



# PROCEEDINGS OF PACHEC '83

**The Third Pacific  
Chemical Engineering Congress**

*Seoul, KOREA  
May 8—11, 1983*

## **Volume III**

- Energy & Resource
- Process Modeling
- Process Simulation
- Process Dynamics & Control
- Computer Applications



**THE THIRD PACIFIC  
CHEMICAL ENGINEERING  
CONGRESS**

*Seoul, KOREA  
May 8-11, 1983*

**PROCEEDINGS**

## Organizing Committee

### Congress President

Professor Chai-sung Lee  
Seoul National University

### Chairman, Organizing Committee

Professor Young Gul Kim  
Korea Advanced Institute of Science  
& Technology

### Secretary-General

Professor Ho Nam Chang  
Korea Advanced Institute of Science  
& Technology

### Program

Chairman  
Dr. Won Hee Park  
Korea Advanced Institute of Science  
& Technology

#### Vice Chairman

Dr. Chang-Koo Yun  
Korea Advanced Institute of Science  
& Technology

### Finance

#### Chairman

Mr. Min Che Chon, President  
Chon Engineering Company

#### Vice Chairman

Mr. Chong Won Lee, Executive Director  
Korea Petrochemical Industry Association

Mr. Hong Kyu Chang, Vice President  
Honam Ethylene Corporation

Mr. Keun-Sun Choi, Vice President  
Lucky Limited

Professor Baik Hyon Ha  
Hanyang University

### Steering

#### Chairman

Professor Woong Ki Kang  
Korea University

#### Vice Chairman

Professor Wha Young Lee  
Seoul National University

## REGIONAL COORDINATORS

### Coordinators for North America

Professor W. Robert Marshall  
University of Wisconsin

Professor Dee H. Barker  
Brigham-Young University

### Coordinator for Japan

Professor Mompei Shirato  
Nagoya University

---

Silhouette on the Cover:

One of the two Pulguksa pagodas of stone in Kyongju dating from 691 A.D. A Korean scroll of sutra, which was found inside of the delicate structure, is listed as the oldest surviving printed work in the world by the Guinness Book.

The lines in the background are from the first few pages of the promulgation of Hangul, which was printed from metal type in 1446. The new system of Korean alphabet was created through decades of labor by Royal Academicians in early 15th century.

## **PROGRAM COMMITTEE**

### **Program**

**Chairman**

**Dr. Won Hee Park**

**Vice Chairman**

**Dr. Chang-Koo Yun**

### **Proceedings Editors**

**Professor Chul Kim**

**Ajou University**

**Professor Son-Ki Ihm**

**Korea Advanced Institute of Science and Technology**

**To order individual volumes, contact the Congress Secretariat**

**Third Pacific Chemical Engineering Congress  
c/o The Korean Institute of Chemical Engineers  
35, 5-ka, Anam-dong, Seongbuk-ku  
Seoul, Korea  
Tel.: 94-5458**

## Preface

The Proceedings have been divided into the following 4 volumes to keep each volume within manageable size:

### Volume I

#### Fundamentals (1)

Fluid Mechanics, Fluid-Solid Interactions  
Fluid Operations, Mass Transfer

### Volume II

#### Fundamentals (2)

Kinetics & Catalysis, Heat Transfer  
Polymers, Thermodynamics

### Volume III

Energy & Resource, Process Modeling  
Process Simulation, Process Dynamics & Control  
Computer Applications

### Volume IV

Bioengineering, Environment, Technology Management  
Chemical Engineering Education

All texts of manuscripts received prior to the printing deadline of March 31, 1983 are included in these volumes. Some manuscripts not received by the deadline were regrettably excluded although the authors were permitted to present them at technical sessions. The papers were printed directly from the camera-ready originals submitted by authors.

Many volunteers, mostly graduate students of the Korea Advanced Institute of Science & Technology, have worked mightily to bring out these volumes and to them the Program Committee owes much. Since these names do not appear anywhere in the Program, we wish to mention them here: Sang Wook Kang, Jeong Ae Chang, Kyung Beom Lee, Yong Chae Chee, Do-Hyun Kim, Eun Kee Kim, You Sin Yeom, Yeong Cheol Kim, Sang Gon Seo, Jeong Wha Chang.

The Program Committee

# Contents

## Volume I

### Fluid Mechanics Fundamentals (I)

- Transport Phenomena among Turbulence Promoters at/on Wall Surface in Rectangular Duct ..... I-1  
*H. Miyashita, Y. Shiomi and K. Wakabayashi*
- Numerical Study of Viscous Flows in Rectangular Cavities with Translating Top and Bottom Walls ..... I-7  
*H.W. Ryu and D.I. Lee*
- Flow Characteristics in Channel with Symmetric Wavy Wall for Steady Flow ..... I-13  
*T. Nishimura, Y. Ohori and Y. Kawamura*
- Method of Multi-interval Expansion for a Boundary Layer Flow Problem ..... I-19  
*O. Rho and K. Song*
- Effect of the Wound Thread Around a Vertical Tube on Flowing Down of the Liquid Film and Wave Properties of the Free Surface ..... I-24  
*S. Toyama, T. Aragaki, S. Nakayama and M. Suzuki*

