

**History:  
International Fluidization Conference  
Series**

**by**

**L.-S. Fan**

**and**

**Dale Keairns**

**In collaboration with**

**John Grace, Wen-Ching Yang, Xiaotao Bi**

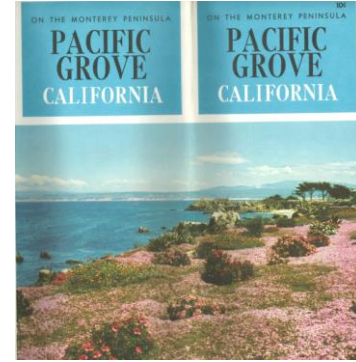
**Hans Kuipers, Masa Horio, and Ted Knowlton**

*Fluidization XVI – Guilin, 2019*

# Background

International Fluidization Conference Series was initiated in **1975, under the auspices of the U.S. Engineering Foundation, with Dale Keairns as the Conference Convener.** It was later transitioned to Engineering Conference International (ECI) and AIChE as the hosting organizations. The concurrent conferences on or prior to 1975 on this same subject took place at:

- International Symposium on Fluidization, Eindhoven, 1967
- Symposium on Fluidization (IChemE, Tripartite Chemical Engineering Conference), Montreal, 1968
- Fluidization and Its Applications (Ste Chimie Industrielle), Toulouse, 1973
- Fluidized Combustion (Institute of Fuel) London 1975
- International Conferences on Fluidized Bed Combustion, USA, 1968, 1970, 1972, 1975 (primary sponsors including DOE, EPA, Energy Research & Development Administration)



1<sup>st</sup> conference site: Pacific Grove/Asilomar, California

# Background (cont.)

## Two Major Conference Series Branched Out:

- **International Conference on Circulating Fluidized Beds – 1<sup>st</sup> Conference organized by Prabir Basu in Halifax, Canada, in 1985, 13<sup>th</sup> Conference to be held in Vancouver, Canada in 2020,**
- **International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering – 1<sup>st</sup> Conference organized by L.-S. Fan in Columbus Ohio in 1992, 14<sup>th</sup> Conference to be held in Guilin, China in 2019**

# Fluidization Conference Series

Conference	Year	Location	Chair/co-chairs
I	1975	Asilomar/Pacific Grove, CA, USA	D. L. Keairns
II	1978	Cambridge, England	J. F. Davidson, D. L. Keairns
III	1980	Henniker, NH, USA	John R. Grace, John M. Matsen
IV	1983	Kashikojima, Japan	Daizo Kunii, Ryoza Toei
V	1986	Elsinor, Denmark	Knud Østergaard, Ansgar Sørensen
VI	1989	Banff, Alberta, Canada	John R. Grace, Leslie W. Shemilt, Maurice A. Bergougnou
VII	1992	Gold Coast/Brisbane, Australia	O.E. Potter, D.J. Nicklin
VIII	1995	Tours, France	Jean-François Large, Claude Laguérie
IX	1998	Durango, Colorado	Liang-Shih Fan, Ted M. Knowlton
X	2001	Beijing, China	Moonson Kwauk, Jinghai Li, Wen-Ching Yang
XI	2004	Ischia, Naples, Italy	Umberto Arena, Riccardo Chirone, Michele Miccio, Piero Salatino
XII	2007	Harrison Hot Springs/Vancouver, British Columbia, Canada	Xiaotao Bi, Franco Berruti, Todd Pugsley
XIII	2010	Gyeong-ju, Korea	Sang Done Kim, Yong Kang, Jea Keun Lee, Yong Chil Seo
XIV	2013	Noordwijkerhout, Netherlands	J.A.M. Kuipers, R.F. Mudde, J.R. van Ommen, N.G. Deen
XV	2016	Montebello, Quebec, Canada	Jamal Chaouki, Franco Berruti, Xiaotao (Tony) Bi, Ray Cocco
XVI	2019	Guilin, China	Chi-Hwa Wang, Wei Ge

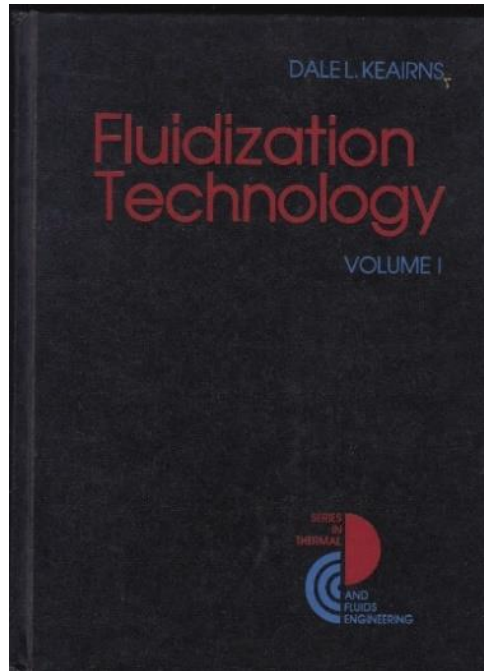
# Presentation Format

- One all-attended session with one **rapporteur** reporting, discussing and criticizing each paper in the session
- One all-attended session with 5-7 minute oral presentation by **lead authors** of each paper followed by posters and general question session
- Parallel sessions in usual large conference style

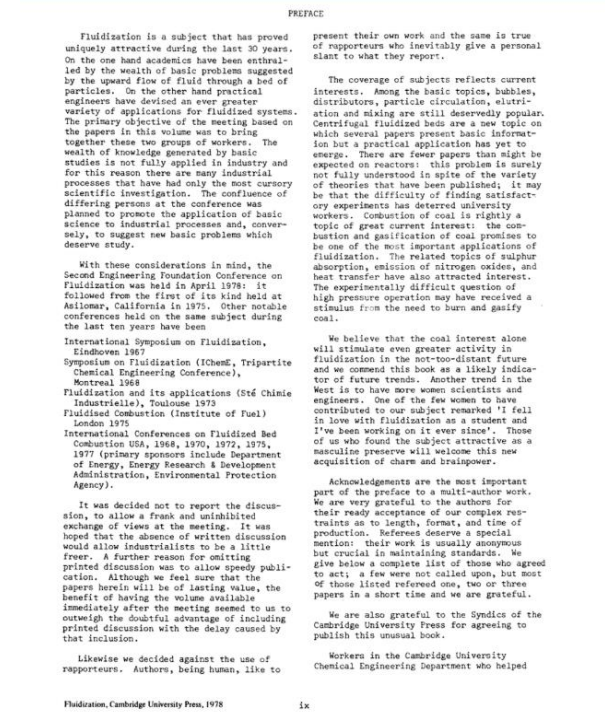
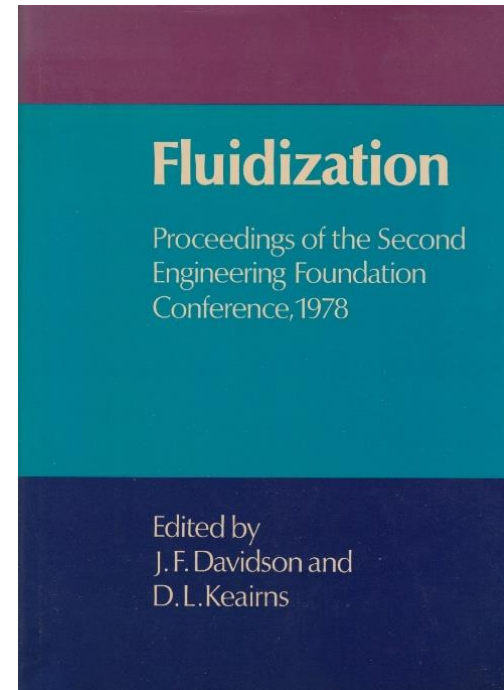
# Fluidization Conference Proceedings I & II

