BASIC PRINCIPLES AND CALCULATIONS IN CHEMICAL ENGINEERING

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PRE-REQUISITES : 10+2 Examination in science

INTENDED AUDIENCE : Chemical,BioChemical, chemical science and Technology / Chemical Engineering Petroleum science and technology

INDUSTRIES APPLICABLE TO : Industrial Reseach and development section of chemical and Biochemical Engineering

COURSE OUTLINE :

The objective of the course is to introduce chemical engineering students to the basic principles and calculation techniques used in the chemical industries and to acquaint them with the fundamentals of the material and energy balances as applied to chemical engineering processes. The course is mainly intended for graduate chemical engineering student. It will expose them to solve the problems in material and energy balances that arise in relation to the problems involving in different chemical process units. It also will introduce them to numerical methods used to solve the problems. The course will introduce in simple language and ample of examples so that it will encourage learners to get used to the course.

ABOUT INSTRUCTOR :

Prof. Subrata Kumar Majumder is a Professor in the Chemical Engineering Department, IIT Guwahati, India. His research interests include multiphase flow and reactor development, hydrodynamics in multiphase flow, mineral processing, process intensifications and micro-nano bubble science and technology and its applications. He is a Fellow of the International Society for Research and Development, 8A Kapteinsvigein, London, UK. He is also a recipient of various honours and awards like: Editor, Journal of Chemical Engineering Research Studies, Guest editor, American Journal of Fluid Dynamics, published by Scientific & Academic Publishing Co., CA, 91731, USA, Editorial board member of Scientific Journal of Materials Science, IIME Award on beneficiation from Indian Institute of Mineral Engineers (IIME), Editorial board Member of the Journal of Science and Technology, Scientific and Academic Publishing, USA, Advisory board member of Excelling Tech Publishers (ETP), London, UK. He is a life member of Indian Institute of Chemical Engineers, Indian Institute of Mineral Engineers, member of Institute of Engineers (India), Member of Asia-Pacific Chemical, Biological & Environmental Engineering Society (PCBEE), senior member of International Association of Engineers (IAE), Japan. He authored four books, five book chapters, and has more than 80 publications in several reputed international journals. Presently he is working in the field of Microbubble science and technology and its applications in mineral beneficiation, food processing and arsenic, ammonia and dye removal and process intensifications by developing ejector-induced gas aided extraction process.

COURSE PLAN :

Week 1: Introduction
Contents:
Definition, history and role of chemical engineers: Definition of chemical engineering, role of chemical engineers in society
Basic features of chemical process: Classifications and modes of chemical processes; basic features of chemical process and unit operation
Unit systems and dimensions: Dimensional homogeneity and its analysis, Analysis of problem with solution

Week 2: Process Variables and Rate
Contents:
Variables and properties of material in systems: Physical and transport properties of materials and mixtures, Analysis of problem with solution
Pressure and temperature of flow process: Pressure and temperature and their measurements in flow process, problem solving
Rate of chemical processes: Flow rate and its measurements, Flow rate and its measurements, Rate of momentum transfer, Rate of heat transfer, Rate of mass transfer, Analysis of problem with solution Solving problems3

Week 3: Fundamentals of Material Balance
Contents:
Principles of material balance and its calculation: basis of engineering calculations, the general material balance equation, Balances on single and multiple unit processes without reaction, Solving problems
Material balances on non-reactive processes: Material balances on non-reactive processes with recycle and bypass, Solving problems
Material balances on reactive processes: Material balances on reactive processes, Solving problems
Material balances on combustion processes: Material balances based on combustion reactions, Solving problems

Week 4: Basic Principles of Compressible System
Contents:
State equation of ideal gas and calculation: Basic equations of state for ideal gas and their calculations;
State equation of non-ideal gas and calculation: Basic equations of state for non-ideal gas and their calculations

Week 5: Basic Principles of Multiphase System
Contents:
Phase equilibrium and Vapour Pressure: Phase equilibrium, Gibb's phase law, Clausius-Clapeyron Equation, Antoine's Equation, Cox Chart
Equilibrium laws: Raoul's Law, Henry's law, volatility, their calculations with examples
Saturation and Humidity: Principles of saturation, humidity, Psychometric chart and its use, problem solving
Process of phase change: Condensation, vaporization, Examples

Week 6: Energy and Its Forms

Contents:

Principles of Energy: concepts and units, Different forms of energy and their calculations, The general energy balance equation

Laws and Properties of thermodynamics: Laws of thermodynamics, definitions of thermodynamic properties like Heat capacity, enthalpy, entropy; Calculation of enthalpy changes (without change of phase), enthalpy changes for phase transitions

Heat of formation, reaction and solution: Definition and calculations

Week 7: Energy Balances on Non-reactive Processes

Contents:

The mechanical energy balance: basic understanding with example

Enthalpy balances without reaction: basic understanding with example

Energy balances on non-reactive processes of multiple inlet and outlet streams: basic understanding with example

Enthalpy balances for heat of solution: Analysis with example

Week 8: Energy Balances on Reactive Systems

Contents:

Energy balance with standard heat of reaction: basic understanding with example

Energy balance with heat of reaction: basic understanding with example

Energy balances on heat of combustion: basic understanding with example

Week 9: Balances on Unsteady State Processes

Contents:

Material balances of unsteady state process: basic understanding with example

Unsteady state energy balance: basic understanding with example; Example of simultaneous material and energy balance

Week 10: Computational Techniques

Contents:

The methods of least squares: Linear equation fitting with experimental data with example

Non-linear algebraic equation system: basic understanding with example

Numerical Integration: basic understanding with example

Week 11: Computer-aided Balance Calculations

Contents:

Degree of freedom analysis: basic understanding with example

Process flow sheeting and codes: basic understanding

Week 12: Case Studies on Chemical Process

Contents:

Case study-I on chemical process: Analysis with example

Case study-II on chemical process: Analysis with example 3