2017
Student Design Competition

If there are any questions about the design problem, Student Chapter Advisors and Design Assignment Instructors are directed to contact:

Tiffany Rau, Design Competition Chair,
tiffanyrau@aol.com
Chelsea Monty, Design Competition Chair,
cm78@uakron.edu
Sarah Ewing, Student Program Lead,
sarae@aiche.org

Please read the rules **before**, **during** and **after** preparing and submitting the solution to AIChE.

NOTE: THE PAGE LIMIT FOR THE REPORT IS 125 NUMBERED PAGES!

AIChE 2017 Student Design Competition

"Manufacturing Facility for Nylon 6 6"

DEADLINE FOR ELECTRONIC SUBMISSION TO AIChE IS MIDNIGHT, Friday, June 16, 2017.

January 2017

Dear Chemical Engineering Department Heads and Student Chapter Advisors,

I am pleased to send you the 2017 AIChE Student Design Competition statement. Please forward it to those faculty teaching design courses. I've included this year's challenge below:

"Manufacturing Facility for Nylon 6 6"

As always, the names of the sponsoring organization and the authors are being withheld to ensure confidentiality. Both will be announced after the deadline- Friday, June 16, 2017.

 An entry form is required for each participant – it's attached to this email. Please submit one form for each participant, along with the completed solution.

We welcome participation by individuals and teams of up to four students. Please indicate the names of all team members on each entry form, and be advised that each team member is required to submit a separate entry form.

 AIChE Student Membership is Required - Because the Student Design Competition is a benefit of AIChE student membership, entrants must be AIChE active student members. Any non-member submissions will not be considered. Students can join at http://www.aiche.org/students/.

 Final submission of solutions to AIChE must be in electronic format (PDF and MS-Word). The main text must be 125 pages or less, and an additional 100 page or less is allowed for supplementary material only. The final submission to AIChE must consist of 2 electronic files.

 Student Chapter Advisors are asked to select the best solution or solutions, not to exceed two from each category (individual and team).

 All submissions must be submitted in an electronic format no later than Friday, June 16, 2017. Please use the directions below and maintain a copy for your files.

- Complete this online form if it's a team submission: https://chenected.wufoo.com/code/2017-student-design-competition-team/
- Complete this online form if it's an individual submission: https://chenected.wufoo.com/code/2017-student-design-competition-individual/

Please take time to review the rules, found on the following pages. It is important that all solutions strictly adhere to the Final Report Format.

If I can be of assistance, please contact me via email at sarae@aiche.org.

Thank you for your support of this important student competition.

Sincerely,

Sarah Ewing
AIChE Student Programs
(646) 495-1364
sarae@aiche.org

2017 AIChE Annual Student Design Competition
Contest Rules

Solutions will be graded on (a) substantial correctness of results and soundness of conclusions, (b) ingenuity and logic employed, (c) accuracy of computations, and (d) form of presentation.

Accuracy of computations is intended to mean primarily freedom from mistakes; extreme precision is not necessary.

It is to be assumed that the statement of the problem contains all the pertinent data except for those available in handbooks and literature references. The use of textbooks, handbooks, journal articles, and lecture notes is permitted.

Students may use any available commercial or library computer programs in preparing their solutions. Students are warned, however, that physical property data built into such programs may differ from data given in the problem statement. In such cases, as with data from literature sources, values given in the problem statement are most applicable. Students using commercial or library computer programs or other solution aids should so state in their reports and include proper references and documentation. Judging, however, will be based on the overall suitability of the solutions, not on skills in manipulating computer programs.

Departments, including advisors, faculty, or any other instructor, cannot provide technical aid specifically directed at the solution of the national student design competition.

The 2017 Student Design Competition is designed to be solved either by an individual chemical engineering student working entirely alone, or a group of no more than four students working together. Solutions will be judged in two categories: individual and team. There are, however, other academically sound approaches to using the problem, and it is expected that some Advisors will use the problem as classroom material. The following confidentiality rules therefore apply:

1. For individual students or teams whose solutions may be considered for the contest: The problem may **not** be discussed with anyone (students, faculty, or others, in or out of class) before or during the period allowed for solutions. Discussion with faculty and students at that college or university is permitted only after complete final reports have been submitted to the Chapter Advisor. No information about the problem statement including the title or any other information should be released to the student prior to the 30 day time allowance. Students should have their professor sign off starting the date that the student received the problem.