Conference	Year	Location	Chair/co-chairs
I	1975	Pacific Grove, CA, USA	D. L. Keairns
II	1978	Cambridge, England	J. F. Davidson, D. L. Keairns

## Fluidization I



## Fluidization II



# Fluidization Conference I & II Topics

Conference	Year	Location	Chair/co-chairs
I	1975	Pacific Grove, CA, USA	D. L. Keairns
II	1978	Cambridge, England	J. F. Davidson, D. L. Keairns

## Fluidization I

Session Topics:

- **Bubble Phenomena**
- **Gas Exchange and Fluid Bed Modeling**
- **Liquid Phase Fluidization**
- **Three-Phase Fluidization**
- **Fluidized Bed Performance with Internals**
- **Solids Mixing and Transport**
- **Fossil Fuel Processing**
- **Applications**

## Fluidization II

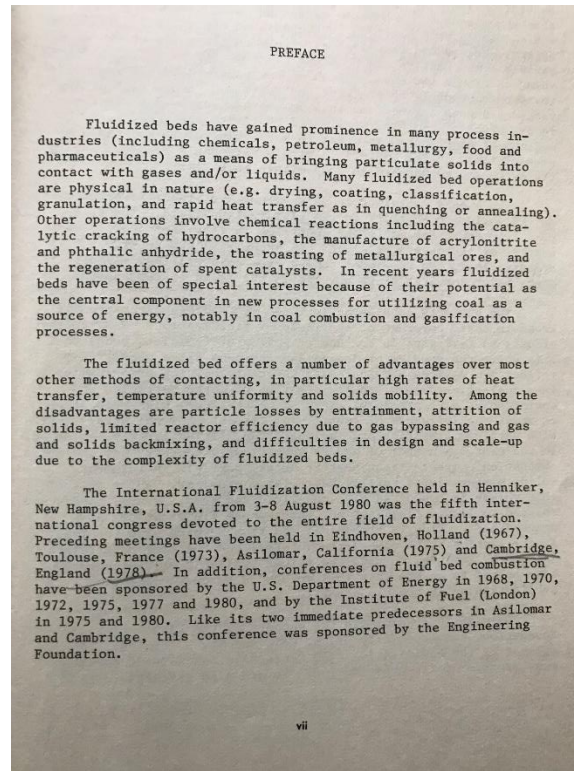
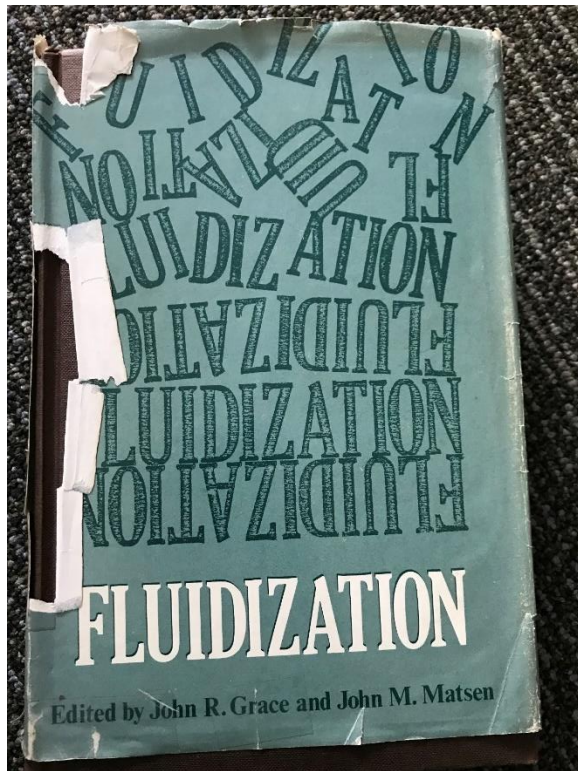
Session Topics:

- **Bubbles**
- **Distributors**
- **High Pressure**
- **Basic Measurements**
- **Spouted Beds**
- **Particle Circulation and Flow**
- **Entrainment, Segregation and Mixing**
- **Reactors and Mass Transfer**
- **Three-Phase Fluidization**
- **Gasification**
- **Combustion**
- **Desulfurization and NOx Removal**
- **Heat Transfer**

