Wiley's renowned Kirk Othmer Encyclopedia of Chemical Technology this compact reference features the same breadth and quality of coverage and clarity of presentation found in the original      **Process Integration and Intensification** Jirí Jaromír Klemeš,Petar Sabev Varbanov,Sharifah Rafidah Wan Wan Alwi,Zainuddin Abdul Manan,2014-05-26 The authors have provided all the elements required for complete understanding of the basic concepts in heat recovery and water minimization in chemical and related processes and followed these with carefully selected and developed problems and solutions in order to ensure that the concepts delivered can be applied Simon Perry The University of Manchester This graduate textbook covers fundamentals of the key areas of Process Integration and Intensification for intra process heat recovery Heat Integration inter process heat recovery and cogeneration Total Site as well as water conservation Step by step working sessions are illustrated for deeper understanding of the taught materials The textbook also provides a wealth of pointers as well as further information for readers to acquire more extensive materials on the diverse industrial applications and the latest development trends in Process Integration and Intensification It is addressed to graduate students as well as professionals to help the effectively application of Process Integration and Intensification in plant design and operation      **Chemical Engineering Design** Gavin Towler,R K Sinnott,2012-01-13 Bottom line For a holistic view of chemical engineering design this book provides as much if not more than any other book available on the topic Extract from Chemical

Engineering Resources review Chemical Engineering Design is a complete course text for students of chemical engineering. Written for the Senior Design Course and also suitable for introduction to chemical engineering courses, it covers the basics of unit operations and the latest aspects of process design, equipment selection, plant and operating economics, safety and loss prevention. It is a textbook that students will want to keep through their undergraduate education and on into their professional lives.

Chemical Engineering Design Ray Sinnott, Gavin Towler, 2019-05-26. Chemical Engineering Design SI Edition is one of the best known and most widely used textbooks available for students of chemical engineering. The enduring hallmarks of this classic book are its scope and practical emphasis, which make it particularly popular with instructors and students who appreciate its relevance and clarity. This new edition provides coverage of the latest aspects of process design, operations, safety, loss prevention, equipment selection, and much more, including updates on plant and equipment costs, regulations, and technical standards. Includes new content covering food, pharmaceutical, and biological processes and the unit operations commonly used. Features expanded coverage on the design of reactors. Provides updates on plant and equipment costs, regulations, and technical standards. Integrates coverage with Honeywell's UniSim software for process design and simulation. Includes online access to Engineering's Cleopatra cost estimating software.

**Process Integration** Mahmoud M. El-Halwagi, 2006-04-06. With growing global competition, the process industries must spare no effort in insuring continuous process improvement in terms of increasing profitability, conservation of resources, and prevention of pollution. The question is how can engineers achieve these goals for a given process with numerous units and streams. Until recently, conventional approaches to process design and operation put emphasis only on individual units and parts of the process. A more powerful integrated approach was lacking. The new field of Process Integration looks towards the processing plant as a whole in its attempt to find solutions and improvements. Research over the past two decades has resulted in many techniques that allow engineers to better understand complex facilities and significantly enhance their performance. This textbook presents a comprehensive and authoritative treatment of the concepts, tools, and applications of Process Integration. Emphasis is given to systematic ways of analyzing process performance. Graphical, algebraic, and mathematical procedures are presented in detail. In addition to covering the fundamentals of the subject, the book also includes numerous case studies and examples that illustrate how Process Integration is solving actual industrial problems. Systematic methodology for analyzing the process as an integrated system, identifying global insights of the process, and generating optimum strategies and solutions. Proper mix of fundamental principles, insightful tools, and industrial applications. Generic techniques that are applicable to a wide variety of processing facilities. Packed with case studies, practical tools, charts, tables, and performance criteria. Extensive bibliography to provide ready access to process integration literature. Excellent review of state of the art, technology, development trends, and future research directions.