2. For students whose solutions are not intended for the contest: Discussion with faculty and with other students at that college or university who are not participating in the contest is permitted.

3. For all students: The problem may not be discussed with students or faculty from other colleges and universities, or with individuals in the same institution who are still working on the problem for the contest, until after June 16, 2017. This is particularly important in cases where neighboring institutions may be using different schedules.

Submission of a solution for the competition implies strict adherence to the following conditions: (Failure to comply will result in solutions being returned to the appropriate Faculty Advisor for revision. Revised submissions must meet the original deadline.)

ELIGIBILITY

 ONLY AIChE STUDENT MEMBERS MAY SUBMIT A SOLUTION. Non-member entries will not be considered. To become a Student member, you can join online at: http://www.aiche.org/students/.

 Entries must be submitted either by individuals or by teams of no more than four students. Each team member must meet all eligibility requirements.

 Each Faculty Advisor should select the best solution or solutions, not to exceed two from each category (individual and team), from his or her chapter and submit them per the instructions below.

TIMELINE FOR COMPLETING THE SOLUTION

 A period of no more than thirty (30) days is allowed for completion of the solution.

 The finished report should be submitted to the faculty advisor within the 30-day period.

REPORT FORMAT

 The body of the report must be suitable for reproduction, that is, computer-generated and in a printable format. Tables, supporting calculations and other appendix material may be handwritten.

 The solution itself must bear no reference to the students' names and institution by which it might be identified. Please expunge all such references to the degree possible.

 Final submission of solutions to AIChE must be in electronic format (PDF and MS-Word). The main text must be 125 pages or less, and an additional 100 page or less is allowed for supplementary material only. The final submission to AIChE must consist of 2 electronic files.

SUBMITING THE SOLUTION TO AIChE

 There should not be any variation in form or content between the solution submitted to the Faculty Advisor and that sent to AIChE. The Student Chapter Advisor, or Faculty Advisor, sponsoring the student(s), is asked to maintain the original manuscript(s).

 Advisors: once you have identified the entries you will submit, follow these steps:

1. Have each student fill out and sign the 2017 Entry Doc.
2. Scan the Entry Doc for each student.
3. Complete this online form if it's a team submission: https://chenected.wufoo.com/code/2017-student-design-competition-team/
4. Complete this online form if it's an individual submission: https://chenected.wufoo.com/code/2017-student-design-competition-individual/

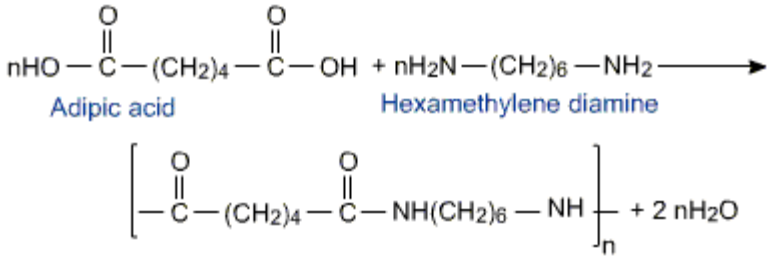
DEADLINE: **Midnight on Friday, June 16, 2017.**

"Manufacturing Facility for Nylon 6 6"

DEADLINE FOR ELECTRONIC SUBMISSION TO AIChE IS MIDNIGHT, Friday, June 16, 2017.

Project Background and Motivation

Nylon 6 6 is a co-polymer produced via step-growth polymerization of Adipic Acid and Hexamethylene diamine (HMDA). The two monomers each have 6 carbon atoms, which is what gives Nylon 6 6 its name. Nylon 6 6 is a widely used chemical product in a variety of industries, including textiles. The reaction chemistry is illustrated below:



[1]

Process Description

Nylon 6 6 is synthesized by polycondensation of hexamethylenediamine and adipic acid. Equivalent amounts of hexamethylenediamine and adipic acid are combined with water in a reactor. This is crystallized to make nylon salt, which has precisely stoichiometric equivalents. The nylon salt goes into a reaction vessel where polymerization process takes place either in batches or continuously (this choice is up to each individual group, but you must justify your decision!). Removing water drives the reaction toward polymerization through the formation of amide bonds from the acid and amine functions. Thus molten nylon 6 6 is formed. It can either be extruded and granulated at this point or directly spun into fibers by extrusion through a spinneret (a small metal plate with fine holes) and cooling to form filaments (your choice!). [2]