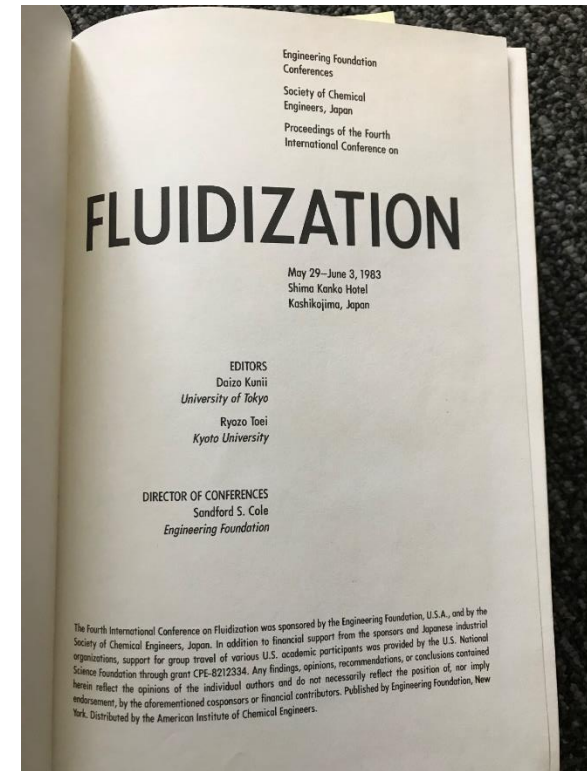
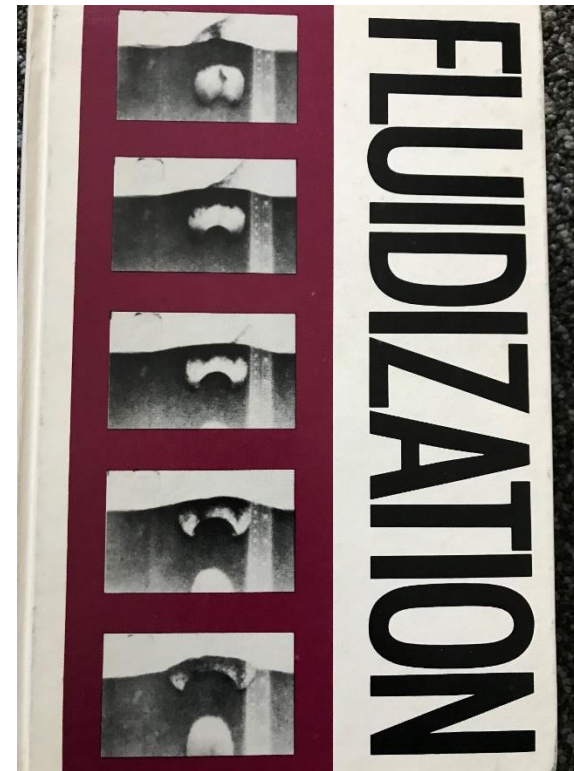
# Fluidization Conference Proceedings III & IV

Conference	Year	Location	Chair/co-chairs
III	1980	Henniker, NH, USA	John R. Grace, John M. Matsen
IV	1983	Kashikojima, Japan	Daizo Kunii, Ryoza Toei

## Fluidization III



## Fluidization IV





# Fluidization Conference III & IV Topics

Conference	Year	Location	Chair/co-chairs
III	1980	Henniker, NH, USA	John R. Grace, John M. Matsen
IV	1983	Kashikojima, Japan	Daizo Kunii, Ryoze Toei

## Fluidization III

C. E. Jahnig, D. L. Campbell, H. Z. Martin, **History of fluidized solids development at Exxon**

L. S. Leung. **The ups and downs of gas-solid flow: a review**

J. J. van Deemter. **Mixing patterns in large-scale fluidized beds**

## Fluidization IV

R. Collins, **Gas flow patterns associated with a growing spherical bubble**

J.G. Yates, D.J. Cheesman, T.A. Mashingaidze, C. Howe, and G. Jefferis, **The effect of vertical rods on bubbles in gas fluidized beds**

K. Viswanathan, and D.S. Rao, **Gross solid circulation in fluidized beds**

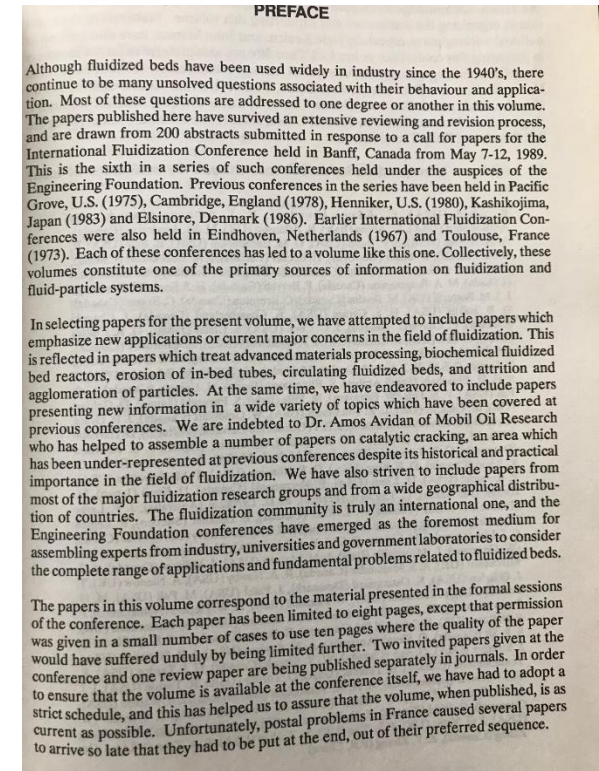
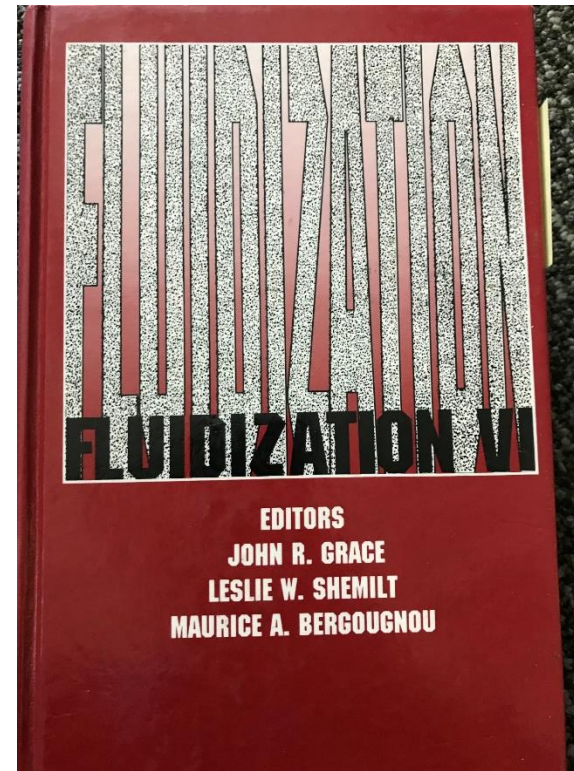
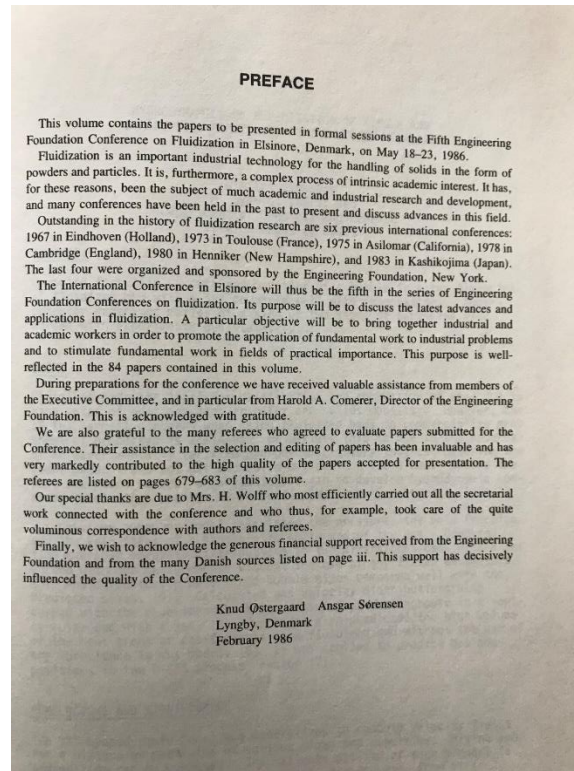
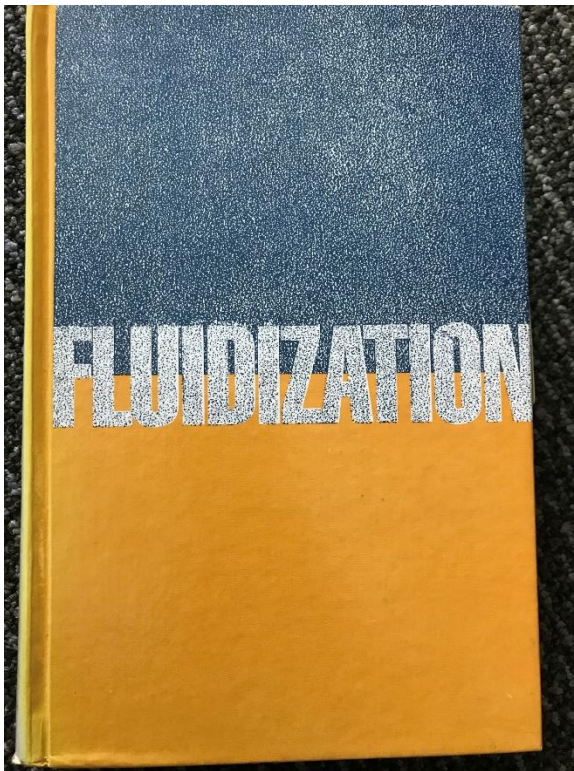
Y. Matsuno, H. Kage, H. Yamaguchi, Y. Ideue, and T. Hirose, **A consideration on the determination of the elutriation rate constant by a batch gas-solid fluidized bed experiment**

