Nirma University

Institute of Technology

Chemical Engineering Department

M.Tech in Environmental Process Design

1.1.3.1 PG-CH-EPD

3CH1109 Process Integration for Resource Conservation [3 0 0 3]

Course Learning Outcome:

After successful completion of the course, student will be able to

- understand the concepts of process integration for chemical industries
- apply various approaches for mass and heat integration methods in process industries
- analyse concept of pinch technology and its applications in heat and mass integration
- devise heat and mass exchanger network to minimize waste or to maximize the recovery of resources

Syllabus:

Mass Integration: Introduction to process synthesis, process analysis, process integration, categories of process integration, generating alternatives for debottlenecking and water reduction in chemical process, traditional approach to process development and improvement, targeting for minimum discharge of waste, Targeting for minimum purchase of fresh utilities, mass-integration strategies for alternate targets, graphical techniques for direct-recycle strategies, source–sink mapping diagram and lever-arm rules, selection of sources, sinks, and recycle routes, direct-recycle targets through material recycle pinch diagram, design rules from the material recycle pinch diagram. Algebric and graphical approach for synthesis of mass exchange networks. Case studies related to these topics.

Heat Integration: Introduction to pinch technology, hot composite curve, cold composite curve, problem table algorithm, grand composite curve, heuristics for pinch design, maximum energy recovery design, introduction to distillation integration. Case studies related to these topics.

Self Study:

The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. Mahmoud M El-Halwagi, Process Integration (Vol 7), Acedemic Press.
2. Robin Smith, Chemical Process Design and Integration, John Wiley and Sons. Ltd., New Delhi.
3. Uday V Shenoy, Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis, Gulf Professional Publishing.
4. Mahmoud M El-Halwagi, Pollution Prevention through Process Integration: Systematic Design Tools, Academic Press.

3CH1111 Occupational Health and Industrial Safety Management [3 0 0 3]

Course Learning Outcome:

After successful completion of the course, student will be able to

- understand the types and characteristics of major process hazards prevailing at the workplace
- analyse the organizational safety culture by applying the principles of ergonomics and their linkage with occupational health
- employ the principles of inherent safety and industrial hygiene towards accident prevention
- examine and devise appropriate safety criteria in design, process and operation
- demonstrate the application of qualitative and quantitative hazard identification and evaluation techniques to process industries

Syllabus:

Occupational Health: Introduction, need and importance of occupational health. Potential hazards in process industries.

Ergonomics: Its role in designing work place - work environment - effects of light, ventilation, vibration, noise etc -The work physiology and their relevance to safety - Performance evaluation of Man – Environment systems. Human factors – role of the operator, control room design, human error assessment methods

Safety in Design and Operation: Safety assurance in design, safety in operation and maintenance, organizing for safety, accident investigation and reporting. Design of fire fighting systems in process industries

Industrial Safety Management: Techniques with applications in process industries-Principles of Inherent Safety, Environment Risk assessment and Management, Process Hazard Checklists, Hazard and Operability Studies (HAZOP), Preliminary Hazard Analysis (PHA), Safety Reviews, Risk Assessment, Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Hazard Analysis (HAZAN), Failure Mode and Effect Analysis (FMEA). Maximum Credible accidents (MCA) analysis: Designs to Prevent Fires and Explosions, Hazard indices viz. Dow's fire and explosion Index (F & EI) and MOND index – degree of hazard – toxicity index, Emergency Planning, Preparedness and Response & Disaster Management Purpose and scope, onsite and offsite emergency plans and response, industry mock drills and related case studies, Disaster Management Plan, National and International Safety Codes, Protocols and Concerns, Policies and Legislations, Occupational Health & Safety Management Systems (OHSAS - 18001).

Case studies based on course content and related to process industries.

Self Study:

The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. Daniel . A. Crowl, Joseph F. Louvar, Chemical Process Safety – Fundamentals with applications, Prentice Hall International.
2. Bob Skelton, Process Safety Analysis: An Introduction, Institution of Chemical Engineers.
3. R. K. Jain, Sunil S. Rao, Industrial Safety, Health and Environment Management Systems, Khanna Publishers
4. Lawrence Slote., Handbook of Occupational Safety and Health, John Willey and Sons
5. K. U. Mistry - Fundamentals of Industrial Safety & Health, Siddharth Prakashan

3CH1113 Energy Audit of Process Utilities [3 0 0 3]

Course Learning Outcome:
After successful completion of the course, student will be able to

