**ABE 558 Spring 2019**

**Biological and Food Process Design**

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Lecture/lab Tue/Thurs 2:30-5:30pm Hicks Undergraduate Library G980D

**Course Learning Objectives:** Successful completion of the course will enable the students: to incorporate engineering and scientific principles into the analysis and design of a process to convert biological materials into higher valued products using a zero discharge minimum energy plant given economic, environmental, labor and energy constraints.

***Topics***

1. Design adsorption, distillation and membrane separation process

2. Evaluation of process/equipment alternatives

2. Evaluate the economic aspects of product costs

3.       Develop and conduct experiments and develop design algorithms to identify impact of process variables to improve product quality

4.      Develop sustainable processes to minimizing environmental, and energy impact

5.       Optimization (minimum cost maximum profit/zero discharge/minimum energy)

6. Develop Business Plan with consideration to Ethical, Global, Societal

***Emphasis***

7.       Improve computer skills to operate and schedule processes (SuperPro Designer/Scheduler)

8.       Work in teams to design a biological/food process

9. Review technical and patent literature

10. Communicate technical information

**Textbooks:**

Peters, M, K. Timerhaus, R. West, 2003, Plant Design and Economics for Chemical Engineers. 5th Edition, McGrall Hill , NY, NY.

Geankoplis, Christie, 2003, Tansport Processes and Separation Process Principles. 4th Edition, Prentice-Hall, Inc., Upper Saddle River, New Jersey.

**References:**

1. Ladisch, Michael, 2001 Bioseparations Engineering: Principles Practice, and Economics. John Wiley and Sons, Inc, New York

2.    Holland, F. A., J. Siquiros, S. Santoyo, C. L. Heard, and E. R. Santoyo.  1999.  Water Purification Using Heat Pumps.  Routledge, New York, N.Y.  184 p.

3.    Kessler, H. G.  1981.  Food Engineering and Dairy Technology.  Verlag A. Kessler, P.O. Box 1721, D-8050 Freising, F. R. Germany.  619 p.

4.    Mann, J. G. and Liu, Y. A.  1999.  Industrial Water Reuse and Wastewater Minimization.  R. Esposito (ed.), McGraw-Hill, New York, N.Y.  523 p.

5.       Perry, R. H. and Green, D. W.  1997.  Perry's Chemical Engineers' Handbook, 7th Edition.  R. H. Perry, D. W. Green, and J. O. Maloney (eds.), McGraw-Hill, New York, N.Y.

6.       Rotstein, E., R. P. Singh, and K. Valentas.  1997.  Handbook of Food Engineering Practice.  K. J. Valentas, E. Rotstein, R. P. Singh (eds.), CRC Press, Boca Raton, NY.

7.      Wales, S. M.  1988.  Chemical Process Equipment, Selection and Design, Butterworths Series in Chemical Engineering.  H. Brenner, A. Acrivos, J. E. Bailey, M. Morari, E. B. Nauman, and R. K. Prud'Homme (eds.), Butterworth Publishers, Stoneham, MA.  755 p.

8. Turton, R., R. C. Bailie, W. B. Whiting, and J. A. Shaewitz.  1998.  Analysis, Synthesis, and Design of Chemical Processes.  B. M. Goodwin (ed.), Prentice-Hall, Inc., Upper Saddle River, New Jersey.

9. Tzia, C and G. Laidakis, 2003. Extraction Optimization in Food Engineering. Marcel Dekker Inc. Monticello, NY.

10. Cussler and Moggridge 2011 “Chemical Product Design” 2nd edition Cambridge University Press

11. Shuler and Kargi 2002 “Bioprocess Engineering” 2nd edition Prentice Hall

**Course Outline – Topics: Subject to change with notice**

**Course Outline – Topics:**

* Design of Biological Separation Process
* Evaluation of Alternatives
* Process Cost Estimation and Engineering Economics and Analysis
* Profitability and Alternative Investment
* Optimal Design and Performance
* Process Control
* Business Plan Considerations/ Ethical, Global, Societal Considerations
* Plant Design

Equipment Materials Selection

Material handling / Plant layout / Material of construction -3A / Packaging

Water Purification, Treatment, and Reuse Byproduct recovery / conversion / Plant sanitation – CIP

Refrigeration and Steam Production/ Refrigeration cycles / Condensers - Evaporators / Compressors / Load Calculations/ heat recovery

Energy Recovery and Integration Hot water production - Steam / Distribution / Heat recovery

ADMINISTRATIVE POLICY:

Grading scale:

