PROCESS DESIGN: A SYSTEMATIC APPROACH FOR LEARNING IN DEVELOPING COUNTRIES

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Abstract *- The Process Engineering education in developing countries for the next decades, requires to produce a new kind of engineer, quite different of the existing, already known profile. Traditionally ,the engineer in charge of processes has been mainly a technical administrator of thermal and chemical processes, these obviously created without his active participation and, as an unavoidable consequence of this fact, it has caused a weak influence of this engineer on the upgrading and optimization of above mentioned processes. A University in Colombia had faced the challenge to promote the overcoming of this existing situation, through a new education approach presented by its Process Engineering Department and as a result of a research project in education of this engineering field. In this paper, a new and systematic approach for Process Design learning is presented. This approach allows the integration of Chemical and Thermal Systems. It is expected that this new approach will generate a new kind of professional, one with more holistic, integrated knowledge and prepared to be aware of the role of energy in the industrial processes*.

INTRODUCTION

As the main frame of these research results, EAFIT University firmly supports the teaching and learning of Industrial Process Design as a key strategy to achieve a technological shift for the new generations of Process Engineers in Colombia, in the coming years.

Traditionally, Process Design Methodologies had been classified worldwide in three different approaches : Heuristic, Mathematic and Thermodynamic. The Process Engineering department of EAFIT University had prepared a reviewed syllabus that integrates some of these recognized methodologies in a systematic approach, for its under-graduated program in Process Engineering.

DESCRIPTION OF REVIEWED SYLLABUS

The Updated Process Engineering Curriculum includes 4 courses that frame the Process Design area , each one representing 4 credit hours:

- Design of Reactors,
- Process Design,
- Process Optimization and
- Process Simulation.

The above mentioned micro-curriculum courses promote the use of the latest textbooks and commercial software available for Process Design practices. Additionally, a modern Process Design Laboratory to support all the courses has been designed and constructed recently. In fact, these micro-curricula contain theoretical classes (40%), computational classes (40%) and laboratory practices (20%),also including several Industrial visits).
It is expected that this new approach will generate a new kind of professional, one with a more holistic, integrated knowledge and also prepared to be aware of optimization possibilities and the role of energy in the whole entity of industrial processes.

In order to achieve the above mentioned objectives, with this research project , 3 strategies have been proposed:

- Development of universal study cases that can be followed through the different courses of Process Design Area.This study cases are related with processing of national raw materials and final products with strategic meaning for Colombia.
- Use of different and modern computational tools ,
- Continuous support in the process design Laboratory (The first one built in Colombia)

STUDY CASES

Two typical Study Cases are presented here. All of them are being studied in with different focusing ,in at least, three courses of the Process Design area.

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Ethylene Glycol Production

This strategic material is not produced in Colombia.Therefore,we have chose this process as an important reflexive study case.

In the first course, the student is faced to understand the main differences between Analysis and Synthesis approach in process Design, through construction of the flowsheet of Ethylene Glycol production from ethane. Starting with mass balance data of raw materials and products, they have to construct the flowsheet of preparation equipment for reaction, reactors and separation units . During this first course, students perform modeling of the three reactors that compose the process: ethylene production from ethane in a Plug Flow Reactor (PFR), ethylene oxide production in a catalyst reactor and ethylene glycol production from hydrolysis of ethylene oxide in a Continuous Stirred Tank Reactor (CSTR).

In next courses, Ethylene Glycol production is complemented with the construction of other important Diagrams (Piping and Instrumentation Diagram P&ID, Utilities Diagrams, etc),continuing with analysis of the process Conditions and equipment design using an heuristic approach. All this allows to end with capital and manufacturing cost estimation, supported by specialized software.

A Colombian nitric acid plant revamping

Nowadays, the industrial processes used for fertilizers production in Colombia show a poor performance in both environmental and economic aspects. A nitric acid plant, which has a huge air contamination Index (9.2 kg NOx per ton of nitric acid 53% w/w produced) and a large cooling water consumption (32 ton per ton of nitric acid produced), is considered as study case.

In this study case, a Combined Methodology for Energy Integration (CMfEI) that allows to make usage of some advantages from Pinch Technology, Exergy Analysis and Thermoeconomics, is outlined.

Methodology application shows that there are many sources of exergy loss and irreversibilities in the process, caused by large temperature differences in heat transfer and several cases of bad allocations of heat exchangers. Therefore, several proposals of revamping can be formulated:

- process with major steam exportation,
- process focused in production of mechanical energy
- combination of steam exportation and mechanical energy production.

Proposed designs are discussed in class and students have to apply CMfEI to each one. Calculations of new Contamination Index are performed. Students found savings up to 30% in water consumtion and 10% in capital and manufacturing costs.

MODERN COMPUTATIONAL TOOLS

The Process Design Area is continuously looking for the most updated software available worldwide to support the learning of curriculum subjects. Some of them are listed as follows:

1. Visual Encyclopedia of Chemical Engineering Equipment, developed by Susan Montgomery at Michigan University.(USA)
2. Software for Process Simulation: Hysys Process V.2.2,and Aspen Plus.
3. Interactive Computer Modules, included in CD-Rom of Fogler textbook (1997).
4. Mathematical equation solvers
5. Capital Cost Estimation Software (Capcost) West Virginia University.(USA)
6. Spreadsheets for simpler modeling and simulation. Programming software for rigorous simulation (Matlab, Visual Studio)
7. Simatic WinCC for Process Control and Supervision
8. Pro-Engineer and Pipe Flo of Engineered Software(USA)

PROCESS DESIGN LABORATORY

This laboratory is specially oriented to support the 4 different courses that frame the Process Design area. It includes a complete Batch Reaction System and Process Simulators.