Design Requirements

Your task is to prepare a complete economic analysis for building a grass roots plant to produce 85MM lbs/yr of Nylon 6 6 from Adipic Acid and HMDA. You may assume that the plant will be built in the Calvert City, Kentucky area. You may use any publically available resources necessary to complete your design including patents, technical reports, literature or other resources. You must keep SAFETY and SUSTAINABILITY in mind as you prepare your design reports. Note that this process requires the use of raw materials that are hazardous and/or flammable. You MUST describe your safety concept for this process. What are the process risks and how can those risks be mitigated? How will you set design pressures and temperatures for your process equipment? Can the principles of inherently safe process design be used to reduce the hazards of this process?

The project will incorporate a wide range of aspects related to chemical process and product design, e.g. flowsheet synthesis and simulation, heat and mass integration for resource

conservation, facility siting, process optimization, process economics, and also environmental, health and safety related issues. In the following section some information is given about the progress reports that need to be submitted during the course of this design project.

Project Objectives

Your objective is to design and analyze an industrial process for the production of Nylon 6 6. The final process will generate not only product streams, but also a side product stream. The final disposition of those streams must be taken into account both in the process design and in the economic analysis. In other words, it is your responsibility to determine what to do with the side product.

Furthermore, due to changes in market conditions, customer demands etc. it may be necessary to reduce the production at certain times during the year to avoid stockpiling too much product on site. Therefore you need to design your process/equipment for 100% capacity as well as a turndown case of 67% capacity.

It is important to not only design a process that is technically feasible but also controllable. You will need to propose a control strategy for the flowsheet. What variables will you control? What variables will you choose as fixed set points? What measured values will your strategy require? Describe how control fluctuations one column affect the other. Are there any special requirements for unsteady state conditions, such as start-up or shut-down? Is any additional equipment required to achieve good control, such as holdup tanks, or heat exchangers? How do your equipment choices affect your control strategy?

Finally, this system uses raw materials and generates products that are hazardous and/or flammable. Describe your safety concept for this process. Also do a HAZOP evaluation of the process. What are the process risks and how can those risks be mitigated? How will you set design pressures and temperatures for your process equipment? Can the principles of inherently safe process design be used to reduce the hazards of this process?

The project will incorporate a wide range of aspects related to chemical process and product design, e.g. flowsheet synthesis and simulation, heat and mass integration for resource conservation, process optimization, process economics, and also environmental, health and safety related issues.

A Few Final Thoughts…

- Remember that this is an open ended project. This means that you can take the project in almost any direction you find interesting. However, all design choices and changes in direction or scope must be fully justified with reasons explained.
- Just like a real-world project, you won't always have all the information you need. Therefore, you will be required to make assumptions along the way. ALWAYS state your assumptions and reasons for making them.

Report Requirements:

This report should follow the outline suggested in Seider, Seader and Lewin. Further details on what should be included in the design report can be found in that text. Write the document from the point of view of the organization's engineer making a report and recommendation to the organizations management.

1. Letter of Transmittal
2. Cover Page
3. Table of Contents
4. Abstract
5. Introduction
6. Process Flow Diagram and Material Balances
7. Process Description
8. Energy Balance and Utility Requirements
9. Equipment List and Unit Descriptions
10. Equipment Specification Sheets
11. Equipment Cost Summary
12. Fixed Capital Investment Summary
13. Safety, Health, and Environmental Considerations
14. Other Important Considerations
15. Manufacturing Costs (exclusive of Capital Requirements)
16. Economic Analysis
17. Conclusions and Recommendations
18. Acknowledgements
19. Bibliography
20. Appendix

References:

Seider, W., J.D. Seader, and D.R Lewin, Product and Process Design Principles: Synthesis, Analysis and Evaluation, Wiley, 2003.

Nieschlag, HJ, J.A Rothfus, and VE Sohns,Nylon 1313 from Brassylic Acid, I and EC Product Research and Development, Vol 16, Pg 101, March 1977

Nylon 1313 Synthesis and Polymerization of Monomers, Journal of Polymer Science Part A-1 Vol 5 1967.

[1] Preparation of Nylon-66 - membrane solutions
http://nylon66membrane.com/Preparation-of-Nylon-66.html

[2] Nylon 66
https://en.wikipedia.org/wiki/Nylon_66

Note: This problem statement has some hypothetical data and thus does not necessarily represent an accurate real case.