Homework 10%

Designs 30%

Quizzes 10%

Semester Project

Presentations 10%

Phase/Final Report 40%

1. **Submit ALL** assignments via Blackboard by 11:59pm on the day it is due. Late homework will be reduced 1% (of assigned point value) per day the first week (up to 5%), 10% per day (up to 50%) Extensions granted with valid rationale on an individual basis. ***Students will receive an “incomplete” for the course if they fail to submit all assignments via Blackboard by no later than the Monday after finals week.***
2. All reports/homework/assignments will be submitted on Blackboard using pdf format
3. Each assignment should be a report that includes methods, equations, and results of your code or calculations. Your commented code should be included as an appendix or an addition to their report. Do not just submit numbers and code without any explanation. If you choose to submit handwritten calculations, the images should also be included as an addition to the report, and not replace the report itself. Semester project reports must be accompanied by an executive summary, which will include the overall process and final results/conclusions from the assignment.
4. Include all code or calculations with each assignment as a runnable .m file.
5. Working with others is encouraged, however each student is required to do their own work. The grade will be divided by the number of individuals any assignment that is deemed to be too similar. Cheating will not be tolerated. Students will receive a ‘0’ for every assignment where cheating is found. If it happens more than once, further action will be taken and it could lead to a failing grade in the course.
6. Finally, cite your sources! Even within your code, make sure to properly cite your equations.

**Timetable for Process and Plant Design Project:**

The overall objective of the process design project is to develop optimal quality product using a zero discharge minimum energy plant, applying concepts covered in any of your classes at Purdue to the processes initiated in ABE 557. The project consists of five technical reports 1) product/process development-design improvement, 2) experimental results and economic analysis, 3) process optimization and control, 4) plant systems and 5) business plan. A written report will be required at the completion of each phase.

**Phase 1: Draft (Due Mar 5 )**  Product and Process Review and Update

1. Update the detailed review of technical and patent literature for product/process Ethical, Global, Societal Considerations. Review the current market demand and current market value.
2. Indicate the plant production rate (lb/month). Update the detailed equipment sizing calculations of all unit operations, heat exchangers, pumps, mixes, storage tanks, separation operations. Include in an appendix all relevant vendor materials specifications.
3. Review all process related resource requirements (water, heating and cooling loads with temperature ranges. Give a table of load breakdowns by equipment and load totals.
4. Estimate emissions (water and air) amount of waste from each unit operation.
5. Conduct a heuristic, morphological, functional and evolutionary analysis of the process (determine the function of each unit operation) and evaluation of alternatives.

**Phase 2: Draft Experimental Results and Economic analysis (Due March 26 )**

1. Experimental Results Based on last semesters developed Plackett-Burman experimental design or other DOE, resent results and identify the recipe and procedure used by the processing plant. This requires clearly defined processing steps including (but not limited to) temperatures, times, ingredients, methods so that the reader can duplicate the product. The product will be produced on a lab-scale. The intent of this phase is to understand the full production process of a product and how to analyze the quality of a product during manufacturing
2. Process/Plant Costs

a Purchase equipment cost - use the most recent 2016 MSI index

b Estimation of capital investment cost and total product costs - refer to text chapter 6 and use Table 9 to estimate plant ratio factors for a solid/fluid type of process. Include tables with headings as shown in text Table 18 with ratios used to perform estimations of total product costs.

**Phase 3: Process Control and Optimization (Due April 2)**

1. Process control Each member of the group will develop for their unit operation a block diagram of a process control system indicating sensors, valves, actuators

1. Optimal Design-Each member of group develop an economic optimal design of a specific unit operation.

**Phase 4: Plant systems: (April 9)**

1. Each member of the group will develop one of the topics
2. Application of HACCP concepts - include process diagram(s) and chart(s) Quality Assurance,/HACCP/ Safety and Validation// Ventilation/ air quality
3. Material handling / Plant layout / Material of construction -3A / Packaging
4. Water Purification, Treatment and Reuse
5. Byproduct recovery / conversion / Plant sanitation - CIP / Ventilation
6. Energy Integration: Hot water production - Steam / Distribution / Heat recovery - Refrigeration cycles / Condensers - Evaporators / Compressors / Load Calculations
7. Process scheduling of batch processes (each process should have several batch operation) (also relates to equipment sizing)

**Phase 5: Business Plan (Due April 16)** Technical report:

1. Market
2. Organizational/operation chart.
3. Economic Results TCI, TPC. ROI Economic Evaluation (Costs - preliminary cost estimation)
4. Financial Plan:

Profit and loss forecast

Discounted cash flow analysis

Break-even chart

**Phase 6: Poster/ Final Presentations**

1. **April 18 Poster in ADM building.**

April 14 Posters submitted for printing

April 19 Video taping of posters

Suggested Poster outline

Title/Group Members/

Overall Objective To develop a profitable business

Sub objectives (Design Zero Discharge Minimum Energy Plant

**Phase I**

Market Size, Process Description, literature, patents

Ethical, Global, Societal Considerations

Process Flow. Mat/Eng Bal.