Batch Reaction system is composed of several main equipments as illustrated in following block overall diagram:

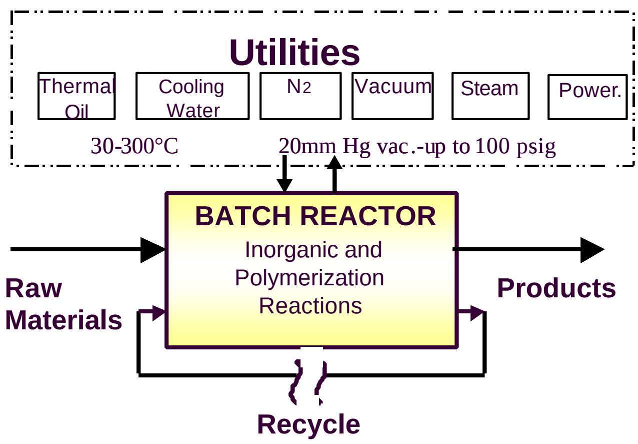

FIGURE 1.
INPUT/OUTPUT OVERALL DIAGRAM

The main Process subsystem includes:

- Agitated and Jacketed Reactor,
- Rectifying column,
- Shell and Tube Condenser,
- raw materials and Product tanks.

The utility system comprises:

- Heating thermal media (thermal oil) that heat up the reactor jacket up to 300 degrees Celsius,
- Central Cooling water system,
- Steam ejector (1 stage) to produce 20 inches Hg absolute pressure, using superheated steam.
- Inert gas injection (Nitrogen) to control the reactor pressure and avoid oxidative effects in some reactions.
- Compressed Air for pneumatic controls.

The automation of the complete batch reaction system includes the information interchange between the process control computer and the process according with the following diagram:

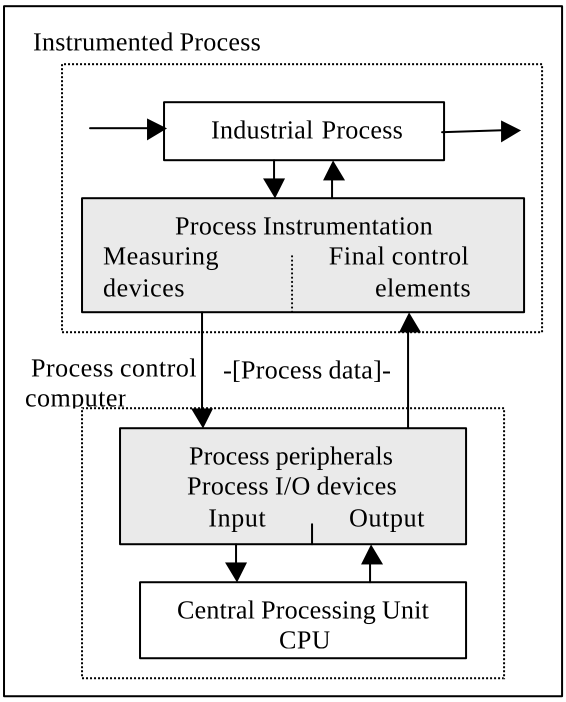

FIGURE 2.
PROCESS INFORMATION INTERCHANGE

The outstanding scope of the recently built laboratory includes: Academic objectives and Technological objectives.

Main academic objectives are directed to support Learning and Teaching of studies of :

- Chemical Reaction kinetics (Polymerization and Inorganic reactions)
- Thermodynamic Equilibrium
- Heat Transfer studies
- Power of Fluid Agitation
- Control Strategies (PID and Fuzzy Control)
- Process Simulation
- In line Quality Control
- Process control and Automation

Main technological objectives include:

- Research work in new kind of materials (i.e.biopolymers)
- Parametric Optimization of existing Industrial processes.
- Use of new control algorithms (Fuzzy logic)
- Data communication (Profibus and Intranet)
- Customized software development

CONCLUSIONS

1. The learning and practice of Process Design represents a great opportunity for under-graduated and post-graduated programs in process and chemical engineering education. Its learning may contribute for new engineers to construct a more deep, integrated and creative knowledge of process engineering .

2. The learning and teaching of Process design, should be an important strategy in developing countries, in order to allow that the engineering science may effectively contribute for the solution of existing problems in government and private sectors of these countries, including achievements in employment and international industrial competitiveness.

3. Supported in Process Design laboratory, in engineering software and in Process Simulation practice, the Academy may lead projects with private and government sectors that promote a closer relationship and mutual credibility among these important sectors of society.

4. Teaching of Process Design, requires that each different course, be integrated in a systemic pattern, avoiding the traditional unconnected treatment of different subjects.

5. The Process Design Laboratory, offers the opportunity to students and Academics to represent the industrial world in a very realistic approach, therefore these elements, represent a fundamental support for the process Design learning process,

because, they effectively can accelerate the comprehension of all the subsystems that integrate the whole industrial system and its relations.

6. The proposed pedagogic models for process design courses, promote the participation of different kind of disciplines: (mechanical, electric, process, control engineering) ,and therefore the teamwork skills of students,are reinforced.

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