Process Systems Engineering A

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Master course in Chemical Engineering – Five Credits – Mandatory – First year, Second semester

Concise program

1. Introduction to Process Systems Engineering. History of the Computer Aided Process Engineering. Design from scratch, revamping, retrofitting, and process intensification.
2. Steady-state and dynamic simulation of continuous and discontinuous industrial processes. Cost estimation. Economic assessment of the CAPEX and OPEX terms. Classical conceptual design of an industrial process and evaluation of the economic potentials. Mixed-integer linear and non-linear programming for design purposes.
3. Dynamic conceptual design: a time-series analysis of the price/cost of commodities and utilities. Cost indexes for CAPEX terms. Discounted back approach to OPEX terms and dynamic simulation of future scenarios according to market demand, price/cost fluctuations, and uncertainties. Feasibility study under market fluctuations.
4. Economics: fixed capital investment and working capital. Evaluation of the capital investment. Short accounts on interest and investment, freight and insurance, depreciation, profitability, cash flow, and breakeven point.
5. Data reconciliation. Gross error detection. Coaptation. Model identification.
6. Process optimization: design mode; online mode; management/supervision. Hierarchical approach. The objective function and the structure of multidimensional continuous/discontinuous problems. Short accounts on scheduling, planning, and supply chain management (for batch and continuous processes).
7. Digital twins: conventional and advanced. Virtual Environments, Virtual Reality, and Augmented Virtual Reality. Integration of dynamic process simulation and dynamic accident simulation. The Plant Simulator.

Labs

The labs are based on the design and simulation of a chemical plant with UniSim Design™ and Aspen HYSYS™.

Note: the course is in English and all the material is in English as well.

Course Objectives

The course teaches how to design a new plant either grass roots or revamp it according to economic standards subject to both environmental and social constraints. This is achieved by applied case studies with labs based on the design and simulation of chemical plants with UniSim Design™ and Aspen HYSYS™ programs.

The course provides a systematic approach to the chemical design of plants based on either well-established processes or new ones. Further elements for revamping, intensifying, and retrofitting chemical processes are provided. In addition, the course teaches methods to perform data reconciliation of measured industrial data and make them consistent, identify gross errors, and determine quantities that are either not measured or unmeasurable.

The economic assessment of both fixed and variable costs is carried out by evaluating the corresponding capital and operative costs. Further elements of economic sustainability of industrial processes are provided to prepare the chemical engineer to cope with both the environmental and social pillars of sustainability and be able to optimize both the existing and new plants. Finally, the course provides a few elements of digital twins applied to chemical plants.

Expected learning results

The student will learn how to select the best candidate process and design the corresponding plant according to the client's specifications. The student will know how to make a detailed cost quantification of the plant in terms of capital and operative expenses and how to meet both the environmental and social constraints for sustainability. Good knowledge of process simulators based on a continuous hands-on approach throughout the whole course labs is assumed. The most important result achieved by the students is their capability to make critical decisions based on well-defined rules with the flexibility of an ever-changing horizon of specifications, laws, constraints, and optimal perspectives.

Prerequisites

Design of unit operations of chemical plants. Knowledge of the most important industrial/chemical processes and the main process variables that allow running and controlling them. Thermodynamics, kinetics. Familiarity with computers and some “programming language” tools (such as but not limited to Excel, MATLAB, Mathcad, Mathematica, …).

Exam rules

Assessment formality

The Process Systems Engineering A (PSE-A) final evaluation consists of:

- The preparation of a written report in English that is the summary of the ongoing labs based on the design of a specific chemical plant.
- An oral exam (that might switch to a written exam in case of a high number of students and according to their average preparation).

The PSE-A final mark will be valid for 365 days, starting from the official day of the exam session concerned.

The final grade of the Process Systems Engineering A+B exam will be given by the arithmetic mean of the two PSE-A and PSE-B marks, eventually rounded up.