### Fluid Mechanics Fundamentals (II)

- Dynamics of Bubbles in Viscoelastic Media ..... I-29  
*D.D. Kee and J. Mordarski*
- Rheological Study on the Concentrated Bimodal Suspensions of Spherical Particles ..... I-32  
*J.W. Lee and K.J. Lee*
- Thermocapillary and Buoyancy Driven Flows in Liquid Metal Discs ..... I-38  
*W.N. Gill, C.C. Hsu, J. Verhoeven and M.A. Noack*
- Development and Collapse of Taylor Vortex on the Rotating Inner Cylinder in the Coaxial Rest Outer Cylinder ..... I-44  
*A. Ogawa, H. Nagabayashi and Y. Fujita*

### Fluid Mechanics Fundamentals (III)

- Thermal Instability of Non-Newtonian Fluids in Vertical Slot ..... I-50  
*J.Y. Yoo and J.H. Song*
- Velocity Distribution of Fully Developed Turbulent Flow in an Eccentric Annulus ..... I-57  
*F. Ogino, M. Funatsu, M. Yoshida and T. Mizushima*
- Analysis of Pressure Recovery in a Rectangular Diffuser with Subsonic Two-phase Annular Air-Water Flow ..... I-63  
*S. Viswanathan, A.W. Gnyp and C.C. St. Pierre*
- Hydrodynamic Analysis of Maxwell Fluid Flow in Calendering Processes ..... I-69  
*J.W. Lee, K.J. Lee and J.S. Yu*

### Fluid-Solid Interaction (I)

- Size Distribution of Product of a Screen Mill ..... I-75  
*Y. Kuga, J. Koga and K. Yamaguchi*
- Dynamic Behavior of Particulate Solid in Unsteady Mixing Vessel ..... I-81  
*Y. Takahisa, M. Shimazaki and Y. Ohtani*
- Rapid Measurement of Size Distribution of Fine Powders in Weight Basis and in Dry State ..... I-86  
*A. Suganuma, H. Yamamoto, K. Yoshie, and R. Aoki*

Recent Developments in Gravitational Sedimentation .....	I-92
<i>D.A. Dahlstrom and R.C. Emmett, Jr.</i>	
Batch Sedimentation and Thickener Behaviour .....	I-100
<i>P.H.T. Uhlherr, J.R.G. Andrews and K.H. Park</i>	
Filtration Theory for Non-Newtonian Fluids .....	I-106
<i>M. Shirato and E. Iritani</i>	
High Capacity Depth Filter .....	I-112
<i>N. Tambo and Y. Matsui</i>	

## Fluid-Solid Interaction (II)

Scale up of Granulation Process .....	I-118
<i>B. Kinno and S. Nioh</i>	
The Behavior of the Dispersed Phase in Ternary Liquid-Liquid Extraction through Fluidized Beds .....	I-124
<i>B.K. Kim, K. Kim and M.S. Ryu</i>	
Mechanism of Classification in a Sturtevant-type Air Classifier .....	I-131
<i>T.S. Suh, M. Yamazaki, J. Tsubaki, G. Jimbo and T. Koike</i>	
Electric Potential Distributions and Its Roll in Naturally Charged Fluidized Bed .....	I-136
<i>S. Ogata, M. Fujino, K. Tagawa and H. Shinohara</i>	
Flow Characteristics of Rice Hulls in Spouted Beds .....	I-142
<i>S.K. Kang, D.S. Synn and H.K. Ahn</i>	
Volumetric Liquid Phase Mass Transfer in Solid-suspended Bubble Column .....	I-148
<i>K. Koide, A. Takazawa and M. Komura</i>	

## Fluid Operations

Empirical Approach to the Vibration of Heating Tubes of Process Furnaces Due to Two Phase Flow .....	I-154
<i>Y. Ebisawa</i>	
Effect of Mixing Intensity on a Semi-Batch Reaction in a Stirred Tank Reactor .....	I-159
<i>W-M. Lu and S-J. Wang</i>	
Analysis of Liquid Mixing in a Three Phase Rotating Disk Reactor .....	I-164
<i>Y.S. Ghim, M.J. Kim and H-N. Chang</i>	
Performance of Slurry Reactor .....	I-169
<i>K. Miyanami, K. Tojo and H. Iwanaka</i>	
Spray and Bubbling on Sieve Trays .....	I-174
<i>J.J.J. Chen, W.K. Kwan and P.F.Y. Wong</i>	

## Mass Transfer Operation (I)

Air Separation by Modified Molecular Sieving Carbon .....	I-180
<i>K. Chihara, Y. Sakon and M. Suzuki</i>	
Rate of Adsorption and Desorption in Cyclic Adsorption Processes .....	I-186
<i>S. Nakao and M. Suzuki</i>	
A Study on Bubble Adsorptive Separation .....	I-192
<i>J.H. Shin, S.W. Park and S.S. Lee</i>	
Packed Absorber and Stripper Operation on Gases Produced From Coal .....	I-195
<i>R.W. Rousseau, J.K. Ferrell and R.M. Kelly</i>	

