

MATERIAL AND ENERGY BALANCES CALCULATION FOR CHEMICAL PROCESS

MODULE 3 PART 1 – Material and Energy Balances
ChE 45 – Chemical Engineering Design 1
Lapeña, Don Kim S.

INTRODUCTION

As pre-requisites of any material or energy balance calculation for a chemical process, we should already have:

- A complete **block flow plant diagram**
- Targeted **production rate** or available raw materials feed rate. Either is set as part of the basic design bases.

MATERIAL BALANCE

A material balance taken **over the complete process** will determine the quantities of raw materials required and products produced.

Balances over individual process units set the process stream flows and compositions:

How do we begin the MB calculation for our designed process? Refer to:

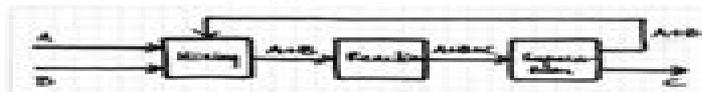
- The complete block flow plant diagram, and the
- Targeted production rate or available raw materials (RM) feed rate (either is set as part of the basic design bases).

Where do we start our calculation (calculation basis)?

- Production rate if RM/feedstock do not have supply restriction.
- RM feed if feedstock's have supply constraints which could be due to seasonality, inherent low supply, very high cost, difficult transportation, etc.

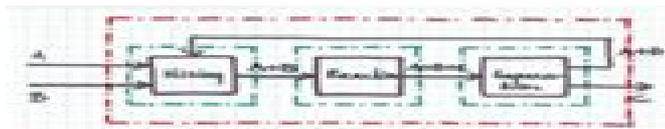
MATERIAL BALANCE REVIEW

In order to visualize the process, you can draw a simple **block flow diagram** that shows the material flows and the process steps. You can also give names (or numbers) to the flows and the process steps and write known or given data (inc. T, P, concentration, other relevant parameters) regarding the flows or the process conditions in the diagram.



We can also choose boundaries (ways to choose balance boundaries):

- An overall balance boundary around the entire process (including the recirculation)
- Balance boundaries around each process step (Mixing, Reaction, Separation)
- Partial mass balances for components A, B, or C using the same balance boundaries as in the first two choices.



Sometimes, you only need one balance to find out what you need while at other times you might need all these balances as well as additional information.

The additional information needed can be any of the following:

- Stoichiometry of the chemical reaction
- Limiting conditions for the reaction
- The extent of reaction or the reaction kinetics including heat effects
- The separation efficiency
- Recirculation ratio

The solution can be found by solving a **single equation** or by solving a **system of many equations** either algebraically or numerically.

The more we decide to be more detailed in our analysis, **the more complicated** will the solution process.

CONTINUOUS OR BATCH PROCESS CALCULATIONS

Continuous – We are more used to continuous process in our MB calculations. Generally, only algebraic linear equations will mathematically model this process.

Batch – required the estimation of processing times, among other requirements. Differential equations will be the usual mathematical model to be used.

SUPPLEMENTAL LEARNING MATERIALS

Refer to Chapter 2 of Chemical Engineering Design by R.K. Sinnott (4th edition)

Review the following topics, study the example problems:

- Choice of system boundary
- Choice for basis of calculation
- Number of independent components
- Constraints on flows and compositions
- General algebraic method
- Tie components
- Excess reagent
- Conversion and yield
- Recycle processes
- Purge
- By-pass
- Unsteady-state calculations
- General procedure for MB problems

Introduction To Material Energy Balances Solution

**Gintaras V. Reklaitis, Daniel R.
Schneider**



Introduction To Material Energy Balances Solution :