# Fluidization Conference Proceedings V & VI

Conference	Year	Location	Chair/co-chairs
V	1986	Elsinor, Denmark	Knud Østergaard, Ansgar Sørensen
VI	1989	Banff, Alberta, Canada	John R. Grace, Leslie W. Shemilt, Maurice A. Bergougnou

## Fluidization V

## Fluidization VI



# Fluidization Conference V & VI Topics

Conference	Year	Location	Chair/co-chairs
V	1986	Elsinor, Denmark	Knud Østergaard, Ansgar Sørensen
VI	1989	Banff, Alberta, Canada	John R. Grace, Leslie W. Shemilt, Maurice A. Bergougnou

## Fluidization V

D. Gidaspow, M. Syamlal, Y. Seo, **Hydrodynamics of Fluidization of a single and binary size particles: Supercomputer modeling**

P. U. Foscolo, L. G. Gibilaro, S. P. Waldram, R. Di Felice, **The application of a particulate model to fluidization dynamics**

M. H. Peters, **Statistics mechanics of fluidized particles.**

A. Padhye, T. J. O'Brien, **A numerical study of the effect of operating conditions on the minimum fluidization velocity**

R. A. Newby, D. L. Keairns, **Test of the scaling relationships for fluid-bed dynamics**

## Fluidization VI

Y. Tung, Z. Yang, Y. Xia, W. Zheng, Y. Yi and M. Kwauk, **Assessing fluidizing characteristics of powders**

I.H. Farag, H.M. Ettouney and C.B.C. Raj, **Three-phase fluidized bioreactors: experimental and simulation analysis**

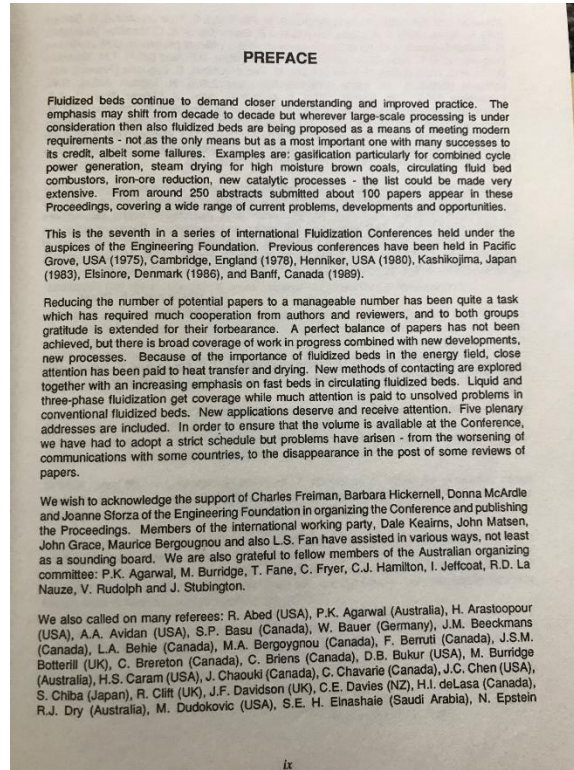
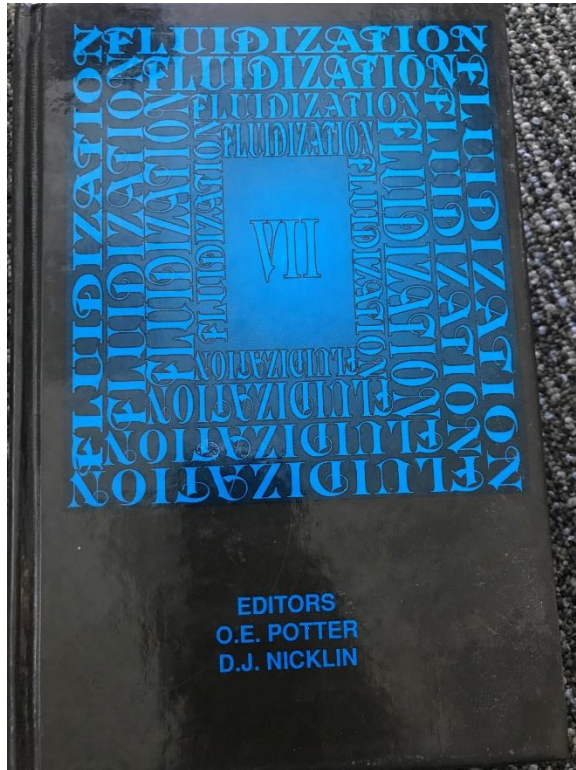
K. V. Thambimuthu and R. Clift, **Ash filtration and agglomeration in fluidized beds**