Gas Absorption in Multi-Stage Gas-Liquid Spouted Vessel .....	I-201
<i>M. Nishikawa, K. Shino, T. Kayama and K. Hashimoto</i>	
Gas Absorption at a Liquid Surface Agitated by a Pitched Blade Paddle .....	I-207
<i>K. Sato</i>	
Chemical Absorption into Concentrated Slurry .....	I-213
<i>E. Sada, H. Kumazawa and C.H. Lee</i>	
Gas Absorption into Wavy and Turbulent Non-Newtonian Falling Liquid Films in a Wetted-Wall Column .....	I-219
<i>S.M. Yih and T-Y. Hsu</i>	

### Mass Transfer Operation (II)

Behavior of a Minute Amount of Diethyl Sulfide in Distillation of Hydrocarbons .....	I-225
<i>A. Ikari, Y. Hatate and A. Maruyama</i>	
Influence of Foam Height on Point Efficiency at Binary and Ternary Components Distillation Using Plate Column .....	I-231
<i>H. Hatayama</i>	
SHE-A New Selfstabilizing High Performance Extraction Column .....	I-237
<i>R. Marr, W. Gaubinger and G. Husung</i>	
An Analysis on the Steady State Behaviour of a Mixer-Settler Extraction Column .....	I-242
<i>W.J. Oh, D.P. Ju and C. Kim</i>	
Cocurrent Extraction in a Reciprocating Plate Column .....	I-248
<i>S.H. Noh and M.H.I. Baird</i>	
Liquid-liquid Extraction of Aromatics in a Spray Column Operated in the Region of Dense Packing of Drops .....	I-254
<i>S.L. Dhabe and S.A. Puranik</i>	
Stability Analysis of an MSMR Crystallizer with Size Dependent Growth Rate .....	I-259
<i>L.P. Leu, T. Fitzgerald and F. Kayihan</i>	

### Mass Transfer Operation (III)

Electrodeposition over Rotating Objects of Non-uniform Figures .....	I-265
<i>A.A. Manieh</i>	
A Study on the Ion Exclusion Process .....	I-271
<i>K-S. Doh and K-S. Kang</i>	
A Basic Study on Desalination by Thermally Regenerable Ion Exchanger — Equilibria, Kinetics and Dynamics .....	I-279
<i>T. Kataoka and H. Yoshida</i>	
Computer Simulation of a Continuous Membrane Column .....	I-285
<i>S.T. Hwang and R.A. Yoshisato</i>	
Removal of Tar Aerosols from Gaseous Effluents .....	I-291
<i>L. Jacob and A. Buekens</i>	
Pilot Planting and Scale-up of Mixers in Gas-Liquid-Solid Processes Involving Mass Transfer and Chemical Reaction .....	I-298
<i>J.Y. Oldshue</i>	
Hydrodynamics and Gas-Liquid Mass Transfer in an Air Lift Slurry Reactor .....	I-303
<i>K. Muroyama, Y. Mitani and A. Yasunishi</i>	
Measurement of Mass Transfer Coefficients in Packed Towers .....	I-309
<i>P.L. Spedding, M.T. Jones and G.R. Lightsey</i>	

## Mass Transfer (I)

- Analytical and Experimental Studies of Mass Transport through Liquid Membranes ..... I-315  
*H.S. Park, P-S. Han, J-H. Yu and W-K. Kang*
- Separation and Enrichment of Weak Organic Acids or Bases by Immobilized Liquid Membranes ..... I-321  
*H. Hikita, H. Ishikawa, T. Murakami and M. Hata*
- Liquid Membrane Permeation: A Process for Selective Metal Recovery ..... I-327  
*R. Marr, J. Draxler, M. Prötsch, A. Bowier and A. Kriechbaumer*
- Simulation of Chromium (VI) Ion Transport in a Carrier-Containing Emulsion Drop ..... I-333  
*H.S. Lee, Y.D. Yoo and S.K. Ihm*
- Kinetics of Isotopic Exchange in a Batch System ..... I-339  
*T-C. Huang, and F-N Tsai*
- Non-Isothermal Gas Absorption with and without Chemical Reaction ..... I-345  
*S. Asai, H. Hikita and O.E. Potter*
- Characteristics of Net-type Spacer as Mass Transfer Promoter in Electrodialysis ..... I-351  
*O. Kuroda, S. Takahashi and M. Nomura*

## Mass Transfer (II)

- Solution of Stretched Differential Equations via Legendre Function ..... I-357  
*R-Y. Chang and M-L. Wang*
- Flow Properties of Effluent and the Separation of the  
Dye by means of Centrifugal Liquid Chromatograph ..... I-365  
*H. Utsugi, A. Endo, N. Suzuki, S. Hagiwara, M. Umemura and T. Fukuda*
- A Statistical Mechanical Model for Adsorption and Surface Diffusion in the Presence of  
Gas-Adsorbate Interaction ..... I-371  
*C.S. Lee, Y.J. Shin and S.I. Hong*
- Mass Transport in Fixed Beds with Active and Dimensional Non-uniformity ..... I-377  
*G. Brunello, L.R. Terron, S.A. Batistela and R.Y. Shima*
- Separation Behavior and Mass Transfer of Various Metal Chelates  
by the Vacuum Sublimation Method ..... I-383  
*J.B. Kim, J.E. Sohn and D.W. Park*
- Nucleation Characteristics of Aqueous Ammonium Sulfate Solutions ..... I-387  
*C.S. Choi, T.J. Kim and W.H. Lee*

