SUMMARY REPORT

# TEACHING OF UNDERGRADUATE MASS AND ENERGY BALANCES

A Mini-Session Presented at the

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## INTRODUCTION

In 1971, the Chemical Engineering Education Projects Committee conducted a survey on the teaching of Mass and Energy Balances in over 150 chemical engineering departments in the United States and Canada. The survey compiled data on texts, laboratories and course contents. In successive years, other courses in chemical engineering have been surveyed. Responses to that first questionnaire totaled 59. This year, 109 responses were received.

The survey is conducted with a questionnaire sent to Chemical Engineering Department chairmen in late April. A follow-up letter is sent in early August to those departments which have not responded. Results are reported and discussed at the Undergraduate Free Forum at the AIChE Annual Meeting. A written summary is sent to each department submitting a completed questionnaire. A copy of the questionnaire is attached to this report.

## PREREQUISITES

The prerequisites for Mass and Energy Balances reflect its position as a sophomore course at most universities. A student who has completed his freshman year generally has one to two semesters of calculus and one year of general chemistry. Consequently, very few other courses are listed as prerequisites.

| COURSE | % of Schools Requiring this Course |
|---|---|
| Calculus (1 or 2 semesters) | 50 |
| Chemistry (1 year) | 68 |
| Organic Chemistry (1 semester) | 4 |
| Physical Chemistry | 8 |
| Thermodynamics | 6 |
| Physics | 8 |
| Computers | 8 |
| None | 4 |

## COURSE LEVEL

The mass and energy balances course is offered as a one semester course or a two quarter course at over 95% of the universities surveyed. Eighty per cent of the schools on the semester system and 91% of the schools on the quarter system offer this course during the sophomore year.

Fifty one per cent of the schools schedule a problem laboratory of 1 to 3 hours in addition to the usual three hours of lecture.

### SEMESTER SYSTEM

| Semester | Number of Colleges |
|---|---|
| Freshman, first | 4 |
| Freshman, second | 8 |
| Sophomore, first | 48 |
| Sophomore, second | 36 |
| Junior, first | 9 |
| Junior, second | 1 |

### QUARTER SYSTEM

| Quarter | Number of Colleges |
|---|---|
| Sophomore, first | 14 |
| Sophomore, second | 13 |
| Sophomore, third | 4 |
| Junior, first | 3 |

Fifty one percent of the schools schedule a problem laboratory of 1 to 3 hours in addition to the usual three hours of lecture.

## COMPUTERS IN MASS AND ENERGY BALANCES

The responses to the percent of homework assignments utilize the digital computer are summarized below:

| % of Assignments | Number of Colleges |
|---|---|
| 0-10% | 77 |
| 10-30% | 22 |
| 30-50% | 8 |

The survey asked for the semester in which chemical engineering students receive their first formal FORTRAN course. The replies show that 68% of the colleges give FORTRAN in the freshman year.

FORTRAN COURSE

| Semester | Number of Colleges |
|---|---|
| Freshman, first | 38 |
| Freshman, second | 34 |
| Sophomore, first | 15 |
| Sophomore, second | 14 |
| Junior, first | 5 |

## PROJECTS

Projects lasting one month or longer were assigned in 16% of the courses. On the average, there project involves groups of 3 to 4 students. The project grade was 10% to 30% of the total course grade.

The following comments were made about the nature and purpose of the project.

1. Oil refinery problem, including the solution of many simultaneous material balance equations.(Univ of Akron)
2. Usually a detailed material balance problem involving 3-9 unit operations, including reaction, mixed phase, etc. (Univ. of Alabama)
3. A case study of the Draft Pulping process is used. The group performs mass and energy balances on this process. The case study provides both a motivation for learning the text material and a feeling for the contextual significance of this material. It ties everything together. (Bucknell University)
4. Case study of the type in Felder & Rousseau's Text covers all the major topics from the course. Use as a preparation for the final exam. (Clarkson College)
5. Newton-Raphson method is used to determine the weight of a gas at specified conditions, assuming the gas obeys the vander Waals equation of state. (Manhattan College)
6. Case study involving analysis of a complete chemical process. (N.C. State University)
7. Case study from Felder & Rousseau or a library study of a major chemical product in the chemical process industries.(Ohio State University)
8. Material and Energy Balance on a process chemical plant. (Pratt Institute)
9. Case studies from Felder & Rousseau. (Princeton Univ., Rensselaer Polytechnic Institute, McNeese University)
10. Complete mass and energy balances on a process consisting of a reactor, absorbes distillation columns and about 8 heat exchanges. (Univ. of Virginia)

## TEXTBOOK

In previous surveys, there has almost always been a text which was used in a significant majority of the courses. This survey is no exception. Sic texts, plus personal notes, were mentioned. The text by Felder and Rousseau was used in 64% of the courses. Himmelblau's book was used in 29% of the courses. No other text was used in more than two courses.

| AUTHOR | NUMBER OF SCHOOLS |
|---|---|
| Felder & Rousseau | 64 |
| Himmelblau | 29 |
| All others (4) | 7 |

The six textbooks cited are listed below:

1. Felder, R.M. and Rousseau, R.W.:
   "Chemical Processes"

2. Himmelblau, D.:
   "Basic Principles and Calculations in Chemical Engineering"
   ed., Prentice-Hall

3. Chilton & Perry:
   "Chemical Engineers' Handbook"
   ed., McGraw-Hill

4. Rudd:
   "Process Synthesis"

5. Russell and Denn:
   "Introduction to Chemical Engineering Analysis"

6. Ceckler & Thompson:
   "Introduction to Chemical Engineering"

## TEXTBOOK COMMENTS

The compilation of comments on the textbook involves some subjective judgement. Over 80% of the questionnaires included comments on the texts. The comments listed below were mentioned on over 20% of the replies.

Felder & Rousseau

- Strengths
  - Many problems
  - Well organized
  - Good examples
  - Clearly written
- Deficiencies
  - Shortage of example problems
  - Problems not difficult enough
  - Depth of treatment is not enough
  - Needs more computer problems
  - More development of unsteady-state processes

Himmelblau

- Strengths
  - Excellent examples
  - Challenging problems
- Deficiencies
  - Some topics require more explanation
  - Errors in many examples
  - More problems requiring computer solutions

## SURVEY ON THE ENGINEER -IN- TRAINING EXAMINATION

A series of questions were prepared to determine the extent to which the E.I.T. examination is taken by seniors in chemical engineering. Some colleges require their seniors to take (but not pass) the test as a graduation requirement.

Unfortunately, the questionaire repeatedly referred to the P.E. examination rather than the E.I.T. This was entirely my fault, and I apologize for this blunder. I hope to include more carefully prepared questionnaire on this subject with next year's survey.