D.F. King, **Estimation of dense bed voidage in fast and slow fluidized beds of FCC catalyst**

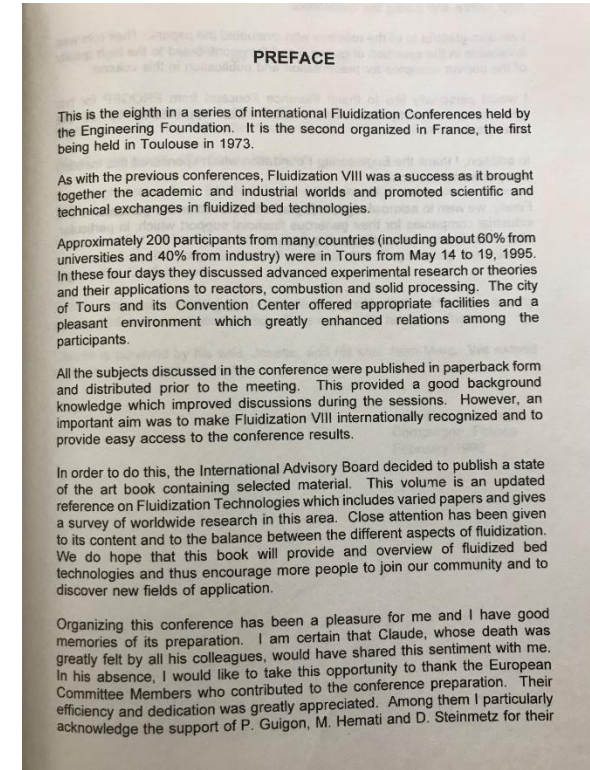
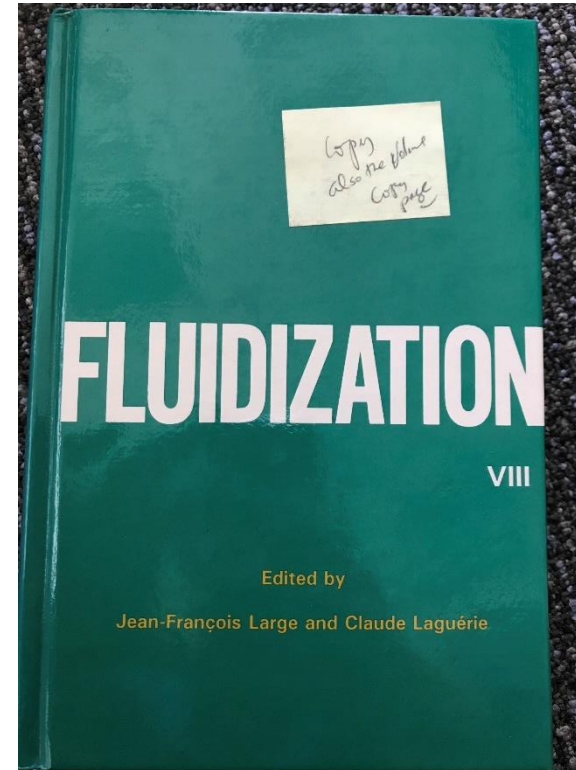
# Fluidization Conference Proceedings VII & VIII

Conference	Year	Location	Chair/co-chairs
VII	1992	Brisbane, Australia	O.E. Potter, D.J. Nicklin
VIII	1995	Tours, France	Jean-François Large, Claude Laguérie

## Fluidization VII



## Fluidization VIII



# Fluidization Conference VII & VIII Topics

Conference	Year	Location	Chair/co-chairs
VII	1992	Brisbane, Australia	O.E. Potter, D.J. Nicklin
VIII	1995	Tours, France	Jean-François Large, Claude Laguérie

## Fluidization VII

J. F. Davidson, **Fluidized combustion of solids, gases and mixtures thereof**

Desmond King, **Fluidized Catalytic crackers: an engineering review.**

T. M. Knowlton, **Pressure and temperature effects in fluid particle systems**

Daizo Kunli, Octave Levenspiel, **Heat transfer between fluidized beds and wall surface**

Keith Masters, **Industrial fluid bed drying: trend and development**

## Fluidization VIII

B. Kozanoglu, E.K.Levy, T. Ulge, R. Sahan, T. Schmitt, **Particle setting rates in bubbling fluidized beds**

C.H.Soong, K. Tuzla, J.C. Chen, **Experimental determinations of cluster size and velocity in circulating fluidized bed**

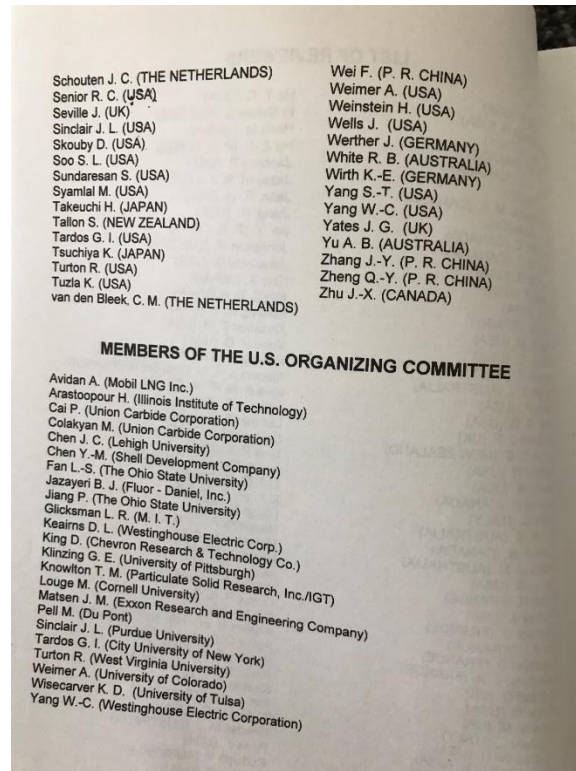
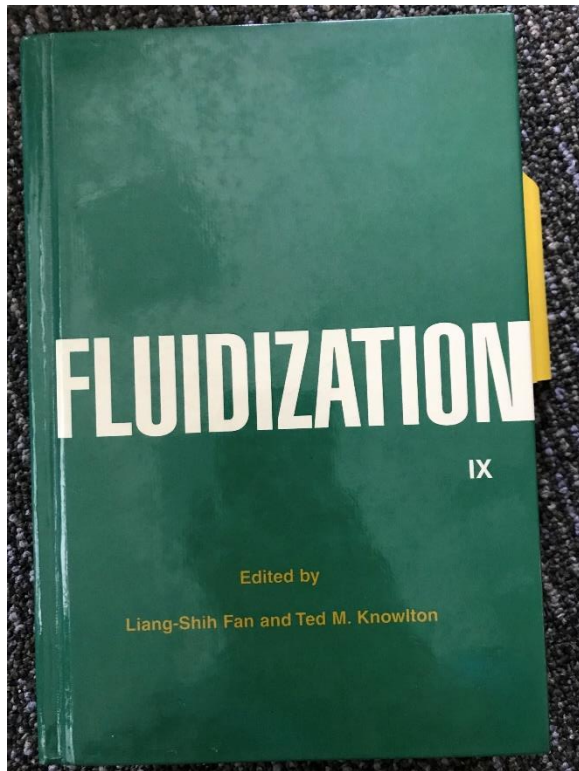
B. Caussat, M. Hemati, J.P. Couderc, **A local analysis of hydrodynamics and mass transfer inside and around a single bubble**