## Mass Transfer (III)

- Peculiar Behavior of Mass Transfer of the Intermediate Component in Ternary Distillation ..... I-393  
*H. Kosuge, T. Johkoh and K. Asano*
- Measurements of Axial and Lateral Dispersions in Porous Media ..... I-399  
*N-W. Han and R.G. Carbonell*
- Liquid-phase Mixing in a Bubble Column ..... I-405  
*W.J. Anderson, L. Fitzpatrick and C. Mayers*
- Mass Transfer Studies in Spiral-Wire Packed Pulse Column for Liquid-Liquid Extraction ..... I-411  
*W.S. Kim and B.S. Kim*
- Combined Effects of Free and Forced Convection on Momentum and Mass Transfer  
through Liquid-Liquid Interfaces ..... I-417  
*M. Hozawa, T. Tsukada, N. Imaishi, T. Kondo and K. Fujinawa*

Liquid Phase Dispersion in a Packed Column with Countercurrent Two-phase Flow .....	I-423
<i>D.K. Choe and W.K. Lee</i>	
Correlation of Liquid-side Mass Transfer Coefficients between Particles and Liquid .....	I-429
<i>H. Ohashi, T. Sugawara and K. Kikuchi</i>	

## Volume II

### Heat Transfer

Heat Transfer Characteristics of Three Phase Fluidized Beds .....	II-1
<i>Y. Kang, I.S. Seo and S.D. Kim</i>	
Particle-to-Fluid Heat Transfer Coefficients at Low Flow Rates in Packed Beds: Approaching a Limited Value or Unlimited Decline? .....	II-7
<i>N. Wakao, S. Kagueli and S. Tanisho</i>	
Measurements of the Effective Thermal Conductivity and Diffusivity of Packed Coals during Carbonization .....	II-13
<i>T. Miura, J. Fukai, K. Sugiyama, H. Tajima, K. Miura and S. Ohtani</i>	
Thermal Convection in a Horizontal Fluid Layer .....	II-19
<i>C.K. Choi, C.S. Lee and D.H. Kwon</i>	
The Effect of Free Stream Concentration on Heat and Binary Mass Transfer with Thermodynamic Coupling in Forced Convection on a Rotating Disc .....	II-25
<i>A. Atimtay and W.N. Gill</i>	
Characteristics of Convective Heat Transfer in Nonisothermal, Variable-Density Impinging Jets .....	II-31
<i>K-Kataoka, H. Shundoh, H. Matsuo and Y. Kawachi</i>	
Variational Embedding Technique to Inward Cylindrical Solidification with Convective and Radiative Boundary Conditions .....	II-37
<i>C-K. Chen, Y-M. Chang, S.S. Chang and K. Lin</i>	

### Polymer Reaction Engineering

A Study of the High Pressure Polyethylene Tubular Reactor .....	II-42
<i>B.J. Yoon and H-K. Rhee</i>	
Some Scaling-up Aspects of Loop Reactor for Olefin Polymerization .....	II-48
<i>Y. Murakami, M. Takao, S. Ono and T. Hirose</i>	
Surface Modification of Kevlar <sup>R</sup> Fibers for Improved Adhesion to Epoxy Resin Matrices .....	II-54
<i>A.S. Hoffman, T.S. Keller, A. Miyake, B.D. Ratner and B.J. McElroy</i>	
Synthesis of Vinylchloride/Acrylonitrile Copolymer of Constant Composition .....	II-64
<i>Y.O. Ahn, K.Y. Park, T.K. Park and P.K. Oh</i>	

### Polymer Properties and Structure

Suspension Polymerization of Styrene under Ultrasonic Irradiation—Size Distribution of Polymer Droplets .....	II-70
<i>Y. Hatate, A. Ikari, F. Nakashio and K. Kondo</i>	
Study of Particle Size Distribution in Continuous Emulsion Polymerization of Styrene .....	II-76
<i>W.Y. Chiu, M-C. Tsai and C-C. Lin</i>	
Polyurethane Interpenetrating Polymer Networks Synthesized under High Pressure .....	II-82
<i>D.S. Lee, D.S. Lim and S.C. Kim</i>	

Studies on Atactic Polypropylene, Relation Between Physical Properties, Thermal Properties and Molecular Structure of Polypropylene .....	II-88
<i>H.B. Harjono, J. Mu'min, I. Noezar and V.S. Praptowidodo</i>	
Crystallization Kinetics of Poly(ethylene terephthalate) and Poly(ethylene oxide) Blend .....	II-93
<i>W.H. Jo, Y.H. Park and J. Jeong</i>	
Properties of Thermoplastic Polymers Extended with Organic Fillers .....	II-98
<i>G.R. Lightsey and G.G. Gonzalez</i>	

