TEE-810-Advanced Process Energy Analysis and Optimization – 3 CHs

Background

1. Give brief rundown of the existing programme.

    a. Industrial processes often have large utility requirements to heat and cool process streams to convert, separate and transport raw materials to products. Efficient use of utilities reduces operating costs and CO_2 emission per unit product.

    b. For chemical processing, this means that processes should use raw materials as efficiently as is economic and practicable, both to prevent the production of waste that can be environmentally harmful and to preserve the reserves of raw materials as much as possible.

    c. With current depleting energy resources of Pakistan, energy conservation remains the prime concern for many process industries.

    d. The first of its kind professional course in Pakistan "Advanced process energy analysis and optimization" is designed to reduce energy for processes and sites through better design. This is achieved through the application of pinch analysis, exergy analysis and energy optimization to issues concerning energy use, utility systems and power generation.

    e. An energy targeting and optimization software "SuperTarget" from KBC, which is used by multi-national EPC contractors like CB&I, Jacobs engineering and Fluor for energy optimization, will be introduced first time in Pakistan through this course.

    f. SuperTarget has automated tools for both grass roots and retrofit heat exchanger network design, which are backed up by multi-case data handling and continuous targeting throughout the design cycle. Continuous targeting gives a true picture of savings and potential in existing process industry.

Rationale

2. Rationale for offering/launching the new course. Due to old technologies and poor designs, there is considerable room in existing process industries of Pakistan for energy conservation and optimization.

a. It is essential to guide thermal energy engineers for both the design and selection of the steps as individual operations and their integration to form an efficient process focusing on energy conservation and optimization principles.

b. To design and develop the heat exchanger networks for energy optimization both in grassroots and retrofit cases.

Educational Objectives

3. Objectives of the programme under which the proposed course will be conducted are:

a. To discuss the essential concepts of energy conservation, integration and optimization in new and retrofit designs.

b. To describe the first law analysis.

c. To explain the pinch analysis for energy integration and targeting.

d. To provide the essential knowledge of heat exchanger network performance analysis.

e. To enlighten with the concept of exergy analysis.

f. To heat and power integration

g. To describe the heat exchanger equipment and retrofitting of heat exchanger networks.

h. To enable students to carry out energy integration analysis using SuperTarget.

i. To provide hands on training for energy optimization using MATLAB.

Input Obtained from Industry/Corporate Sector/Subject Specialists/Academia

4. The working paper has been sent to the Attock oil Refinery and Power Gen. Limited in order to obtain relevant feedback from the subject/Academia specialist.

International Practice

5. Specify the universities of repute where the proposed course is being conducted.

a. Technical University of Delft, The Netherlands

b. École Polytechnique Fédérale De Lausanne (EPFL), Switzerland

c. Telemark University College , Norway

Proposed Timeframe of Commencement

6. Spring semester 2016.

Course Contents

7. Give details of the course, on the following lines:

   a. Course Code TEE-810

   b. Title Advanced Process Energy Analysis and Optimization

   c. Credit Hours 3

   d. Objectives

   The objectives of this course are:

   (1) To elaborate the essential concepts of energy conservation, integration and optimization.

   (2) To explain the pinch analysis for energy integration and targeting.

   (3) To discuss in detail the first law analysis for process plants.

   (4) To enlighten with the concept of exergy analysis

   (5) To provide the essential knowledge of heat exchanger network performance analysis.

   (6) To describe the heat exchanger equipment and retrofitting of heat exchanger networks.

   (7) To enable students to carry out energy integration analysis using SuperTarget.

   e. **Outcomes**. The course should enable the student to:

   (1) Calculate targets ("best performance") for external heating/cooling with maximum heat integration.

   (2) Design of heat exchanger networks with minimum external heating/cooling with the fewest number of units and lowest possible total area in the heat exchangers.

   (3) Suggest energy optimal integration solutions for distillation columns, evaporators, heat and power systems (steam turbines with extraction), heat pumps and refrigeration.

   f. **General Competence**. The course will give the student insight on:

   (1) Systems thinking, the interaction between process equipment units and efficiencies.

   (2) Reasons for energy consumption (amounts and motives)

in industrial processes.

(3) Operational aspects in process plants.

(4) Structure of typical (generic) industrial processing plants.

(5) Brief introduction to the use of mathematical optimization within process design.

g. Contents with suggested contact hours.

No.	Topics	Book	Contact Hours
(1)	**The nature of process design and integration** • Process Design and Integration • The Hierarchy of Chemical Process Design and Integration • Continuous and Batch Processes • New Design and Retrofit • Approaches to Chemical Process • Design and Integration • Process Control	RS	3
(2)	**Heat Exchanger Networks I- Energy Targets** • Composite Curves • The Heat Recovery Pinch • Threshold Problems • The Problem Table Algorithm • Non-global Minimum Temperature Differences • Process Constraints • Utility Selection	RS	5

	• Furnaces • Cogeneration (Combined Heat and Power Generation) • Integration of Heat Pumps • Heat Exchanger Network Energy		
(3)	**Heat Exchanger Networks II – Capital and Total Cost Targets** • Number of Heat Exchange Units • Heat Exchange Area Targets • Number-of-shells Target • Capital Cost Targets • Total Cost Targets • Heat Exchanger Network and • Utilities Capital and Total • Costs – Summary	RS	5
(4)	**Heat Exchanger Networks III – Network Design** • The Pinch Design Method • Design for Threshold Problems • Stream Splitting • Design for Multiple Pinches • Remaining Problem Analysis • Network Optimization • The Superstructure Approach to Heat Exchanger Network Design • Retrofit of Heat Exchanger • Networks • Addition of New Heat Transfer Area in Retrofit	RS	8
(5)	**Heat Exchanger Networks IV – Stream Data** • Process Changes for Heat	RS	3

	Integration • The Trade-Offs Between Process Changes, Utility Selection, Energy • Cost and Capital Cost • Data Extraction • Exercises		
(6)	**Heat Integration** • Heat Integration of Reactors • Distillation columns • Evaporators and dryers • Steam systems and cogeneration • Cooling and refrigeration systems	RS	5
(7)	**Energy Targeting using SuperTarget** • Introduction to SuperTarget • Guided extended case study • Data extraction and targeting • MER design and evolution • Design report	-	8
(8)	**Energy Optimization** • Objective Functions • Single-variable Optimization • Multivariable Optimization • Constrained Optimization • Linear Programming • Nonlinear Programming • Profile Optimization • Structural Optimization • Solution of Equations using Optimization	FZ	8
Total			45

h. Details of lab work, workshops practice (if applicable).

No lab is required.

i. Recommended Reading (including Textbooks and Reference books).

Ser	Title	Author(s)	Assigned Code	Remarks
1.	Chemical Process Design and Integration, John Wiley and Sons, New York, 2005.	R. Smith	RS	Text Book
2.	Product and Process Design Principles: Synthesis, Analysis and Design, John Wiley & Sons, New York, 2010.	W. D. Seider, J. D. Seader, D. R. Lewin, S. Widagdo	SL	Reference Book
3.	Pinch Analysis and Process Integration, second edition, Elsevier Ltd, 2006.	I. C. Kemp	CK	Reference Book
4.	Handbook of Process Integration, Woodhead Publishing, 2013.	J. Klemes	JK	Reference Book
5.	Energy and Process Optimization for the Process Industries, John Wiley & Sons, New York, 2014	Frank Zhu	FZ	Reference Book
6.	Energy Optimization in Process Systems, Elsevier Ltd, 2009.	S. Sieniutycz, J. Jeżowski	SJ	Reference Book