U. Arena, A. Cammarota, R. Chirone, **Fragmentation and attrition during the fluidized bed combustion of the two waste-derived fuels**

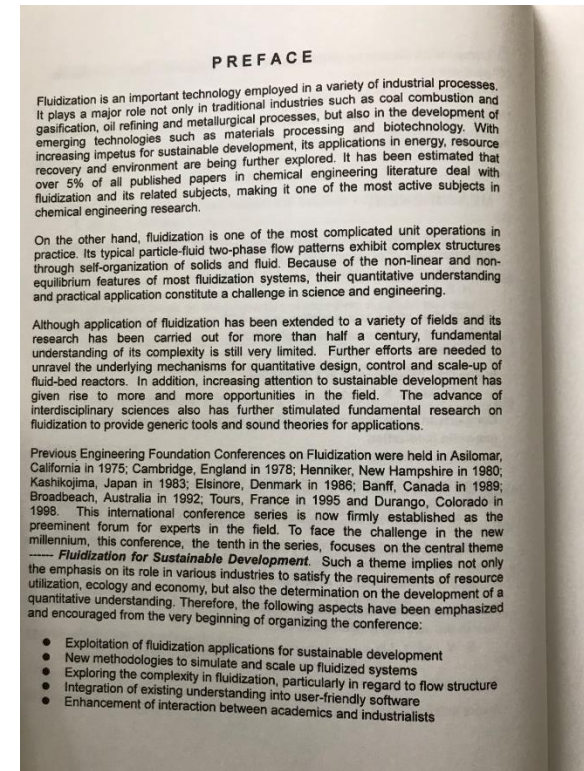
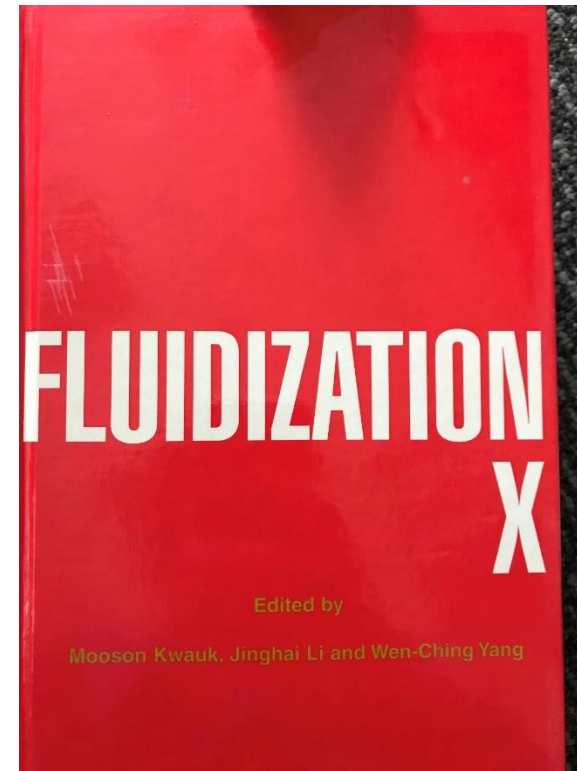
# Fluidization Conference Proceedings IX & X

Conference	Year	Location	Chair/co-chairs
IX	1998	Durango, Colorado	Liang-Shih Fan, Ted M. Knowlton
X	2001	Beijing, China	Moonson Kwauk, Jinghai Li, Wen-Ching Yang

## Fluidization IX



## Fluidization X



# Fluidization Conference IX & X Topics

Conference	Year	Location	Chair/co-chairs
IX	1998	Durango, Colorado	Liang-Shih Fan, Ted M. Knowlton
X	2001	Beijing, China	Moonson Kwauk, Jinghai Li, Wen-Ching Yang

## Fluidization IX

R. Jackson, **The nature and role of effective stress in fluidized system**

J. A. M. Kuipers, B. P. B. Hoomans, W. P. M. van Swaaij, **Hydrodynamic models of gas-fluidized beds with their roles for design and operation of fluidized bed and chemical reactors**

W. -C. Yang, **30-years of industrial research on fluidization- Bridging the gap between theory and practice**

S. Mori, **Development of new fluidization technologies for energy conversion and environmental processes**

## Fluidization X

L. Plass, **Future R&D directions required in fluidization and fluid-particle systems for sustainable development in chemical industries**

A. M. Squires, **Microreactors simulating present( and future?) fluid beds**

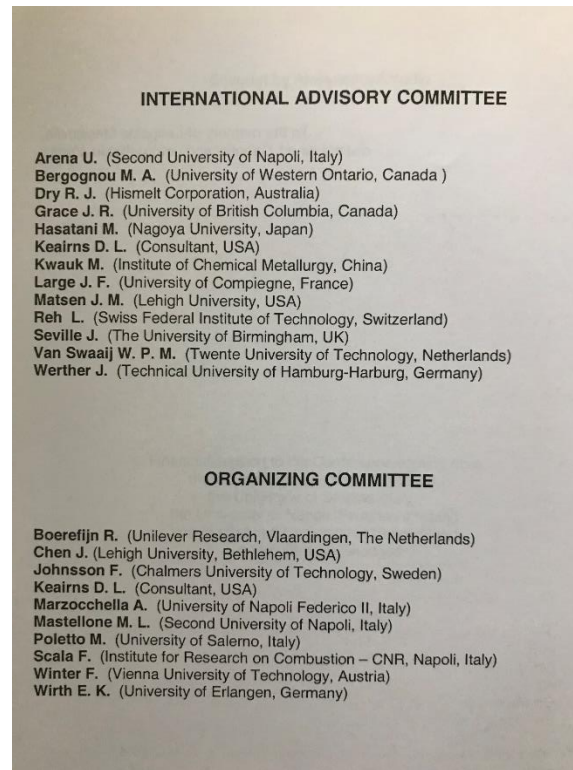
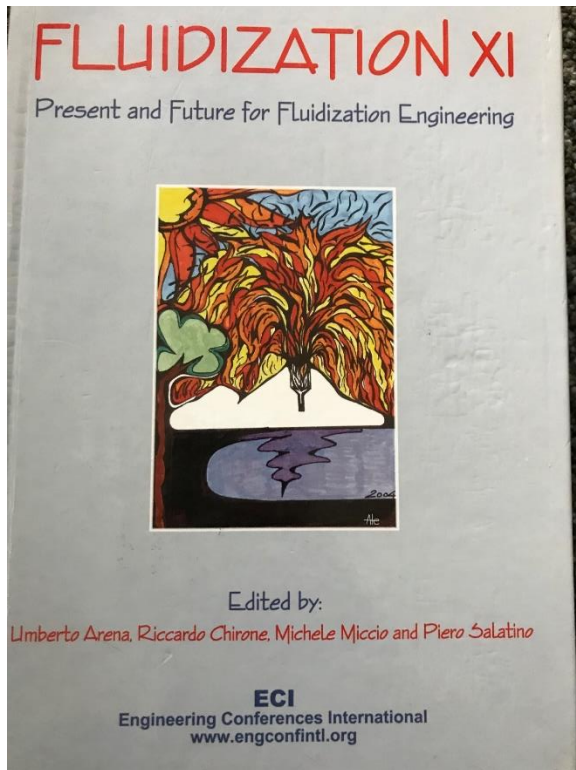
J. Chen, **Developments of fluidization technology in China's oil refinery industry**