## Polymer Rheology and Process

The Dependence of Viscoelastic Flow Functions on Molecular Structure for Linear and Branched Polymers .....	II-104
<i>E.B. Christiansen, S. Ramachandran and H.W. Gao</i>	
Foam Extrusion Characteristics of Low-density Polyethylene .....	II-110
<i>C.D. Han and C.Y. Ma</i>	
Computer Simulations of Commercial Melt Spinning Processes .....	II-117
<i>L.S. Tung, R.L. Ballman, W.J. Nunning and A.E. Everage</i>	
Analysis of Plastics Extrusion and Calendering by Numerical Methods .....	II-124
<i>J. Vlachopoulos, E.E. Agur and E. Mitsoulis</i>	
Tubular Blown Film Extrusion of Low-density Polyethylene .....	II-130
<i>C.D. Han and T.H. Kwack</i>	
Drying Characteristics of a Drop of Polymer Solution (PAN-DMF System) .....	II-136
<i>Y. Sano, S. Yamamoto and R.B. Keey</i>	

## Kinetics and Catalysis (I)

Kinetics of the Oxidation of Ferrous Iron in the Presence of Sulfur Dioxide .....	II-143
<i>C-F. Kao</i>	
Anodic and Homogeneous Reactions of Propylene in the Bromide Aqueous Solutions .....	II-149
<i>T.C. Chou, J.J. Jow and S.T. Yu</i>	
The Complete Kinetic Analysis of Complex Reactions Catalyzed by a Standard Hydrosulfurization Catalyst .....	II-155
<i>K.L. Kim, H.J. Yoo and K.S. Choi</i>	
Effect of Structure on the Reactivity of Grain Porous Solids .....	II-161
<i>S. Kimura, Y. Takagi, H.C. Park, S. Tone and T. Otake</i>	
On the Kinetics of Autocatalytic Type of Gas-Solid Reactions .....	II-167
<i>J. Papa and C.R. Auza V.</i>	
Catalytic Effects of Calcined Limestone on "NO <sub>x</sub> " Reduction: Fundamental Kinetics of "NO <sub>x</sub> " Reduction in Fluidized Bed Combustor and Cement Kiln .....	II-173
<i>M. Tsujimura, M. Tsunoda, T. Furusawa and D. Kunii</i>	
A Kinetic Study of the Hydrogenolysis of Sorbitol on a Raney Nickel Catalyst .....	II-179
<i>F-W. Chang, K-T. Kuo and C-N. Lee</i>	

## Kinetics and Catalysis (II)

Oxidation of Methacrolein and Isomerization of n-Butene over Heteropoly Compounds .....	II-185
<i>J.J. Kim and W.Y. Lee</i>	
Diffusional Kinetics of Low Pressure Methanol Synthesis .....	II-191
<i>S. Lee, J.M. Berty, V. Parekh, R. Gandhi and K. Sivagnanam</i>	

Selective Formation of Alkylaromatics over Zeolite Catalysts: Alkylation of Toluene with Ethanol .....	II-197
<i>S.E. Park and H. Chon</i>	
Thermal Degradation of High Density Polyethylene at Elevated Pressure Using a Continuous Flow Stirred Tank Reactor .....	II-202
<i>K. Murata and K. Sato</i>	
Investigation of Ethylene Epoxidation Mechanism with a Cyclic Reactor System .....	II-208
<i>D.W. Park and G. Gau</i>	
The Mechanism of Alcohol Formation in Hydrogenation of Carbon Monoxide on a Promoted Metal Oxide Catalyst .....	II-214
<i>H.R. Park</i>	
Isomerization of o-Xylene and Coke Formation on Mordenite .....	II-220
<i>B.H. Ha and Y.W. Lee</i>	
Formation of Hydrazine by Photolysis of Ammonia in a Gas Phase Flow System .....	II-226
<i>T. Okazaki, H. Hayashi and Y. Konishi</i>	
Hydrocracking of Kuwait Vacuum Distillate for Middle Distillate and Lubricant Base Stock Production .....	II-232
<i>A.S. Nasution</i>	

### Kinetics and Catalysis (III)

Coadsorption of H <sub>2</sub> O with H <sub>2</sub> and CO on Ruthenium(001) .....	II-238
<i>H.I. Lee and J.M. White</i>	
Change in Surface Area of Silica-Alumina Catalysts Owing to Sintering in Steam .....	II-244
<i>K. Hashimoto and T. Masuda</i>	
Characterization of Pt/TiO <sub>2</sub> Catalysts .....	II-250
<i>T.J. Lee and Y.G. Kim</i>	
Effects of Metal Loading and Support Materials on Surface Properties of Co Catalysts .....	II-256
<i>J.G. Choi, H.K. Rhee and S.H. Moon</i>	
Role of Hydrogen Spillover in the Hydrogenation Reaction on "Monometallic" and "Bimetallic" Platinum Metal Catalysts .....	II-262
<i>K. Nakano and K. Kusunoki</i>	
Preparation and Regeneration of Ethylbenzene Dehydrogenation Catalysts .....	II-268
<i>S.J. Chen and F.C. Sheu</i>	

### Kinetics and Catalysis (IV)

Dehydrocyclization of Normal Heptane to Toluene Using Bi-metallic Reforming Catalysts .....	II-274
<i>A.S. Nasution</i>	
Analysis of Formation of Methane from Hydrogen and Carbon Monoxide by a Fluidized Catalytic Reactor .....	II-280
<i>T. Kai, S. Furusaki and K. Yamamoto</i>	
Alkylation of Benzene with Propylene over a Solid Phosphoric Acid Catalyst .....	II-286
<i>S. Marzuka and J. Papa</i>	
The Reaction of p-Substituted t-Butylbenzene over Silica-Alumina Catalyst .....	II-291
<i>T. Takahashi, M. Nomura and M. Tashiro</i>	

