Mass Transfer Operations I - Web course

COURSE OUTLINE

The importance of Mass Transfer operations in chemical processes is insightful. There is scarcely any industrial process that does not require a preliminary purification of raw materials or final separation of products. This is the realm of mass transfer operations. The mass transfer operations are largely the responsibility of chemical engineers, but increasingly practitioners of other engineering disciplines are finding them necessary for their work. The objective of this course is to provide a means to teach undergraduate chemical engineering students the basic principles of mass transfer and to apply these principles, aided by computational tools, to the design of equipment used in separation processes. The material treated in this course will cover six chapters. Chapters are divided into sections with clearly stated objectives at the beginning. This framework of this course outlined may be useful to further understanding of any other type of mass transfer operations. Abundant of problems are solved to illustrate the concepts equipment used in separation processes. The material treated in this course will cover six chapters. Chapters are divided into sections with clearly stated objectives at the beginning. This framework of this course outlined may be useful to further understanding of any other type of mass transfer operations. Abundant of problems are solved to illustrate the concepts clearly. Some end-of-chapter problems are included accompanied by their answers.

Contents:

Introduction: Introduction to Mass transfer operation, Assignment and short type questions; Diffusion: Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, Diffusion through variable cross-sectional area, Diffusion coefficient: measurement and prediction, Measurement of liquid-phase diffusion coefficient, Multicomponent diffusion, Diffusivity in solids and its applications, Assignment and short type questions; Mass transfer coefficients: Introduction to mass transfer coefficient, Equimolar counter-diffusion of A and B (NA = -NB), Correlation for convective mass transfer coefficient, Correlation of mass transfer coefficients for single cylinder, Theories of mass transfer, Penetration theory, Surface Renewal Theory, Boundary Layer Theory, Interphase mass transfer theory, Overall mass transfer coefficients, Assignment and short type questions; Absorption: Introduction to absorption, Design of packed tower, Design of packed tower based on overall mass transfer coefficient, Counter-current multi-stage absorption (Tray absorber), Continuous contact equipment, Absorption with chemical reaction, Absorption accompanied by irreversible reactions, Absorption resistance, Assignment and short type questions; Distillation: Introduction to distillation, Distillation columns and their process calculations, Continuous distillation columns, Analysis of binary distillation in trayed towers: McCabe-Thele Method, Determination of the stripping section operating line (SOL), Analysis of binary distillation by Ponchon-Savarit Method, Stepwise procedure to determine the number of theoretical trays, Introduction to Multicomponent Distillation, Assignment and short type questions; Humidification and air conditioning: Basic concepts, Adiabatic saturation temperature, Humidification and dehumidification operations and design calculations, Mechanical Draft Towers: forced draft towers and induced draft towers, Design calculations of cooling tower, Key points in the design of cooling tower and Step-by-step design procedure of cooling tower, Evaporation loss of water in cooling tower, Example problems on humidification, Example problems on dehumidification; Multicomponent absorption.

COURSE DETAIL

SN	Modules	Lecture Contents	Lectures No. (Coordinator)
1	1. INTRODUCTION	Introduction to Mass transfer operation	1 (SKM)

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

Additional Reading:

Literature published in different journals or books

Coordinators:

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		Assignment and short type questions	SKM
2	2. DIFFUSION	Fick's law of diffusion	1(CD)
3		Steady state molecular diffusion in fluids under stagnant and laminar flow conditions	2(CD)
4		Diffusion through variable cross-sectional area	3(CD)
5		Diffusion coefficient: measurement and prediction	4(CD)
6		Measurement of liquid-phase diffusion coefficient	5(CD)
7		Multicomponent diffusion	6(CD)
8		Diffusivity in solids and its applications	7(CD)
		Assignment and short type questions	CD
9	3. MASS TRANSFER COEFFICIENTS	Introduction to mass transfer coefficient	1(SKM)
10		Equimolar counter-diffusion of A and B ($N_A = -N_B$)	2(SKM)
11		Correlation for convective mass transfer coefficient	3(SKM)
12		Correlation of mass transfer coefficients for single cylinder	4(SKM)
13		Theories of mass transfer	5(SKM)
14		Penetration theory, Surface Renewal Theory, Boundary Layer Theory	6(SKM)
15		Interphase mass transfer theory	7(SKM)