Introduction to Material and Energy Balances Gintaras V. Reklaitis, Daniel R. Schneider, 1983 A thorough introduction to balance equation concepts Geared for the course offered to chemical engineering majors in their sophomore year Develops a framework for the analysis of flowsheet problem information with extensive use of degree of freedom analysis Presents systematic approaches for manual and computer aided solution of full scale balance problems Provides a detailed development of the structure properties and interrelationships of species and element balances based on the algebraic view of reaction stoichiometry and the rate of reaction concept Material And Energy Balances For Engineers And Environmentalists (Second Edition) Colin William Oloman, 2023-06-20 Material and energy M E balances are fundamental to biological chemical electrochemical photochemical and environmental engineering disciplines and important in many fields related to sustainable development This comprehensive compendium presents the basic M E balance concepts and calculations in a format easily digested by students engineering professionals and those concerned with related environmental issues The useful reference text includes worked examples for each chapter and demonstrates process balances in the framework of M E concerns of the 21st century The additional problems and solutions in the Appendix embrace a wide range of subjects from fossil fuels to fuel cells solar energy space stations carbon dioxide capture and sodium ion batteries *Modeling, Analysis and Optimization of Process and Energy Systems* F. Carl Knopf, 2011-12-14 Energy costs impact the profitability of virtually all industrial processes Stressing how plants use power and how that power is actually generated this book provides a clear and simple way to understand the energy usage in various processes as well as methods for optimizing these processes using practical hands on simulations and a unique approach that details solved problems utilizing actual plant data Invaluable information offers a complete energy saving approach essential for both the chemical and mechanical engineering curricula as well as for practicing engineers *Material and Energy Balance Computations* Ernest J. Henley, Edward Marshall Rosen, 1969 Principles of Chemical Engineering Processes Nayef Ghasem, Redhouane Henda, 2025-03-31 Principles of Chemical Engineering Processes Material and Energy Balances continues to serve an essential text guiding students on the basic principles and calculation techniques used in the field of chemical engineering and providing a solid understanding of the fundamentals of the application of material and energy balances This third edition has been updated to reflect advances in the field and feedback from professors and students Packed with illustrative examples and case studies this book Features learning objectives and homework problems in every chapter new material on software modeling and additional and enhanced solved examples and problems Discusses problems in material and energy balances related to chemical reactors and explains the concepts of dimensions units psychrometry steam properties and conservation of mass and energy Demonstrates how Python MATLAB and Simulink can be used to solve complicated problems of material and energy balances and now features an introduction to the basics of building Simulink models

Demonstrates how Python and its libraries such as NumPy and SciPy can be used to solve complex problems in material and energy balances and introduces the basics of building models using Python frameworks similar to Simulink Shows how to solve steady state and transient mass and energy balance problems involving multiple unit processes and recycle bypass and purge streams Develops quantitative problem solving skills specifically the ability to think quantitatively including numbers and units the ability to translate words into diagrams and mathematical expressions the ability to use common sense to interpret vague and ambiguous language in problem statements and the ability to make judicious use of approximations and reasonable assumptions to simplify problems Offers educational software and sample tutorials and quizzes for download Aimed at both chemical engineering students and professionals this book helps readers understand how to calculate manage and apply the key ideas of material and energy use in chemical processes through real world examples Lecture slides and a solutions manual are available with qualifying course adoption

Mass and Energy Balances Seyed Ali

Ashrafizadeh, Zhongchao Tan, 2018-01-10 This textbook introduces students to mass and energy balances and focuses on basic principles for calculation design and optimization as they are applied in industrial processes and equipment While written primarily for undergraduate programs in chemical energy mechanical and environmental engineering the book can also be used as a reference by technical staff and design engineers interested who are in and or need to have basic knowledge of process engineering calculation Concepts and techniques presented in this volume are highly relevant within many industrial sectors including manufacturing oil gas green and sustainable energy and power plant design Drawing on 15 years of teaching experiences and with a clear understanding of students interests the authors have adopted a very accessible writing style that includes many examples and additional citations to research resources from the literature referenced at the ends of chapters

Steady and Unsteady State Balances American Institute of Chemical Engineers, 1987

Transactions of the American Institute of Mining, Metallurgical and Petroleum Engineers American Institute of Mining, Metallurgical, and Petroleum Engineers, 1974 Some vols 1920 1949 contain collections of papers according to subject

AIChEMI Modular Instruction American Institute of Chemical Engineers, 1981

Material and Energy Balances

Stanford William Briggs, 1963

Food Process Engineering Operations George D. Saravacos, Zacharias B.

Maroulis, 2011-04-11 A unique and interdisciplinary field food processing must meet basic process engineering considerations such as material and energy balances as well as the more specialized requirements of food acceptance human nutrition and food safety Food engineering therefore is a field of major concern to university departments of food science and chemical and biological engineering as well as engineers and scientists working in various food processing industries Part of the notable CRC Press Contemporary Food Engineering series Food Process Engineering Operations focuses on the application of chemical engineering unit operations to the handling processing packaging and distribution of food products Chapters 1 through 5 open the text with a review of the fundamentals of process engineering and food processing technology

with typical examples of food process applications The body of the book then covers food process engineering operations in detail including theory process equipment engineering operations and application examples and problems Based on the authors long teaching and research experience both in the US and Greece this highly accessible textbook employs simple diagrams to illustrate the mechanism of each operation and the main components of the process equipment It uses simplified calculations requiring only elementary calculus and offers realistic values of food engineering properties taken from the published literature and the authors experience The appendix contains useful engineering data for process calculations such as steam tables engineering properties engineering diagrams and suppliers of process equipment Designed as a one or two semester textbook for food science students Food Process Engineering Operations examines the applications of process engineering fundamentals to food processing technology making it an important reference for students of chemical and biological engineering interested in food engineering and for scientists engineers and technologists working in food processing industries **SPE Reprint Series** , *Society of Petroleum Engineers Journal* Society of Petroleum Engineers of AIME.,1974 *Elementary Principles of Chemical Processes* Richard M. Felder,Ronald W. Rousseau,Lisa G. Bullard,2020-08-11 This best selling text prepares students to formulate and solve material and energy balances in chemical process systems and lays the foundation for subsequent courses in chemical engineering The text provides a realistic informative and positive introduction to the practice of chemical engineering **Proceedings** American Society for Engineering Education. Conference,1992 **Chemical Industry News** ,1984 Theoretical Chemical Engineering Abstracts ,1984 The International Journal of Engineering Education ,1992 **Handbook on Material and Energy Balance Calculations in Metallurgical Processes** H. Alan Fine,Gordon Geiger,1993 This book approaches the subject of material and energy balances from two directions First it emphasizes the fundamental principles of the conservation of mass and energy and the consequences of these two principles Second it applies the techniques of computational chemistry to materials processing and introduces new software developed by the author especially for material and heat balances The third edition reflects the changes in the professional engineer s practice in the last 30 years reflecting the dramatic shift away from metallurgical engineering and the extractive industry towards materials engineering A large and growing number of recent graduates are employed in such fields as semiconductor processing environmental engineering and the production and processing of advanced and exotic materials for aerospace electronic and structural applications The advance in computing power and software for the desktop computer has significantly changed the way engineers make computations and the biggest change comes from the computational approach used to solve problems The spreadsheet program Excel is used extensively throughout the text as the main computational engine for solving material and energy balance equations and for statistical analysis of data The use of Excel and the introduction of the add in programs enables the study of a range of variables on critical process parameters and emphasis is placed on multi device flowsheets with recycle bypass and purge

streams whose material and heat balance equations were previously too complicated to solve by the normally used hand calculator The Excel based program FlowBal helps the user set up material and heat balance equations for processes with multiple streams and units

Mass and Energy Balances in Materials Engineering Mark A. Schlesinger, 1996 This text takes a practical approach to its presentation of stoichiometry and energy balance principles for materials engineering students by emphasizing their use in actual engineering practice

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