*Toward Zero Discharge* Tapas K. Das, 2005-04-08. This book discusses pathways to achieve pollution prevention and waste minimization at the sources leading toward zero.

discharge Coverage includes life cycle assessment industrial ecology eco industrial parks green engineering and sustainable chemical and allied processes and products development The pulp and paper industry is introduced as a case study in demonstrating how this industry is achieving pollution prevention goals by various techniques and how this industry has become a minimum impact industry moving towards achieving zero discharge status in most process areas Featuring a collection of expert authors this book is essential reading for industrial ecologists and engineers material scientists and state and federal officials

**Process Intensification in Chemical Engineering** Juan Gabriel Segovia-Hernández, Adrián Bonilla-Petriciolet, 2016-04-02 This book will provide researchers and graduate students with an overview of the recent developments and applications of process intensification in chemical engineering It will also allow the readers to apply the available intensification techniques to their processes and specific problems The content of this book can be readily adopted as part of special courses on process control design optimization and modelling aimed at senior undergraduate and graduate students This book will be a useful resource for researchers in process system engineering as well as for practitioners interested in applying process intensification approaches to real life problems in chemical engineering and related areas

Recent Advances in Sustainable Process Design and Optimization Dominic C. Y. Foo, Mahmoud M. El-Halwagi, Raymond R. Tan, 2012 This book is a compilation of the various recently developed techniques emphasizing better chemical processes and products with state of the art contributions by world renowned leaders in process design and optimization It covers various areas such as grass roots design retrofitting continuous and batch processing energy efficiency separations and pollution prevention striking a balance between fundamental techniques and applications The book also contains industrial applications and will serve as a good compilation of recent industrial experience for which the process design and optimization techniques were applied to enhance sustainability Academic researchers and industrial practitioners will find this book useful as a review of systematic approaches and best practices in sustainable design and optimization of industrial processes The book is accompanied by some electronic supplements i e models and programs for selected chapters

*Integrated Planning of Heat Flows in Production Systems* Denis Kurlé, 2018-02-10 The book presents an integrated planning concept for heat flows in production systems comprising various short term and long term related models Detailed explanations about the modeling and implementation of all relevant system elements such as generic and specific machines types technical building services TBS production planning and control aspects heat storage units and waste heat designs follow Due to resulting amounts of data the concept foresees system level appropriate indicators and visualizations for a facilitated evaluation of the model results An application procedure embeds and describes all models as well Three exemplary application cases demonstrate the applicability including the manufacturing of shafts for automotive transmissions a cooling water system and an academic learning environment

*Energy Optimization in Process Systems* Stanislaw Sieniutycz, Jacek Jezowski, 2009-05-06 Despite the vast research on energy optimization and process integration there has to date been no



synthesis linking these together This book fills the gap presenting optimization and integration in energy and process engineering The content is based on the current literature and includes novel approaches developed by the authors Various thermal and chemical systems heat and mass exchangers thermal and water networks energy converters recovery units solar collectors and separators are considered Thermodynamics kinetics and economics are used to formulate and solve problems with constraints on process rates equipment size environmental parameters and costs Comprehensive coverage of dynamic optimization of energy conversion systems and separation units is provided along with suitable computational algorithms for deterministic and stochastic optimization approaches based on nonlinear programming dynamic programming variational calculus Hamilton Jacobi Bellman theory Pontryagin s maximum principles and special methods of process integration Integration of heat energy and process water within a total site is shown to be a significant factor reducing production costs in particular costs of utilities for the chemical industry This integration involves systematic design and optimization of heat exchangers and water networks HEN and WN After presenting basic insight based Pinch Technology systematic optimization based sequential and simultaneous approaches to design HEN and WN are described Special consideration is given to the HEN design problem targeting stage in view of its importance at various levels of system design Selected advanced methods for HEN synthesis and retrofit are presented For WN design a novel approach based on stochastic optimization is described that accounts for both grassroot and revamp design scenarios Presents a unique synthesis of energy optimization and process integration that applies scientific information from thermodynamics kinetics and systems theory Discusses engineering applications including power generation resource upgrading radiation conversion and chemical transformation in static and dynamic systems Clarifies how to identify thermal and chemical constraints and incorporate them into optimization models and solutions

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