### Thermodynamics(I)

Vapor-Liquid Equilibrium Calculation of Systems Containing Hydrogen by Extended BWR Equation of State .....	II-297
<i>H. Nishiumi</i>	

Calculation of High Pressure Vapor-Liquid Equilibria of Asymmetric Mixtures with an Augmented van der Waals Equation of State .....	II-303
<i>C. Yokoyama, K. Arai and S. Saito</i>	
Prediction of High Pressure Vapor-Liquid Equilibria by the ASOG Method .....	II-309
<i>K. Tochigi and K. Kojima</i>	
Phase Diagrams in the Critical Region Using an Equation of State .....	II-315
<i>R.L. Smith and A.S. Teja</i>	
Cubic Chain-of-Rotators Equation of State .....	II-321
<i>H.Y. Kim, H.M. Lin and K.C. Chao</i>	
The Prediction of Thermodynamic Properties by the Use of the Principle of Corresponding States .....	II-327
<i>H.S. Kim, J.W. Lee and B.S. Rhee</i>	
Partial Molar Volume of Salt in Aqueous Mixed Solvent and the Applicability of the Debye-Hückel Theory .....	II-334
<i>H. Nomura, F. Kawaizumi and Y. Miyahara</i>	
Selection of Response Surface Model by Means of Response Surface Methodology for Multicomponent System .....	II-340
<i>J.C. Park</i>	

## Thermodynamics (II)

Gas Chromatographic Determination and Correlation of Weight-Fraction Henry's Constants for Hydrocarbon Gases and Vapors in Molten Polymers .....	II-348
<i>Y. Iwai, M. Ohzono and Y. Arai</i>	
Electron Occupation Diagrams for Representation of Complex Redox Equilibria .....	II-354
<i>J.C. Angus and M.J. Zappia</i>	
VLE Values for Nitrogen-Argon-Oxygen at High Oxygen Concentrations at 1.2 Atmospheric Pressure .....	II-359
<i>I. Funada, S. Yoshimura and M. Yorizane</i>	
Vapor-Liquid Equilibria for the Systems Containing CO <sub>2</sub> and Normal Alkanes at High Pressures .....	II-365
<i>K. Nagahama, D. Hoshino and M. Hirata</i>	
Vapour-Liquid Equilibrium Data, Heat of Mixing and Enthalpy Concentration Diagrams for Dimethyl Sulphoxide-Water System .....	II-371
<i>S.S. Gedam and S.A. Puranik</i>	

## Volume III

### Process Synthesis and Analysis

Synthesis of Chemical Process Reactor Systems .....	III-1
<i>R. Govind and S.P. Chitra</i>	
Operation Scheduling of a Multi-product Process .....	III-9
<i>T. Takamatsu, I. Hashimoto, S. Hasebe and Y. Matsuda</i>	
Simultaneous Revisions of Schedule of Batch Units with a Continuous Process Demanding a Constant Flow Rate .....	III-15
<i>K. Oi</i>	
A Rational Approach to a Choice of Energy Conservation Technologies in a Total Energy System .....	III-21
<i>M. Nishio, I. Koshijima, K. Shiroko and T. Umeda</i>	

The Application of CAE Intelligent Solid Modelling to Process Plants: Process & General Engineering, through Construction to Commissioning, Operation and Maintenance .....	III-27
<i>D.B. Armour</i>	
Analysis of Intermediate Storage in Noncontinuous Processes Involving Stages of Parallel Units .....	III-33
<i>G.V. Reklaitis and I.A. Karimi</i>	
The Synthesis of Optimal Gas Saturates Separation Systems .....	III-41
<i>D.W. Tedder</i>	
Physical Property System for Computer-Aided Process Engineering .....	III-49
<i>T. Maejima, A. Shindo and H. Yagi</i>	

### Computer Control and Graphics

Image Analysis and Quantitative X-Radiography .....	III-55
<i>V.N. Schrodit, L.D. Cheung, C.S. Higgins, L.R. Holden, E.S. Kurth, R.E. Otto and L. Duncan</i>	
Computers, Graphics and Monsanto .....	III-61
<i>E.M. Rosen</i>	
Optimization of a Fed-Batch Culture by Statistical Data Analysis .....	III-66
<i>M. Kishimoto, T. Sawano, T. Yoshida and H. Taguchi</i>	
Computer Control of a Fed-Batch Alcoholic Fermentation Systems .....	III-72
<i>T. Nagamune, I. Endo and I. Inoue</i>	
Efficiency and Flexibility in Dynamic Chemical Plant Simulation .....	III-78
<i>B. Carnahan and J. Fagley, Jr.</i>	
From Process Knowledge to Computer Control: A Methodology .....	III-85
<i>F.G. Shinskey</i>	
A New Approach to the Synthesis of Process Control Systems .....	III-90
<i>Y. Arkun</i>	