I. D. Burdett, R. S. Eisinger, P. Cai, K. H. Lee, **Gas-phase fluidization technology for production of polyolefins**

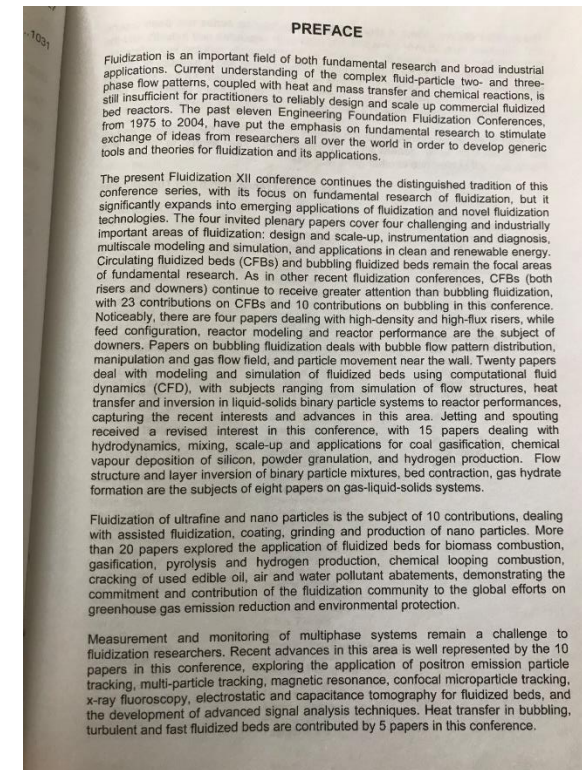
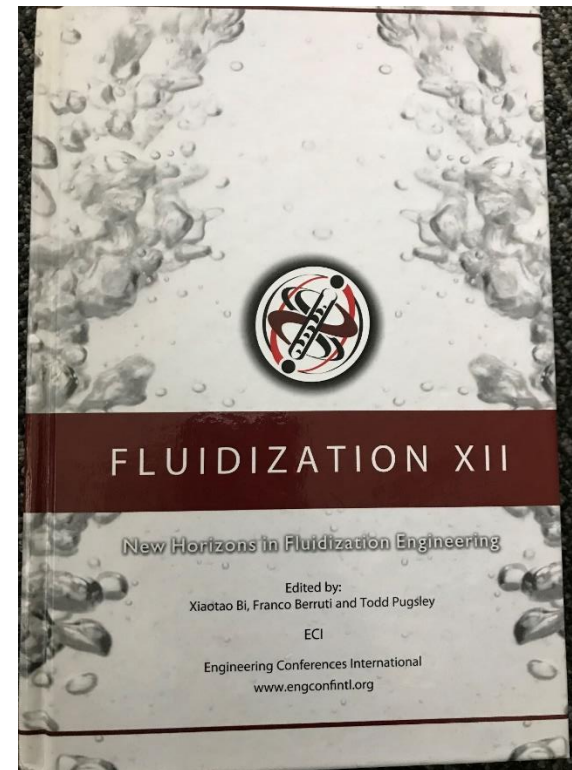
# Fluidization Conference Proceedings XI & XII

Conference	Year	Location	Chair/co-chairs
XI	2004	Ischia, Naples, Italy	Umberto Arena, Riccardo Chirone, Michele Miccio, Piero Salatino
XII	2007	Vancouver, British Columbia, Canada	Xiaotao Bi, Franco Berruti, Todd Pugsley

## Fluidization XI



## Fluidization XII





# Fluidization Conference XI & XII Topics

Conference	Year	Location	Chair/co-chairs
XI	2004	Ischia, Naples, Italy	Umberto Arena, Riccardo Chirone, Michele Miccio, Piero Salatino
XII	2007	Vancouver, British Columbia, Canada	Xiaotao Bi, Franco Berruti, Todd Pugsley

## Fluidization XI

Fan L. S, **Advance in gas-liquid-solid fluidization**

Campbell C. S. , **Granular flow and gas-fluidization**

Seville J. P. K, **Cohesion in fluidization**

## Fluidization XII

T. M. Knowlton, S. B. K. Reddy Karri, J. S. Smith, **Hydrodynamic scale-up of circulating fluidized bed**

Jinghai Li, Wei Ge, Jiayuan Zhang, Shiqiu Gao, Wei Wang, Ning Yang, Qichang Sun and Jian Gao, **Analytical Multi-scale Methodology for fluidization systems– retrospect and prospect**