- understand fundamentals of energy audit methodology and approach
- apply fundamentals of process utilities
- identify energy saving opportunities in process utilities
- analyze the utility system for energy conservation and efficiency
- evaluate the performance of utility system and carry out energy audit

Syllabus:
Energy Audit: need and types of energy audit, Energy audit approach, understanding energy costs, bench marking, energy performance, matching energy use to requirement, energy audit instruments.
Energy Management: Concept, performance evaluation, identifying opportunities for energy savings, Energy utilization and energy saving opportunities in chemical process utilities like Steam system, Boiler, Furnace, Waste Heat Recovery systems, Refrigeration System, Fans, Compressors and blowers, Pumps and Pumping System, Cooling Tower.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.
References:

1. Bureau of Energy Efficiency (BEE) Energy Performance assessment for equipment and utility systems, Guide Books for National Certificate Examination.
2. Steve Doty, Wayne C. Turner, Energy management handbook, Fairmont Press, Inc, and Taylor & Francis Ltd.
3. Jack Broughton, Process Utility Systems – Introduction to design, Operation and maintenance, Butterworth-Heinemann.
4. Donald R. Wulfinghoff, Energy Efficiency Manual, Energy Institute Press
5. Y.P. Abbi , Shashank Jain,Handbook on Energy Audit and Environment Management, TERI Press
6. Mr. Pawan Kumar, Training Manual on Energy Efficiency for Small and Medium Enterprises, Asian Productivity Organization
7. Albert Thumann, Terry Niehus, William J. Younger, Handbook of Energy Audits, Atlantic Publisher

3CH1115 Principles of Water and Wastewater Treatment [3 0 2 5]

Course Learning Outcome:

After successful completion of the course, student will be able to

- understand concepts of physical, chemical and biological treatment of water and wastewater
- characterize water and wastewater
- analyse physicochemical & biokinetic models to various treatment systems for water and wastewater
- devise appropriate treatment flowsheet for treatment, recycle and reuse of wastewater

Syllabus:

Sample Collection and Analysis: Characteristics of water and wastewater, sampling techniques and sample preparation for water and wastewater. Traditional and advanced analytical techniques for various parameters in water and wastewater.

Physicochemical Treatment: various processes for water and wastewater quality control, Equalization, Neutralization, Aeration, Sedimentation, Coagulation and Flocculation, Filtration, Disinfection, Adsorption and Ion Exchange.

Biological Treatment: Monod kinetics and application in bioreactor design principles, Concepts, types and modifications of aerobic and anaerobic, suspended – growth and attached – growth treatments, Concepts of natural treatment systems, such as, Aerated lagoons, Stabilisation ponds, Oxidation ditches, etc.

Sludge treatment: Chemical, Biological, Incineration and disposal of sludge solids.

Advanced wastewater treatment: Nutrient removal treatments, Membrane Technologies, Advanced oxidation processes.

Reuses of wastewater: Concept of gray water, reuse and recycle of wastewater in industrial and agricultural purpose.

Self Study:

The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

Laboratory work:

Laboratory work will be based on above syllabus with minimum 12 experiments to be incorporated.

References:

1. Soli J Archeivala, Shyam R Asolekar, Wastewater Treatment for Pollution Control and Reuse, McGraw Hill Publications.
2. George Tchobanolous, Franklin L. Burton, H. David Stensel, Wastewater Engineering, Metcalf and Eddy Inc., McGraw Hill Publications.
3. Ronald L Droste, Theory and Practice of Water and Wastewater Treatment, Wiley International.
4. Mark J Hammer, Mark J Hammer Jr., Water and Wastewater Technology, Prentice Hall India Publications.

3CH1116 Air Pollution Control System Design [3 0 2 5]

Course Learning Outcome:
After successful completion of the course, student will be able to

- understand fundamentals of air pollution, major collection mechanism and equipments/instruments for a given gaseous or particulate pollutants
- calculate collection efficiency of a given pollution control system and evaluate various parameters that affect collection efficiency and cost
- select and design most appropriate air pollution control system for a given particulate or gaseous emission
- understand different methods for controlling emissions from stationary and mobile sources
- apply concept of air pollution control techniques to the professional society and general public

Syllabus:
Elements of air pollution: History of air pollution, Natural versus polluted atmosphere, Air quality and monitoring, Sources of air pollution, Effects of air pollution, Regulatory control of air pollution. Stack and ambient air sampling, Collection techniques for gaseous and particulate air pollutants.
Engineering control of air pollution: Control of stationery sources and mobile sources. Concept, Design of control device & system like industrial ventilation system, settling chambers, bag filters, inertial devices (cyclone separator), electrostatic precipitators, particulate scrubbers, etc. Control of vehicular air pollution: Vehicle emission standards and fuel quality, Inspection and certification programme. Catalytic converter– Concept, application and design.
Various models related to air pollution and treatment
Case studies from chemical industries: Air pollution assessment and control in petrochemical, pharmaceutical, dyes and intermediate and other process industries.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

Laboratory Work:
Laboratory work will be based on above syllabus with minimum 12 experiments to be incorporated.

References:

1. Kenneth Wark and Cecil F. Warner, Wayne T. Davis, Air pollution: Its Origin and Control, Addison Wesley Longman.
2. Martin Crawford, Air Pollution Control Theory, McGraw Hill.
3. B. P. Pundir, Engine Emissions: Pollutant formation and Advances in Control Technology, Narosa Publishing House.
4. Richard W Bouble, Donald L. Fox, D. Bruce Turner, Arthur C. Stern, Fundamentals of Air Pollution Control Techniques, Academic Press.
5. C. S. Rao, Environmental Pollution Control Engineering, New Age International Publishers.
6. M. N. Rao and H V. N. Rao, Air Pollution, Tata McGraw Hill Publishing.

3CH1114 Seminar - I [0 0 1 1]

Course Learning Outcome:

After successful completion of the course, student will be able to

- carry out critical literature survey
- acquire knowledge in specific area
- enhance technical report writing and presentation skills
- prepare the review articles

Syllabus:

A seminar topic on advance studies of chemical engineering and environmental engineering is allotted to each student. The student is required to submit the detailed report & present his/her work at different stages. The overall assessment is converted into grade in the above subject.

3CH1212 Environmental Laws and Management Practices [3 0 0 3]

Course Learning Outcome:
After successful completion of the course, student will be able to

- acquaint with various regulations and concepts of environmental management
- understand methodologies for environmental impact assessment and environmental auditing
- analyse environmental management and risk assessment systems
- acquire knowledge about various ISO standards, international legislation and protocols on environment
- demonstrate environmental management plan for chemical and allied industries

Syllabus:
Environmental Impact Assessment (EIA): Introduction to EIA, Evolution of EIA, Forecasting environmental changes, Strategic Environmental Assessment (SEA), Environmental clearance procedure in India, EIA documentation and processes, Preliminary stages of EIA, Impact prediction, evaluation and mitigation.
Environmental Auditing (EA): Introduction to EA, General audit methodology, Elements of audit process. Waste audits and pollution prevention assessments. EA in industrial projects, Liability audits and site assessment, Auditing of EMS. Environmental Technology Assessment (EnTA) and Eco-Management and Audit Scheme (EMAS) for industries. Life Cycle Assessment (LCA): Evolution of Life Cycle Assessment, Stages in product LCA, A code of good conduct for LCA, Procedure for LCA, Different applications of LCA
Environmental management system standards: Environmental Management Systems (EMS), EMS standard: ISO 14000 series, Implementation and benefits of EMS conforming to ISO 14000 series. Overview of environmental protection at state and central level. Familiarization with important sections and clauses of Environmental related Acts, Rules and Notifications, such as, Water Act, 1974, Cess Act, 1977, Air Act, 1981, Environmental Protection Act, 1986, Hazardous waste (Management and Handling) rules, etc., and their latest amendments.
International legislations and protocols on environment. International treaties and conventions; Stockholm Convention and Basal convention, Copenhagen conference; Rio-Earth summit, Montreal Protocol, etc. Case studies based on course content and related to process industries.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. Vijay Kulkarni and T.V. Ramachandra, Environmental Management, Capital Publishers.
2. Larry Canter, Environmental Impact Assessment, McGraw Hill Publishers.
3. Kailash Thakur, Environmental Protection Law and Policy in India, Deep and Deep Publishers.
4. Lewis Owen, Tim Unwin, Environmental Management: Readings and Case Studies, Wiley-Blackwell Publishers.
5. Corrado Clini, Ignazio Musu, Maria Lodovica Gullino, Sustainable Development and Environmental Management: Experiences and Case Studies, Springer Publishers.

3CH1213 Solid Waste Treatment and Management [3 0 0 3]

Course Learning Outcome:
After successful completion of the course, student will be able to

- understand the sources and types of solids, managements of municipal and industrial solid waste
- analyse and apply the concepts of recovery, reuse and recycling for management of solid waste
- understand the fundamentals of hazardous waste, biomedical waste and e-waste and its management
- devise solid waste management plan for different categories of solid waste

Syllabus:
Introduction: Types and sources of solid wastes, characteristics and collection. Solid waste volume reduction, storage and transportation.
Solid waste Treatment system: Physical, Chemical and Biological treatment systems. Reuse and recycling of solid waste - Incineration, Composting and composting plants. Ultimate disposal of solid waste -Sanitary landfills planning and design, methods and cost comparison.
Handling of hazardous wastes: Collection of hazardous wastes and care in handling quantities of hazardous wastes generated, storage of hazardous wastes, transportation and shipment of hazardous wastes. Final disposal of hazardous wastes: Site selection, incineration, land filling. Leachates, treatment and disposal.
Biomedical waste management: Concepts, treatment and legislations.
Electronic waste (e-waste) management: Concepts, treatment and legislations.
Case studies based on course content and related to process industries.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. George Tchobanoglous, Hilary Theisen and Samual A. Vigil, Integrated Solid Waste Management-Engineering Principles and Management issues, McGraw Hill Publishers.
2. Michael D. LaGrega, Phillip. L. Buckingham and Jeffery C. Evans. Hazardous Waste Management, Waveland Press Inc.
3. Edward A. McBean, Frank A. Rovers, Grahame J. Farquhar, Solid Waste Landfill Engineering and Design, Prentice Hall.
4. Amalendu Bagchi, Design of Landfills and Integrated Solid Waste Management, John Wiley & Sons.
5. Alfons Buekens, Incineration Technologies, Springer Press.

3CH1215 Wastewater Treatment Systems Design [3 0 2 5]

Course Learning Outcome:
After successful completion of the course, student will be able to

- understand design techniques for the wastewater treatment unit process
- apply the engineering design principles for the identification of appropriate treatment stage for effluents
- analyse existing treatment units for their treatment efficiencies
- demonstrate capability to design a process flow diagram and size of the essential units required to treat the effluent stream

Syllabus:
Basic Design Considerations: Flow sheet, Wastewater collection systems, estimation of wastewater flows, useful design parameters and ratios, calculation procedure
Preliminary and Primary Treatment: Design of units such as, sump, equalization tank, mixing, screens, grit chambers, sedimentation, coagulation and flocculation.
Secondary / Biological Treatment: Design of secondary treatment units such as, aerobic and anaerobic, suspended growth and attached growth bio reactors.
Sludge Treatment: Sources, characteristics and quantity of sludge production, sludge digestion through aerobic and anaerobic methods, sludge drying beds
Advanced Wastewater Treatment: Design of advanced treatment units such as, Nutrient removal units, Membrane treatment units, Advanced oxidation treatment units.
Various models related to water pollution and treatment. Case studies and flow sheets of wastewater treatment systems of chemical and allied industries.

Laboratory work:
Laboratory work will be based on above syllabus with minimum four design exercise to be incorporated.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. Soli J Archeivala, Shyam R Asolekar, Wastewater Treatment for Pollution Control and Reuse, McGraw Hill Publications.
2. George Tchobanolous, Franklin L. Burton, H. David Stensel, Wastewater Engineering, Metcalf and Eddy Inc., McGraw Hill Publications.
3. Ronald L Droste, Theory and Practice of Water and Wastewater Treatment, Wiley International.
4. Mark J Hammer, Mark J Hammer Jr., Water and Wastewater Technology, Prentice Hall India Publications.
5. G L Karia, R A Christian, Wastewater Treatment: Concepts and Design Approach, Prentice Hall India.

3CH1216 Chemical Process Design Principles [3 0 2 5]

Course Learning Outcome:
After successful completion of the course, student will be able to

- select and design of various equipments like heat exchanger, distillation column and absorption column
- select and design suitable separation method for overall process design
- analyse process development aspects
- perform simulation studies for various equipments and plant

Syllabus:
Equipment Design: Criteria & factors for design, Selection criteria of the particular separation methods and equipments, Overview of process design of following chemical engineering equipments like heat exchangers & condensers, rettle type and thermosyphon reboiler, tray and packed distillation column, absorption column.
Process Design: Steps in process design, importance of environmental and safety issues, Process synthesis and simulation to assist in process synthesis, Heuristics for process synthesis, Reactor design and reactor network synthesis, Synthesis of separation train, Reactor-Separator-Recycle network Recent developments in the area of process design.

Self Study:
The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

Laboratory Work:
Laboratory work will be based on above syllabus with minimum four experiments to be incorporated.

References:

1. Warran D Seider, J. D. Seader, Daniel R. Lewin, Product and Process Design Principles, Synthesis, Analysis and Evaluation, Wiley Publication.
2. R. K. Sinnott Chemical Engineering, Vol.6, An Introduction to Chemical Engineering Design, Butterworth-Heinemann Ltd.
3. Richard Turton, Richard C. Bailie,Wallance B. Whiting, Josheph A. Shaeiwitz, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall International.
4. James M. Douglas, Conceptual Design of Chemical Process, McGraw Hill Publications.

3CH1208 Green Technologies for Process Industries [3 0 0 3]

Course Learning Outcome:

After successful completion of the course, student will be able to

- understand various concepts and principles of green chemistry to improve atom economy
- understand various ways of waste minimization by using alternate safer and green solvents for cleaner production
- apply various tools and techniques of cleaner production
- analyse various methods and applications of cleaner production in process industries to reduce pollution load and increase energy efficiency

Syllabus:

Green Technology: Principles, concepts, and applications, concepts of waste minimization and atom economy. Use of conventional organic solvents and associated problems, environmentally benign solvents and their applications. Alternate Solvents- Safer and green solvents, water as solvents, solvent free conditions, ionic liquids, microwave technology and solvent free microwave assisted organic synthesis, Supercritical carbon dioxides an environmentally benign reaction medium for chemical synthesis, Supercritical fluid extraction, Sonochemistry and sonication reactions, Phase transfer catalysis, Photochemical reactions, etc.

Cleaner Production: End of Pipe vs Reduction at Source or Pollution Prevention Approach, necessity and potential of CP, tools and techniques of CP, Methodology and applications of Cleaner production,CP and energy efficiency integration, Barriers to CP and overcoming them, CP and MEA (Multilateral Environmental Agreement).

Case studies: Cleaner Production and Cleaner Technology applications in process industries.

Self Study:

The self study contents will be declared at the commencement of semester. Around 10% of the questions will be asked from self study contents.

References:

1. Paul M. Randall, Engineers' Guide to Cleaner Production Technologies, Technomic Publishing.
2. Mike Lancaster, Green Chemistry: An Introductory Text, RSC Publishing.
3. James H. Clark, Duncan J. Macquarrie, Handbook of Green Chemistry and Technology, Wiley-Blackwell Publishers.

3CH1214 Seminar - II [0 0 1 1]

Course Learning Outcome:
After successful completion of the course, student will be able to

- carry out critical literature survey
- acquire knowledge in specific area
- enhance technical report writing and presentation skills
- prepare the review articles

Syllabus:
A seminar topic on advance studies of chemical engineering and environmental engineering is allotted to each student. The student is required to submit the detailed report & present his/her work at different stages. The overall assessment is converted into grade in the above subject.

3CH1302 Project Part – I [0 0 0 15]

Course Learning Outcome:

The course provides an opportunity to the student to explore their knowledge in the area of their interest. Student will apply idea into application through experiments/ simulation. It will also help them to decide the project area / topic for further research work in their life. . As an outcome of the course, student will be able to develop:

- Problem formulation techniques.
- Analysis techniques of published data.
- Identification of scope and objectives of research work.
- Techniques for the design of experiments.
- Associated administration for project work.
- Development of compilation skill.
- Writing skill.
- Presentation skill.
- Technical Paper writing.
- Report preparation techniques.
- Fundamentals, information, reviews and in-depth knowledge in the desired area.

Syllabus:

The Major Part I is aimed at training the students to analyze independently any problem in the field of Environmental Process Design. The project may be analytical or computational or experimental or combination of them based on the latest developments in the said area. At the end of the semester, the students will be required to submit detailed report. The Major Project Part I should consists of objectives of study, scope of work, critical literature review of the Major Project and preliminary work pertaining to the said work.

3CH1402 Project Part – II [0 0 0 15]

Course Learning Outcome

The course provides an opportunity to the student to explore their knowledge in the area of their interest. Student will apply idea into application through experiments/ simulation. It will also help them to decide the project area / topic for further research work in their life. . As an outcome of the course, student will be able to develop:

- Problem formulation techniques.
- Analysis techniques of published data.
- Identification of scope and objectives of research work.
- Techniques for the design of experiments.
- Associated administration for project work.
- Development of compilation skill.
- Writing skill.
- Presentation skill.
- Technical Paper writing.
- Report preparation techniques.
- Fundamentals, information, reviews and in-depth knowledge in the desired area.

Syllabus:

Major Project Part II is a continuation of the work done by the student during semester III. The student is required to submit thesis as a partial fulfillment of the M. Tech degree. The thesis should consist of detailed study of the problem under taken, concluding remarks and scope of future work, if any. The project report (thesis) is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical, computational and experimental aptitude of the student.