### Process Simulation and Modeling

Discrete Stochastic Models for the Uniformly Sampled Continuous Dynamic Systems .....	III-98
<i>H-P. Huang and Y-C. Chao</i>	
A Statistical Process Optimization Technique for Mixture Experiments .....	III-104
<i>S.H. Park</i>	
A New Dynamic Packed Distillation Model .....	III-108
<i>A. Sümer and B. Kisakürek</i>	
Modeling and Simulation of a Local Solar Still .....	III-114
<i>B.J. Yoon, H-K. Rhee and W-H. Park</i>	
Computer Simulation of Staged Hollow Fiber Desalination Plants .....	III-122
<i>K.J. Baik and C-S. Lee</i>	
Mathematical Modeling of Membrane Moderated Controlled Release .....	III-129
<i>K. Tojo, K. Miyunami and L.T. Fan</i>	

### Process Dynamics and Control

Multivariable Multiple Delay Controller Designs for Heat-integrated Distillation Networks .....	III-135
<i>P.K. Goel, K. Nanbara and E. Nakanishi</i>	
Multi-variable Control System Design of a Heat Integrated Distillation Columns System .....	III-141
<i>T. Takamatsu, I. Hashimoto and Y. Hashimoto</i>	

Discrete-Time Multivariable Adaptive Control of a Nonadiabatic Fixed Bed Reactor .....	III-147
<i>K.S. Lee and W-K. Lee</i>	
Simulation and Control of Balling Circuits .....	III-153
<i>G.W. Barton</i>	
A New Predictor Method for Dead Time Compensation in Linear Systems with Delay in the State .....	III-159
<i>W.H. Kwon and D. J. Lim</i>	
Flow Control of Gas Fuel for an Optimal Operation of Soaking Pits in a Steel Mill .....	III-166
<i>I.S. Kang, C.K. Yun, I.B. Lee, W.H. Park, S.D. Choi and D.K. Kim</i>	

### Reaction Modeling and Reactor Analysis

Oxidation of Sulfur Dioxide in Different Types of Three-phase Reactors .....	III-172
<i>S. Goto and Y. Kojima</i>	
A Model of Phase Transfer Batch Preparation of Benzyl Phenyl Ether .....	III-178
<i>T-B. Lin, M-Y. Yeh and Y-P. Shih</i>	
Reactant-Catalyst Contact in Riser-tube Reactor .....	III-194
<i>M. Masai, S. Tanaka, Y. Tomomasa and S. Tsuruya</i>	
Fixed Bed Reactor Simulations for Exothermic Complex Reactions .....	III-199
<i>J.L. Herve-Vigil and G. Luft</i>	
On a Reactor with Catalytic Membrane Permeated by Hydrogen .....	III-205
<i>H. Nagamoto and H. Inoue</i>	
The General Solution for an Unsteady State Radial and Axial Dispersion Tubular Reactor .....	III-211
<i>D.H. Kim and K.S. Chang</i>	
Probabilistic Mixing Cell Model .....	III-217
<i>C. Ahmed Basha, K. Lakshminarayana and S.R.K. Prasad</i>	

### Coal and Oil Utilization (I)

A Study on Anthracite Combustion in a Fluidized Bed .....	III-223
<i>J.H. Park, C.S. Choi and W.K. Kang</i>	
Fluidized Bed Combustion—Bench Scale to Pilot Scale for Various Types of Coal .....	III-229
<i>J. Tatebayashi, M. Ohide, T. Takada, Y. Okada, K. Yano and S. Yutani</i>	
The Gasification Rates of Australian Coal Derived Chars .....	III-236
<i>G.D. Sergeant and A.T. Knight</i>	
The Gasification of Coal in the Thermal Argon Plasma .....	III-245
<i>A. Kanzawa, H. Anekawa and T. Honda</i>	
Gasification of Coal by Impinging on Iron Bath .....	III-251
<i>K. Otsuka, S. Komatsu, K. Kaneko, N. Sano and T. Soma</i>	
Total Gasification of Coal in Fluidized Bed .....	III-256
<i>S.K. Awasthi, S.N. Srivastava and G.N. Pandey</i>	

### Coal and Oil Utilization (II)

Battelle's Multisolid Fluidized-bed Combustion Process: An Advanced Technology with Multifuel Flexibility and Emissions Control for Boilers and Process Heaters .....	III-264
<i>B.C. Kim, R.D. Litt, H. Nack, C.J. Lyons and J.D. Kim</i>	
Fueling Power Plants with High Sulfur Coal in Compliance with Emission Standards .....	III-272
<i>T.Y. Yan</i>	

Desulfurization of Coal by Carbonization in Hydrogen Streams .....	III-282
<i>H. Ohashi, T. Sugawara and T. Matsunaga</i>	
Hydrogen Utilization On Upgrading Processes .....	III-288
<i>H. Yanagioka and M. Onozaki</i>	
Julia Creek Shale Oil .....	III-293
<i>J. Mandelson</i>	
New Approach to Used Oil Recycling .....	III-299
<i>A.L. Salusinzky</i>	