Process Design/Sizing Calcs

Resource and emissions requirements

Experimental Design, Procedure

**Phase II and III**

Summary of laboratory experiments

Process/ Plant Design/Optimization/Controls

Each Members contribution

**Phase IV and V**

Business Plan, Economic Results TCI, TPC. ROI

Handouts with flow sheets, engineering and economic summaries

1. Brief process summary
2. Process systems review
3. Summary of laboratory experiments (samples)

Handouts with flow sheets, engineering and economic summaries

1. **(Dead Week) Apr 23 and 25 The final group oral presentation**

Sometime after spring break I will meet with each group periodically for 1/2 hour prior to the final presentations. We will meet during the class lecture and class lab sections. Please let me know if you group has a preference of which day you wish to meet.

Presentations are to made during dead week by each group during the class lecture/ lab sections. The entire class is required to attend and evaluate all of the presentations.

Gear your presentations toward the evaluation and synthesis levels of Bloom's Taxonomy.

Your final presentations should include the important results from each phase of your entire project and form the basis for your executive summary. Include specific facts. You should provide samples of your product. Your group should show how process conditions affect product quality

**Phase 7: (Due May 3)** **Final report** will be due on or before Friday of finals week. Final reports must be turned in by Fri May 3 including copies of major papers and patents referenced please submit entire report as a **single document** electronically. Please follow format outlined in course outline. Please include in your final report revised copies of each of your various reports for each Phase. Please pay particular attention to the executive summary which presents in specific detail a shorten version of your project report giving the important facts from each phase

Final Technical report:

Submit final written report in a business plan format:

Title page

Abstract

Executive Summary

Project objectives

Corrected technical report phases

Evaluations & Recommendation

Conclusions

Notation

References

Appendices

Experimental data

**Example Project Report – Outline**

**Objective** – Design system that will produce optimal quality products at minimum costs (maximum profits). Use business plan format.

**Process Design**

Product Description

Marketing Study

* Current Consumption
* Niche Market
* Proposed Sales

Literature Review

* Overview of Process
* Detailed review of technical and patent literature (emphasis on research needs)
* Recipe Options (ingredients temp. time)
* Ingredient Functionality
* Detailed Chemistry
* Microbial Issues (during each step)
* Quality Parameter (during each step)

Preliminary Research

Experimental Design

Test of Variables

* Variable Ranges
* Major Variables
* Minor Variables

Experimental Plan

Procedures – Detailed so that experiment can be duplicated

Results

Final Recipe

* Mass Balance/Energy Balance/Temperature & Times

Process Flow Chart

Process Alternatives

* 5 references
* 1 patent

M & E Balance

Preliminary Process Flow Sheet

* Alternatives
* A) Alternative Processing Methods to Produce Product
* B) Select and justify the best process

C) Discuss alternative methods and equipment for each unit operation

1. Select and justify best process flow

* Design
* Optimal Sizing of each Unit Operation (at least one major operation/group member)

1. Based on Heuristics
2. Based on Minimal Costs

C) Models (mechanistic – algorithm)

* List of design variables (Volume, area, size, Hp, Q) List of properties (Cp, k, h, Dy
* Performance Curves ( Plot effect of each variable)

D) Develop Package System

* E) Select Equipment from Vendor Information (ideal size vs availability, material of construction)
* Process Layout
* Piping /materials handling layout
* Water treatment/reuse/ CIP/Sanitation
* Byproduct utilization
* Energy Integration

Process control PID Process & Instrumentation Diagram

**Economic Analysis**

* Total Capital Costs
* Selling Price (based on market analysis)
* Determine Discounted Cash Flow Return (assume and justify: inflation, salvage value, plant life, tax rate)

**Patent Disclosure**

**Please complete the group evaluations after each phase and submit to me (This is required)**

**ABE 558**

Design Topic \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Evaluator \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Group Evaluation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name of Member** | yourself |  |  |  |  |  |
| Ability to schedule meetings |  |  |  |  |  |  |
| Did they attend scheduled meetings? |  |  |  |  |  |  |
| Initiative in group efforts |  |  |  |  |  |  |
| Completion of assigned duties |  |  |  |  |  |  |
| Quantity of work done |  |  |  |  |  |  |
| Quality of work done |  |  |  |  |  |  |
| Reliability of work done |  |  |  |  |  |  |
| Overall contribution to group |  |  |  |  |  |  |
| Other Factors |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |

Evaluate your group members on a scale of 1-10 10 = best

Comments: