SUMMARY REPORT

TEACHING OF UNDERGRADUATE KINETICS

A mini-session presented at the

Annual Meeting

American Institute of Chemical Engineers

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INTRODUCTION

The attached questionnaire was sent in May 1974 to the chairman of each chemical engineering department in the United States and Canada, together with a cover letter asking that the appropriate faculty member complete and return the questionnaire. A follow-up letter was sent in early September to those schools about (100) which had not responded by that time. Of the 155 universities contacted, ninety questionnaires were returned. This compares with seventy-one responses to the 1972 mini-session (Mass and Energy Balances) and fifty-nine replies to the 1973 mini-session (Thermodynamics).

QUESTIONNAIRE ON THE TEACHING OF
REACTION KINETICS

Instructor: ______________________________

University: ______________________________

Distinctive features of the course as I give it are:

Some explanations of concepts which I have found particularly effective are... (Use another sheet if necessary. I would like to give as many people as possible the opportunity to present these at the session.)

Some particular challenges in teaching Reaction Kinetics are:

________ I (do, do not) plan to attend the Washington AIChE Meeting.

________ I don't know yet.

QUESTIONNAIRE ON THE TEACHING OF REACTION KINETICS

1. IDENTIFICATION

Instructor: ______________________

University: ______________________

2. COURSE TITLE(S) (undergraduate courses)

1. ______________________________

2. ______________________________

3. TIME AVAILABLE

	Course 1	Course 2
Hrs lecture/week	________	________
Hrs problem lab/week	________	________
Hrs experimental lab-week	________	________

4. TEXT(S) AND RESOURCES (AUTHOR, TITLE)

Course 1 ____
Circle chapters usually covered 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

Course 2 ____
Circle chapters usually covered 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

5. STUDENTS

	Course 1	Course 2
A. Year of Students e.g. seniors	________	________
B. Class Size	________	________

6. MAIN OBJECTIVES OF COURSE:

____

____

____

____

____

____

____

____

7. Is the thermodynamics of chemical equilibria (equilibrium constants, equilibrium conversion, etc.) covered in the kinetics course or in the thermodynamics course? (circle one)

Kinetics — Thermodynamics undergraduate — Other

8. How many weeks of the kinetics course are devoted to catalytic reactions?

________weeks

9. Do you cover the theory of Absolute Reaction Rates in the undergraduate kinetics course?

No — Yes — If yes, how many class sessions?________

10. Please list the titles of graduate courses offered in Kinetics, Catalysis, Reactor Design etc. which deal principally with kinetics and related areas.

11. Describe briefly the role of computers in the undergraduate kinetics course.

12. Describe briefly (attach copy of procedure if possible) any laboratory experiments which your department uses in kinetics or other undergraduate courses to illustrate principles of reacion kinetics.

13. Does your university operate on quarters or semesters?

Quarters of ________weeks — Semesters of ________weeks

14. I would like a copy of the summary report. — Yes — No

Please attach a copy of your course outline.

15. Do you feel there is a need for a better textbook for Chemical Engineering Reaction Kinetics? In what topic areas can the text you now use be improved?

NUMBER AND LEVEL OF UNDERGRADUATE KINETICS COURSES

Eighty-five per cent of the universities surveyed offer a single course in undergraduate kinetics, while the remaining 15% offer two courses. Eighty-seven per cent of the kinetics courses are given to seniors, while only 13% are for juniors. It may be concluded that chemical engineering kinetics exists in most curricula as a single course during the senior year.

LECTURE AND LABORATORY PERIODS

The average time spent in lecture and problem laboratory sessions was 3.06 hours per week for each kinetics course. An average of 0.40 hours per week was devoted to experimental laboratory work in the area of kinetics of reaction. However, only 30% of the universities responding report such experimental work. These schools devote about 1.5 hours per week on experiments. A list of the schools performing experiments, the faculty member completing the questionnaire, and the titles of most of the experiments are given in the "LABORATORY EXPERIMENTS" section of this report.

These people may be contacted for further information regarding kinetics experiments.

TEXTS

The text used in most kinetics courses is Levenspiel's "Chemical Reaction Engineering" second edition. Sixty-one per cent of the kinetics courses use this book. Not all schools responding listed the chapters usually covered in their courses. However, the normalized percentages (based on fifty schools) for each chapter are as follows:

CHAPTER	PER CENT
1	94
2	96
3	96
4	98
5	100
6	98
7	94
8	90
9	26
10	8
11	50
12	30
13	8
14	78
15	8

Thus, the first eight chapters are covered in over 90% of the courses using this text.

The book by Smith "Chemical Engineering Kinetics" second edition is used by 21% of the universities responding. The following table lists the normalized percentage of schools which cover the respective chapters.

CHAPTER	PER CENT
1	100
2	100
3	100
4	94
5	94
6	69
7	69
8	75
9	75
10	50
11	44
12	38
13	38
14	19

The first five chapters are covered in over 90% of the courses using this text.

About 18% of those responding use personal notes or a different text. About five schools either currently use or expressed an interest in using Scott Fogler's Programmed Text in Reaction Kinetics. Since this text has a 1974 copyright, it is too early to determine the impact of this text on the traditional methods of instruction in Reaction Kinetics.

COURSE TIME DEVOTED TO THREE SPECIFIC TOPICS RELATED TO REACTION KINETICS

A. Reaction Equilibria

The equilibrium conversion of chemical reactions is a bridge between thermodynamics and kinetics. The equilibrium constant is valuable in characterizing the kinetic behavior of reversible reactions. Of the schools responding, 67% cover reaction equilibria in the chemical engineering thermodynamics course, 13% cover this in the kinetics course, and 20% teach reaction equilibria in both kinetics and thermodynamics.

B. Catalysis

The average kinetics course lasts 12.0 weeks and devotes 2.4 weeks (19.8%) of the course to the study of catalytic reactions.

C. Theory of Absolute Reaction Rates

The theory of absolute reaction rates is not discussed in the undergraduate kinetics courses of 41.6% of the schools responding. At the remaining schools, about 2.2 class sessions are devoted to this topic.

GRADUATE COURSES

This study did not deal specifically with graduate work in reactor design or kinetics. The topics of reaction kinetics, catalysis and reactor design are often taught in the same course. More important, as anyone familiar with the language of college catalogs knows, the title of a course usually gives little information as to the course content. The following observations are based only on the titles of graduate courses given on the questionnaire. It appears that 45% of the universities offer a graduate course in kinetics of reactions, 36% offer a course in catalysis, and 52% offer a course in reactor design. In arriving at these figures, each graduate course listed was classified into one of the three areas. Obviously a course dealing with the design of fixed bed catalytic reactors must necessarily involve subject matter from all three classifications.

LABORATORY EXPERIMENTS

The following respondents have described experiments, dealing with reaction kinetics, which are used in the laboratories at the respective schools. In most cases, titles of the experiments are listed. Anyone wishing more information on these experiments should write to the person listed.

LABORATORY EXPERIMENTS

Rensselaer Polytechnic Institute (Dr. Gregory P. Wotzak)
"Hydrolysis of Acetic Anhydride"

Queens University(Dr. B. W. Wojciechowski)
"Hydrolysis of Acetic Anhydride in Batch, CSTR and Flow Reactors"

University of Calgary (Dr. Norton G. McDuffie)
"Hydrolysis of Methyl Acetate"
"Catalyst Surface Determination (BET)"
"Fluidized and Packed Bed Behavior"

University of Washington (Dr. L. N. Johanson)
"Hydrolysis in Stirred Tank Reactors"

University of Maine (Dr. Gerald L. Simard)
"Emulsion Polymerization"
"De-alkylation of Cumene"
"Saponification of Ethyl Acetate"

Newark College of Engineering (Dr. Deran Hanesian)
"Tubular Reactor"
"Backmix Reactor"
"Fermentation Reactor"
"Non-isothermal Batch Reactor"
"Heterogeneous Catalysis"
"Surface Area/Pore Size Distribution Measurement"

University of New Hampshire (Dr. G. D. Ulrich)
"Demonstrations"

State University of New York at Buffalo
"Effect of Stirring on Pt-catalyzed Liquid Phase Hydrogenation of Stypene"
"Vapor Phase Catalytic Dehydrogenation of Cyclohexane in Flow Micro-reactor"
"Batch Liquid Phase Homogeneous Reaction"

Pennsylvania State University (Dr. Daubert Kabel)
"Dehydration of Hexanol Over Alumina Catalyst"

Princeton University (Dr. Norman Sweed)
"A Chemical Reactor Laboratory for Undergraduate Instruction"

Texas A & I University (Dr. K. C. Oosterhout)
"Saponification of Ethyl Acetate with NaOH"
"Hydrolysis of Acetic Anhydride"

Texas A & M University (Dr. R. G. Anthony)
"Saponification of Ethyl Acetate"

University of Toledo (Dr. Lynn Bellamy)
"Hydrolysis of Acetic Anhydride"

Worcester Polytechnic Institute (Dr. Alvin H. Weiss)
"Autocatalytic Reaction of $Ca(OH)_2$ and Formaldehyde"
"Mass Transfer Controlled Reaction: NaOH, Methylene Blue, Glucose"

University of Wyoming (Dr. Robert D. Gunn)
"Alkaline Hydrolysis of an Ester"

Yale University (Dr. Daniel E. Rosner)
"Kinetics and Reactors - Laboratory Experiments"

Royal Military College of Canada, Kingston, Ontario (Dr. R. F. Mann)
"Hydrolysis of Crystal Violet by Sodium Hydroxide"
"Dilatometric Study of the Hydrolysis of Acetal"
"Bionunation of Acetone"

Kansas State University (Dr. John C. Matthews)
"Vapor Phase Catalytic Hydrogenation of Nitrobenzene"

Bucknell University (Dr. William J. Snyder)
"Hydrolysis of Acetic Anhydride"
"Hetrogeneous Catalysis - Oxidation of Carbon Monoxide"
"Kinetics of Emulsion Polymerization"

University of Arkansas (Dr. R. Spearot)
"Tubular Flow Reactor"
"Mixing with Reaction"
"Fluidized Bed Reactor"

Brigham Young University (Dr. Calvin Bartholomew)
"Heterogeneous Decomposition of N_2O on Platinum Wire"
"The Oscillating Reaction"
"Saponification of Ethyl Acetate"

University of Idaho (Dr. W. J. Thompson)
"Saponification of Ethyl Acetate"

University of Arizona (Dr. Richard D. Williams)
"Various Laboratory Experiments"

University of British Columbia (Dr. K. L. Purder)
"Liquid Phase Homogeneous Catalysis (Including Enzymes)"
"Gas Reaction-Heterogeneous Reactions"

Colorado School of Mines (Dr. R. W. Baldwin)
Eight different experiments

University of California, Berkeley (Dr. A. T. Bell)
Several different experiments

SEMESTERS/QUARTERS

Of the universities responding, 20% operate on the quarter system and 79% operate on the semester system. The average length of the semester and quarter, taken as a combined unit, is twelve weeks.

REPLIES TO QUESTIONNAIRES

The replies from each school are summarized on the following pages. The following form is used.

NAME OF UNIVERSITY

Authors of Text used in courses. (When one or more numbers appear before the name of the text, this indicates the course for which the text is used. For example:
1, 2 Levenspiel means the text is used for both the first and second courses.)

Level of Course(s) (Listed to the right of the text.)

The following words refer to replies to specific sections of the questionnaire.

EXPLANATIONS ("Some explanations of concepts I have found particularly effective are ...")

FEATURES ("Distinctive features of the course are ...")

CHALLENGES ("Some particular challenges in teaching reaction kinetics are ...")

TEXT Any comments on the texts being used.

UNIVERSITY OF ARIZONA

1. Sr

FEATURES

Use of programmed learning text with conventional lecture, quiz, examination method. This gives advantages of programmed learning without a complete conversion to this mode which is difficult to administer when the students are simultaneously involved in their design course. Use of digital simulation language to illustrate difficult concepts.

CHALLENGES

Dealing with misconception that rate=dN/dt. Use of energy balances from texts which generally give inadequate coverage of this topic.

ARIZONA STATE UNIVERSITY

1. Smith Sr

CHALLENGES

Bridging gap between typical academic approach to reactor design and industrial realities.

TEXT

Could use better text. New edition of Smith does not really update old one. Levenspiel spends too much time on analytical solutions. Aris is not practical.

UNIVERSITY OF CALIFORNIA (BERKELEY)

2. Levenspiel, Smith Sr/Sr

FEATURES

Reactor design taught via case study development of real system, e.g., sequential chlorination of methane. Emphasis on homogeneous catalysis.

EXPLANATIONS

Careful definition of rate of reaction.

CHALLENGES

Students' lack of preparation in the required physical chemistry and math courses.

TEXT

Need for more industrial reactions in problems given in texts.

CALIFORNIA INSTITUTE OF TECHNOLOGY

1. Smith, Levenspiel Sr

FEATURES

Given to seniors and first year graduate students jointly. Emphasizes not only reactor design but chemical kinetics, combustion, catalysis.

CHALLENGES

Chemical kinetics is not a unified subject (like thermodynamics) but rather a collection of topics with few unifying concepts.

UNIVERSITY OF CALIFORNIA (Santa Barbara)

2. Levenspiel Sr/Sr

EXPLANATIONS

Using on-line CRT computer console to show the effects of parameter changes on temperature and composition profiles in reactors and in catalyst pellets.

UNIVERSITY OF SOUTHERN CALIFORNIA

2. Sr/Sr

FEATURES

The importance of chemical kinetics and reactor design are perceived in the light of the overall chemical process.

COLORADO SCHOOL OF MINES

1. Levenspiel Sr

FEATURES

Use of analog computer for process simulation.

YALE UNIVERSITY

1. Sr

FEATURES

Attributes and liabilities of various reactor types; application of chemical reaction engineering techniques in other fields of engineering.

ANATIONS
For gas phase homogeneous kinetics and heterogeneous kinetics, I find the materia in C. N. Hinshelwood's classics, "The Kinetics of Chemical Change" and "The Structure of Physical Chemistry" particularly instructive and useful for graduates and undergraduates alike.

GEORGIA INSTITUTE OF TECHNOLOGY

1. Levenspiel Sr
FEATURES
Use of computers in reactor design. Description of many industrial reaction systems and reactors (e.g., reforming, oxidation, cracking, etc.) Periodic reactor operation.
TEXT
Better coverage of unsteady-state operation of plug flow and CSTR reactors.

THWESTERN UNIVERSITY

1. Jr
FEATURES
Coverage of theories of chemical kinetic: emphasis on selectivity as well as conversion problems; extensive use of computer.
CHALLENGES
Providing adequate coverage in time available; suitable experiments.
TEXTS
All texts are woefully inadequate in the chemical content.

TRI-STATE COLLEGE

1. Levenspiel Sr
FEATURES
Extensive computer work.

UNIVERSITY OF NOTRE DAME

1. Levenspiel Sr
FEATURES
Heavy emphasis on heterogeneous reaction systems.
CHALLENGES
Paucity of physical chemistry in regard to kinetics.

KANSAS STATE UNIVERSITY

1. Levenspiel Sr
EXPLANATIONS
We have a small rotary dryer and data from it are an excellent supplement to RTD work. We run it cold, processing, say, corn, and pulse it with dyed kernel Data can be used with either tanks in series or the dispersion model.

UNIVERSITY OF KENTUCKY

1. Levenspiel Sr
FEATURES
Creating classroom atmosphere of openness based on concepts of relational teaching affirmation and realness. Students grade their own homework and hour exams in class. Solving problems is the only basis for presenting any theory.
CONCEPTS
Rate determining step in catalytic reactions is likened to the rate of people sitting down in the football stadium. They have to cross a street, go through gates, walk in aisles. The lowest step will determine the rate of seating.
CHALLENGES
Lack of data from industrial reactors.

UNIVERSITY OF LOUISVILLE

1. Levenspiel Sr
FEATURES
Lecture on demand; discuss problems or homework in detail.

LOUISIANA STATE UNIVERSITY

1. Levenspiel, Smith — Sr

FEATURES
Solving reactor design problems using groups of four students each. Using some lecture periods for problem work in which the instructor moves from group to group asking and answering questions.

EXPLANATIONS
Using enthalpy balance in which one includes enthalpies of formation along with sensible enthalpies for everything that goes into and comes out of the reactor, avoiding the heat of reaction concept.

CHALLENGES
Teaching the energy balance on a reactor where a number of reactions occur.

UNIVERSITY OF SOUTHWEST LOUISIANA

1. — Sr

HELLENGES
parting to the student a cohesive and clear concept of the interrelationship of the many variables involved in predicting reaction conditions and severity.

McNEESE STATE UNIVERSITY

1. Levenspiel — Sr

CHALLENGES
Cover adequate amount of material in time available.

UNIVERSITY OF MAINE

1./1. Smith — Jr/Sr

CHALLENGES
Providing sound base in reaction rate theory plus introduction to reactor desig in one semester.

TEXT
Alternate Smith's text with Levenspiel's. Text by Meissner, "Processes and Systems in Industrial Chemistry," is an excellent source of problems.

WORCESTER POLYTECHNIC INSTITUTE

1. Levenspiel — Jr

FEATURES
Error analysis; reaction sets and composition paths.

CHALLENGES
Need for understanding chemistry; use of empiricism.

TEXT
Need discussion of heterogeneous catalysis.

UNIVERSITY OF MASSACHUSETTS

1. Smith — Sr

CHALLENGES
Motivation of students to cover breadth and depth of material required in one course.

TEXT
Need for treatment of solid catalytic reactor design, particularly with deactivating catalyst.

UNIVERSITY OF MICHIGAN

1. — Sr

CHALLENGES
Selecting open-ended problems in chemical kinetics and reactor design for the students to tackle in addition to the standard closed-end home problems.

UNIVERSITY OF DETROIT

1. Levenspiel — Sr

FEATURES
Mechanisms are covered only briefly.

CONCEPTS
Concept of the real reactor; one which has dead spaces, recirculation and is any combination of CSTR, plug flow and batch, depending upon the system. The study of residence time distribution is important from theoretical and practical standpoints.

MICHIGAN TECHNOLOGICAL UNIVERSITY

2. Smith Sr

FEATURES

Three weeks devoted to uncatalyzed fluid-solid reactions, using personal notes.

CHALLENGES

Objective treatment of use of chemical reaction rate data to discriminate between different rate equations. Fair treatment of pro and con arguments concerning Langmuir-Hinshelwood approach.

WASHINGTON UNIVERSITY

2. Levenspiel Jr/Jr

CHALLENGES

Coupling of mass transfer and reactor design to real industrial problems.

TEXT

Need for more real industrial problems. Need for graduate level text in reaction engineering.

1. Levenspiel Sr

FEATURES

One week on absolute reaction rate theory and estimation of k (using Frost and Pearson, "Kinetics and Mechanism") to get a feel for what happens when molecules collide; strong emphasis on physical and chemical reasons WHY system behaves as it does.

EXPLANATIONS/CONCEPTS

Meeting with students in groups of 5-8 in a conference room where I set up a physical situation, or take a graph from the book or use a homework problem and ask WHY about all the facets of the situation I could expect them to understand.

UNIVERSITY OF NEW HAMPSHIRE

1. Smith Sr

FEATURES

Use of demonstration lab where students are assigned concepts to demonstrate using normally available laboratory equipment, students design, construct and demonstrate apparatus used to measure or elucidate kinetic phenomena. Examples: effect of pressure and temperature, evaluate a reverse reaction rate; compare batch and continuous reactors; demonstrate a catalytic reaction; demonstrate residence time distributions for different types of reactors.

TEXT

Smith is excellent in organization and content but students find the descriptions inadequate.

UNIVERSITY OF NEBRASKA

1. Levenspiel Sr

FEATURES

Behavioral objectives are written for four to five groups of chapters in Levenspiel. Assignments and lectures are arranged closely to follow these behavioral objectives given to students.

PRINCETON UNIVERSITY

1. Sr

FEATURES

Emphasis on diffusion-reaction coupling. Exam questions given to students one week before exam. Several questions are selected for a closed book examination. Strong use of laboratory.

EXPLANATIONS/CONCEPTS

Langmuir-Hinshelwood Kinetics; CO oxidation in auto exhaust; Coupled Heat and Mass Transfer: Oxidation on a monolith; Direct use of First Law of Thermodynamics in energy balance to avoid confusion associated with "heat" of reaction.

CHALLENGES

Finding a text that combines rigorous theory with practical problems.

TEXT

Need intensive treatment of fundamentals; combine rigorous and practical aspects of problems.

NEWARK COLLEGE OF ENGINEERING

Sr

1. Levenspiel

FEATURES

To supplement theory, we have built six experiments in reaction engineering area.

EXPLANATIONS/CONCEPTS

Use of computers in non-isothermal, non-adiabatic design.

SYRACUSE UNIVERSITY

Sr/Sr

2. Levenspiel

CHALLENGES

Students do not become familiar with the subject matter without extensive problem solving and discussion of problems in class. This slows down the rate at which new material can be introduced.

TEXT

Need more coverage of design for multiple reactions - temperature and pressure effects.

CORNELL UNIVERSITY

Sr

1. Levenspiel

FEATURES

More on catalytic mechanism than in Levenspiel. Problems on real processes.

EXPLANATIONS

True meaning of reaction order. Generality of the subject - biological systems, etc.

COLUMBIA UNIVERSITY

Sr

1. Levenspiel

FEATURES

Course consists of 35% chemical kinetics, 65% reactor analysis.

CONCEPTS

The use of matrix-vector notation in general stoichiometry is very helpful.

CLARKSON COLLEGE OF TECHNOLOGY

Jr/Sr

2. Levenspiel

FEATURES

Reactor Analysis and Design, as opposed to chemical kinetics, are stressed.

CONCEPTS

Definition of Reaction Rate; An intensive property of the reaction mixture; r_A=time rate of formation of A per unit extent of the system. Need to get rid of the notion supplied by physical chemists that the definition of rate is dC_A/dt. This is not a proper definition.

CHALLENGES

Synthesis of many areas of chemical engineering.

TEXT

Too much emphasis on trivia for a first course. Great need for real world problems, rather than A + B = C.

RENSSELAER POLYTECHNIC INSTITUTE

Sr

1. Levenspiel

FEATURES

Use of phenomenological approach; use of experimental methods (parosimeter, BET methods) to determine kinetic data, catalyst properties, etc.

EXPLANATIONS/CONCEPTS

Reaction rates explained by a model of molecular rate processes (collision probabilities, energy dependence of reaction probabilities, Boltzmann distribution, steric factors, etc.).

CHALLENGES

Integration of students background into design approach to chemical reactors.

TEXT

Levenspiel (2nd ed.) goes a long way toward fulfilling need for comprehensive text.

MANHATTAN COLLEGE

1. Sr

EXPLANATIONS/CONCEPTS

Presentation of a large number of short, illustrative examples.

STATE UNIVERSITY OF NEW YORK

1. Levenspiel Sr

CHALLENGES

Convey a feeling for real chemical reactions, in contrast to A + B = C.

TEXT

First edition of Levenspiel was more lucid than the second. I feel most teachers do not cover non-ideal reactors, which Levenspiel devotes much space to. I would prefer this omitted (in an introductory text) and either: (1) a smaller, less expensive book (paperback is OK) or (2) more treatment of unsteady state and of real kinetic data.

NORTH CAROLINA STATE UNIVERSITY

1. Levenspiel Sr

EXPLANATIONS/CONCEPTS

I introduce the concept of the rate of a reaction following the development outlined by Boudart. It takes a little while for the students to get used to, but it makes such topics as steady-state kinetics and design of gas phase flow reactions much easier to teach without getting bogged down in stoichemistry.

CHALLENGES

Giving students the tools they need to design ideal reactors without reducing the course to a series of exercises in freshman calculus; Relating kinetics to thermodynamics, heat transfer and mass transfer.

UNIVERSITY OF NORTH DAKOTA

1. Sr

EXPLANATIONS

Formation of stoichiometric table when moles are not conserved, and when pressure, temperature and volumes are not consistent.

CHALLENGES

Show applications of kinetics and reactor design to process design. Use of laboratory data to scale-up reactors.

UNIVERSITY OF DAYTON

1. Levenspiel Sr

FEATURES

Design problems assigned to team of students; explanation of articles in literature.

EXPLANATIONS/CONCEPTS

Self-study approach seems appropriate.

CHALLENGES

Good problems which illustrate material are either too hard or too easy.

CLEVELAND STATE UNIVERSITY

1. Levenspiel Sr

FEATURES

Applications of numerical methods to problems with simultaneous differential equations and problems with boundary conditions rather than initial conditions such as axial dispersion with series-paralled reaction systems.

CHALLENGES

To get students to derive relationships between conversion and space time or residence time from the basic differential equation rather than use an integrated formula which hopefully has the proper rate order.

UNIVERSITY

1. Levenspiel — Jr

FEATURES

Emphasis on design rather than mechanism. Use of data (interpretation) to obtain useful kinetic expressions.

UNIVERSITY OF TOLEDO

1. Levenspiel — Sr

FEATURES/CHALLENGES

Simplification of complex industrial problems so that analytical techniques developed in the text can be applied [illegible]

TEXT

Need: (1) Multiple reaction analysis, (2) [illegible], (3) Physical Reactor Design considerations (Materials, Equipment, etc.)

UNIVERSITY OF CINCINNATI

1. Levenspiel — Sr

FEATURES

Inclusion of a reactor design problem of sufficient complexity to demonstrate the relationships of kinetics, thermodynamics, heat transfer, reactor geometry, etc., and application of optimization to reactor design.

CHALLENGES

Integration of transport phenomena with kinetics in design of reactors.

UNIVERSITY OF OKLAHOMA

2. Smith — Sr

FEATURES

Course is project oriented. Problems are worked in class. Reactor design project requiring 30-80 hours is required.

CONCEPTS

This is a course in "advanced assumption making" in order to solve certain problems. This [illegible] needs to be instilled on [illegible] level if a Ch.E is to succeed, [illegible] in industry.

CHALLENGES

[illegible] the course realistic and industrially [illegible].

OKLAHOMA STATE UNIVERSITY

1. Levenspiel — Sr

FEATURES

Emphasis on applications. Many, many class illustrations. 70% discussion and 30% lecture. High frequency of 10 point quizzes.

CHALLENGES

To physically envision the meaning of his notation and symbols.

TEXT

Need a good master's level book.

OREGON STATE UNIVERSITY

1. Levenspiel — Sr

FEATURES

Reactor design is emphasized rather than reaction kinetics. Area consists of catalytic systems, absolute reaction rate theory, and the non-isothermal packed bed reactor.

UNIVERSITY OF PENNSYLVANIA

2. Smith — Jr/Sr

EXPLANATIONS

Presentation of reactor design as involving and tying together all they have learned in thermodynamics, transport phenomena, etc.

CHALLENGES

Ability to use real situations and obtain meaningful results in time available.

TEXT

Smith is weak in first part, especially in non-ideal effects; good in heterogeneous systems.

PENNSYLVANIA STATE UNIVERSITY

2. Smith — Jr/Sr

FEATURES

Combining reaction kinetics with industrial chemistry.

...ETTE COLLEGE

1. Smith — Sr

FEATURES

Use of computer to solve systems of differential equations arising in reactor design.

DREXEL UNIVERSITY

1. Levenspiel — Sr

FEATURES

Design considerations of non-ideal reactors. Introduction to optimization as a tool in reactor design.

CHALLENGES

Showing how the fundamentals of heat and mass transfer and hydrodynamics are integrated with chemical kinetics in the design of the chemical reactor.

TEXT

Need for more treatment of heterogeneous reactor design.

BUCKNELL UNIVERSITY

1. Levenspiel — Sr

FEATURES

Heavy emphasis on heterogeneous catalysis, emphasis on experimental techniques.

TEXT

Levenspiel needs more on catalytic systems.

LEHIGH UNIVERSITY

1. Smith — Sr

FEATURES

Emphasis on catalysis and chemical reactions of industrial significance.

CHALLENGES

Combination of equilibrium, kinetic and heat transfer considerations.

TEXT

Need for good graduate text.

UNIVERSITY OF RHODE ISLAND

1. Levenspiel — Sr

TEXT

Improved discussion of catalytic converters.

CLEMSON UNIVERSITY

1. Levenspiel — Sr

FEATURES

Emphasis on practical characteristics of reactor design; Derivation of design equations for all types of reactions from general population balance model.

CHALLENGE

Making it real to the typical student. Convincing a student that a reactor design problem involves kinetics, stoichiometry, thermodynamics, heat transfer, fluid flow, mass transfer, etc.

TEXT

Levenspiel needs more realistic problems, and better presentation of fundamental equations. Particularly weak on temperature and heat effects.

TENNESSEE TECHNOLOGICAL UNIVERSITY

1. Levenspiel — Sr

CHALLENGES

Packing important material to be covered in a short period of time.

UNIVERSITY OF TENNESSEE

1. Smith — Sr

CHALLENGES

Most students at undergraduate level have little facility for handling differential equations.

TEXAS A & I UNIVERSITY

1. Levenspiel Sr

TEXT

Moving toward self-paced approach.

UNIVERSITY OF TEXAS

1. Smith Sr

FEATURES

Emphasis on reactor design; real problems, thorough coverage of catalysis.

TEXAS A & M UNIVERSITY

1. Levenspiel Sr

CHALLENGES

Stimulation of student to learn methods of analysis of kinetic data.

TEXT

[illegible]d more coverage on design of non-[illegible]hermal reactors.

TEXAS TECH UNIVERSITY

1. Levenspiel Sr

CHALLENGES

Illustrating and convincing students that the material can be applied to practical problems.

BRIGHAM YOUNG UNIVERSITY

1. Levenspiel Sr

EXPLANATIONS

Concept of stoichiometry using stoichiometric coefficients.

CHALLENGES

Meaningful in-class experiments and demonstrations. Finding suitable supporting media; films, etc. Applications [illegible] industrial problems, particularly [illegible].

TEXT

[illegible] for good [illegible] text.

UNIVERSITY OF VIRGINIA

1.2. Levenspiel Sr/Sr

FEATURES

Surface chemistry approach to contact catalysis; polymer kinetics.

TEXT

Improvement in heterogeneous catalysis.

WASHINGTON STATE UNIVERSITY

1. Levenspiel Sr

TEXT

Levenspiel poor in practical or industrial illustrations of problems. Smith's text is better in this area.

UNIVERSITY OF WASHINGTON

1. Levenspiel Sr

EXPLANATIONS/CONCEPTS

Correspondence of space time and batch time; differential rate studies for multi-sequential reactors.

WEST VIRGINIA INSTITUTE OF TECHNOLOGY

1. Smith Jr

TEXT

Consideration is being given to a self-paced course.

UNIVERSITY OF WYOMING

1. Levenspiel Sr

FEATURES

Course taught using overhead transparencies and handouts. This method seemed to please most students.

CHALLENGES

Process of relating mathematical equations to physical phenomena is difficult for many students.

TEXT

A few more real reactions in Levenspiel would be helpful instead of A→B, etc.

UNIVERSITY OF WISCONSIN

1. Levenspiel Sr
FEATURES
Working with data from real systems; emphasis on mass and energy balances; data interpretation.
EXPLANATIONS/CONCEPTS
Rate limiting step; use of physical property measurements in dimensionless form as an aid in determining rate expressions.
CHALLENGES
Making students realize that kinetics and reactor design require the integration of material from thermodynamics, differential equations, transport phenomena, stoichiometry.
TEXT
Deficient in data interpretation, catalytic reactions.

UNIVERSITY OF BRITISH COLUMBIA

2. Levenspiel Sr/Sr
FEATURES
Tie theory to industrial practice by examples and lab experiments. Kinetic response of reactors is stressed and tied into control theory.
EXPLANATIONS
Use of analog computer in classroom to illustrate reaction kinetics of complex reactions. Concept of selectivity and yield in choice of reactor configuration has been extended to explain less easily explained points in design.
CHALLENGES
To balance theory and math with practical applications.
TEXTS
Need better treatment of yield and selectivity and fluid-fluid reactions.

LAVAL UNIVERSITY

2. Jr/Sr
FEATURES
No text is completely satisfactory. About six books are used for references.

McGILL UNIVERSITY

1. Jr
FEATURES
P.S.I. format; guided design format on design problems.
CHALLENGES
Presenting the large number of special cases as a unified whole; finding problems that are simultaneously significant (e.g., in industry), realistic, and reasonably short.
TEXT
There is a need for a very industrially slanted book on reaction engineering.

UNIVERSITY OF CALGARY (Alberta, Canada)

1. Sr
FEATURES
Concentrated review of thermodynamics and theoretical kinetics.
EXPLANATIONS/CONCEPTS
Use of analog computers for simulation.

QUEENS UNIVERSITY (Ontario, Canada)

1. Jr
CHALLENGES
Show use of kinetics approaches to fields like biochemistry, population dynamics, etc.
TEXT
Available texts are not satisfactory.