16		Overall mass transfer coefficients	8(SKM)
		Assignment and short type questions	SKM
17	4. ABSORPTION	Introduction	1 (CD)
18		Design of packed tower	2 (CD)
19		Design of packed tower based on overall mass transfer coefficient	3(CD)
		Counter-current multi-stage absorption (Tray absorber)	4(CD)
20		Continuous contact equipment	5(CD)
22		Absorption with chemical reaction	6 (SKM)
23		Absorption accompanied by irreversible reactions	7(SKM)
24		Absorption resistance	8(SKM)
		Assignment and short type questions	CD
25	5. DISTILLATION	Introduction	1(SKM)
26		Distillation columns and their process calculations	2(SKM)
27		Continuous distillation columns	3(SKM)
28		Analysis of binary distillation in trayed towers: McCabe-Thele Method	4(SKM)
29		Determination of the stripping section operating line (SOL)	5(SKM)

30		Analysis of binary distillation by Ponchon-Savarit Method	6(SKM)
31		Stepwise procedure to determine the number of theoretical trays	7(SKM)
32		Introduction to Multicomponent Distillation	8(SKM)
		Assignment and short type questions	SKM
33	6. HUMIDIFICATION AND AIR CONDITIONING	Basic concepts	1(CD)
34		Adiabatic saturation temperature	2(CD)
35		Humidification and dehumidification operations and design calculations	3(CD)
36		Mechanical Draft Towers: forced draft towers and induced draft towers	4(CD)
37		Design calculations of cooling tower	5(CD)
38		Key points in the design of cooling tower and Step-by-step design procedure of cooling tower	6(CD)
39		Evaporation loss of water in cooling tower	7(CD)
40		Example problems on humidification	8(CD)
41		Example problems on dehumidification	9(CD)
SM	SPECIAL MODULE:	Multicomponent absorption	1(SKM)

References:

Text books:

1. Dutta, B.K., “Principles of Mass transfer and Separation Processes”. Prentice-Hall of India, New Delhi (2007).
2. Geankoplis, C.J., “Transport Processes and Separation Process Principles”. 4th Edition, Prentice-Hall of India, New Delhi (2005).
3. Hines, A. L.; Maddox, R. N., Mass Transfer: Fundamentals and Applications, Prentice Hall; 1 Edition (1984).
4. McCabe, W. L. and Smith, J. C., Unit Operations of Chemical Engineering, (3rd ed.), McGraw-Hill (1976).
5. Seader, J.D. and Henley, E.J., Separation Process Principles, Wiley, New York (1998).
6. Treybal, R. E., “ Mass-Transfer Operations”, 3rd Eddition, McGraw-Hill (1981)

Reference books/Journals:

1. Danckwerts, P. V., Gas-liquid reactions, McGraw-Hill Book Co., New York (1970).
2. Deckwer, W.-D., Bubble Column Reactors, Wiley, Chichester (1992).
3. Ghosal, S.K., Sanyal, S.K. and Dutta, S., Introduction to Chemical Engineering, Tata McGraw Hill Book Co. (2004).
4. Gilliland, E. R., Multicomponent Rectification: estimation of number of theoretical plates as a function of reflux ratio, Ind. Eng. Chem., 32, 1220-1223 (1940).
5. Hikita H. and Asai, S. Kagaku Kogaku 27, 823 (1963).
6. Kirkbride, C. G., Petroleum Refiner 23(9), 321 (1944).
7. McCabe, W. L., Thiele, E. W., Graphical Design of Fractionating Columns, Ind. Eng. Chem. 17, 605 (1925).
8. Molokanov, Y. K., Korabline, T. R., Mazuraina, N. I. and Nikiforov, G. A., An Approximate Method for Calculating the Basic Parameters of Multicomponent Fractionation, International Chemical Engineering, 12(2), 209 (1972).
9. Van Krevelen D.W. and Hoftijzer P.J., Rec. Trav. Chim., 67, 563 (1948).
10. Wankat, P. C., Equilibrium Staged Separations: Separations for Chemical Engineers, Elsevier (1988).
11. Wellek R. M, Brunson R. J. and Law, F. H., Canadian Journal of Chemical Engineering, 56, 181 (1978)