### Topics in Nuclear Industry

Pilot Plant Operation of the Uranium Recovery from Graphitic Ore .....	III-306
<i>Y.B. Hahn, Y.T. Yoo, Y.Y. Choi, H.S. Lee, W.S. Ko, K.J. Hahn and S.J. Im</i>	
Tritium Isotope Separation by CO <sub>2</sub> Laser Irradiation .....	III-314
<i>K. Takeuchi, S. Satooka, I. Inoue and Y. Makide</i>	
A Combined Process of Chemical Exchange Method with Thermal Diffusion Method for Separating and Concentrating Radioactive Tritium .....	III-320
<i>A. Kitamoto, Y. Takashima and M. Shimizu</i>	
Recent Developments in Uranium Isotope Separation Technologies .....	III-326
<i>H.J. Lee</i>	
Nuclear Power Accidents: The Lack of Major Public Risks .....	III-334
<i>M. Levenson and F. Rahn</i>	
Feasibility Studies on Ejector-Scrubber System for Nuclear Reactor Safety .....	III-338
<i>Y. Takashima, S. Matsumoto, A. Kitamoto and M. Hanzawa</i>	
Long-term Risk Assessment on High-Level Waste Management .....	III-344
<i>A. Suzuki, H. Umeki, J.H. Ahn, Y. Enokida and R. Kiyose</i>	

### Energy Conservation and Analysis (I)

Rankine Cycle Systems Utilizing Low-level Heat: Measurement of Transport Properties of Working Fluids and Simulation of System Performance .....	III-350
<i>Y. Shigaki, H. Yoshioka and K. Yoshida</i>	
Synthesis and Feasibility of a Thermochemical Cycle for Reducing Carbon Dioxide .....	III-356
<i>E. Kunugita, E. Takatsuki and T. Ikeda</i>	
△ Simulation Analysis Conserves Energy and Feedstock in Ammonia Plant Design and Operation .....	III-360
<i>Y.C. Fang and W. Huang</i>	
Advanced Process for Cost and Energy Saving (ACES) for Urea Production .....	III-367
<i>T. Jojima, H. Uchino, M. Nobue and A. Fukui</i>	
Conervation by Energy Audit and Evaluation—The Fluor Way .....	III-373
<i>C.I. Rhee and H.J. Klooster</i>	
The Gist of Technology Development .....	III-378
<i>M. Miura</i>	
Lean Fuels Combustion Burner Development .....	III-381
<i>R. Aggarwal</i>	

### Energy Conservation and Analysis (II)

△ Application of the Second Law Analysis to the Utility System Design .....	III-386
<i>H. Nishitani, Y. Kutsuwa and E. Kunugita</i>	

OSA Conserves Energy and Resources for Chemical Process Industries .....	III-392
<i>W. Huang</i>	
Municipal Wastewater Reuse for Industrial Applications .....	III-403
<i>A.A. Van Haute</i>	
A Thermodynamic Approach to Distillation System Design for Energy Conservation .....	III-409
<i>Y. Naka, K. Baba, T. Satoh and T. Takamatsu</i>	
A Method for Solving Design Problem of Multieffect Distillation Process .....	III-415
<i>I. Yamada, S. Hiraoka, S. Mori, S. Matsui and S.G. Lee</i>	

## Renewable Energy

Raw Starch Digestion and Ethanol Fermentation of Starch Materials without Cooking for Saving Energy .....	III-421
<i>S. Ueda and Y. Fujio</i>	
Continuous Rapid Alcohol Fermentation from Carbohydrates in a Novel Immobilized Bioprocess .....	III-425
<i>S. Fukushima and K. Yamade</i>	
Hydrogen-rich Synthesis Gas from Catalytic Gasification of Biomasses .....	III-431
<i>M.H. Rei, C.H. Hong, J.Y. Yang and S.Y. Huang</i>	
Prolonged Hydrogen Production by Green Algae in an Alternating Light/Dark Cycle .....	III-438
<i>Y. Miura, K. Yagi, Shoga and K. Miyamoto</i>	
An Integrated Approach for the Effective Utilization of Rural Domestic Fuels in Developing Countries .....	III-443
<i>J.C. Bansal and K.S.N. Raju</i>	

## Alternate Energy

Dialytic Battery Convertible Free Energy of Mixing of Sea Water and River Water .....	III-451
<i>H. Ohya</i>	
Design and Analysis of an Electrochemical Cell for Caustic Concentration and Power Generation .....	III-457
<i>S.P. Ho</i>	
On Solar-Powered Dehumidifier Based on Surface Diffusion Phenomenon through Activated Alumina Plate .....	III-465
<i>R. Toei and H. Tamon</i>	
Analysis of Reliability for a Typical Solar Heating System .....	III-471
<i>M.H. Chun and K-K. Chang</i>	
Heat Transfer Characteristics in a "Volume Heat-Trap" Type Solar Collector Using a Semitransparent Liquid as a Heat Vehicle and Heat Storage Medium .....	III-478
<i>M. Hasatani, N. Arai and Y. Itaya</i>	
Performance of a Solar House in Bangkok .....	III-484
<i>P. Techapeolers and W. Tanthapanichakoon</i>	

## Volume IV

### Technology Transfer (I)

Development of AOS and Export of Sulfonation Technology .....	IV-1
<i>K. Kitano</i>	
Transfer of Personal Computer Technique .....	IV-7
<i>K. Ito</i>	