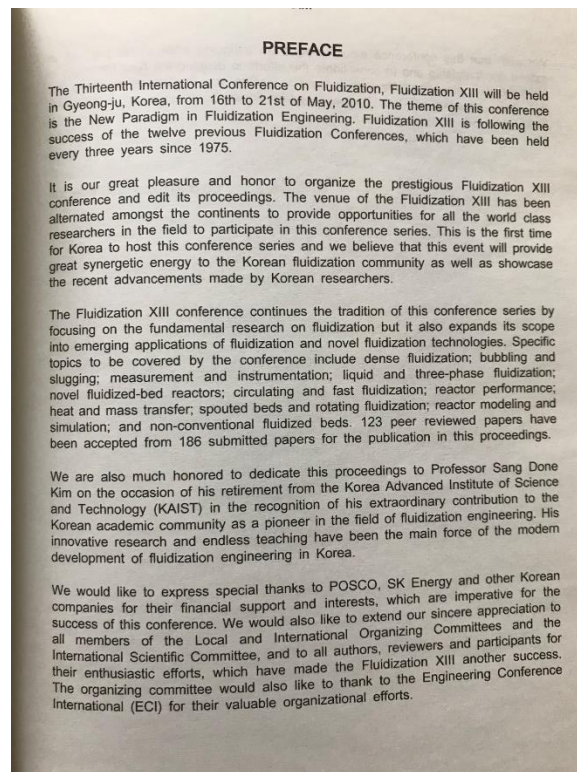
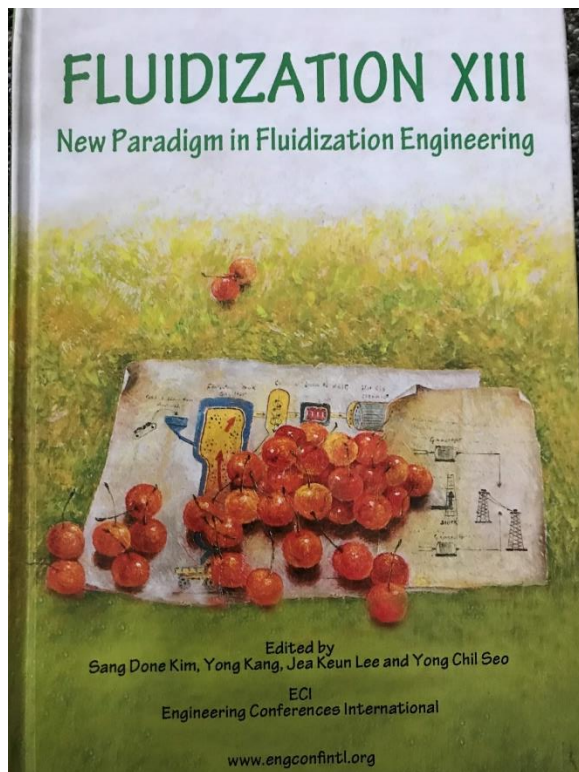
J. Ruud van Ommen, Robert F. Muddle, **Measuring the gas- solids distribution in fluidized beds– a review**

Filip Johnsson, **Fluidized bed combustion for clean energy**

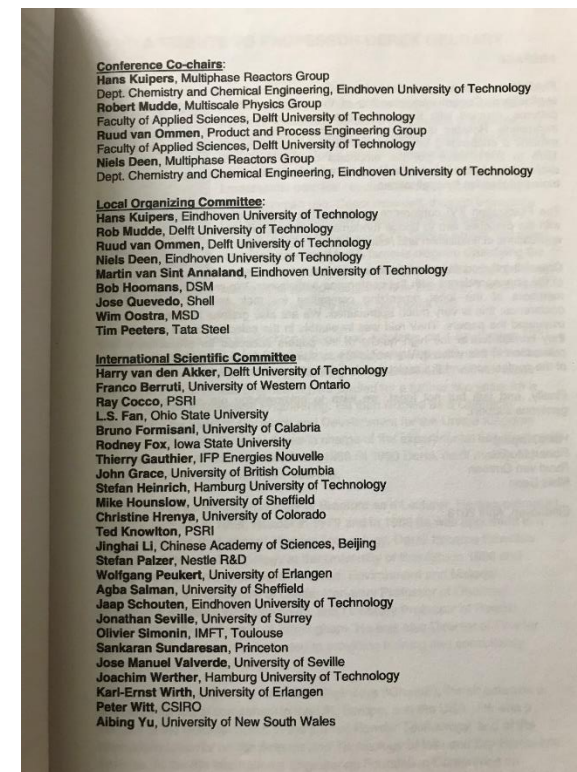
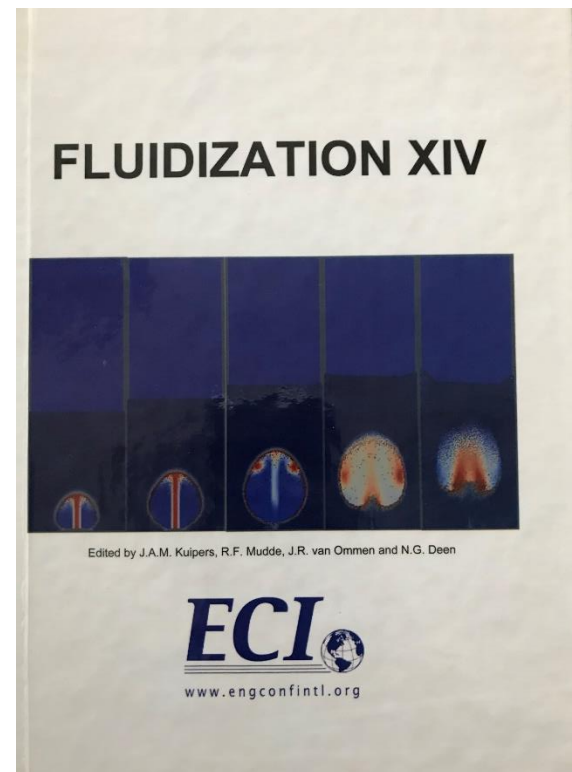
# Fluidization Conference Proceedings XIII & XIV

Conference	Year	Location	Chair/co-chairs
XIII	2010	Gyeong-ju, Korea	Sang Done Kim, Yong Kang, Jea Keun Lee, Yong Chil Seo
XIV	2013	Noordwijkerhout, Netherlands	J.A.M. Kuipers, R.F. Mudde, J.R. van Ommen, N.G. Deen

## Fluidization XIII



## Fluidization XIV



# Fluidization Conference XIII & XIV Topics

Conference	Year	Location	Chair/co-chairs
XIII	2010	Gyeong-ju, Korea	Sang Done Kim, Yong Kang, Jea Keun Lee, Yong Chil Seo
XIV	2013	Noordwijkerhout, Netherlands	J.A.M. Kuipers, R.F. Mudde, J.R. van Ommen, N.G. Deen

## Fluidization XIII

John R. Grace, **A perspective on development of novel fluidized bed process** for a more sustainable global future

Jonathan Seville, **A single particle view of fluidization**

J. Ruud van Ommen, Robber Pfeffer, **Fluidization of nanopowders: experiments modelling and applications**

Masayuki Horio, **Fluidization: past & future**

## Fluidization XIV

Sankaran Sundaresan, **Coarse-grained models** for momentum, energy and species transport in gas-particle flows.

Prof. Heinrich (TU Hamburg) and Prof. Palzer, **Fluidization of amorphous granules - Practical challenges, product structures and progress in modeling**

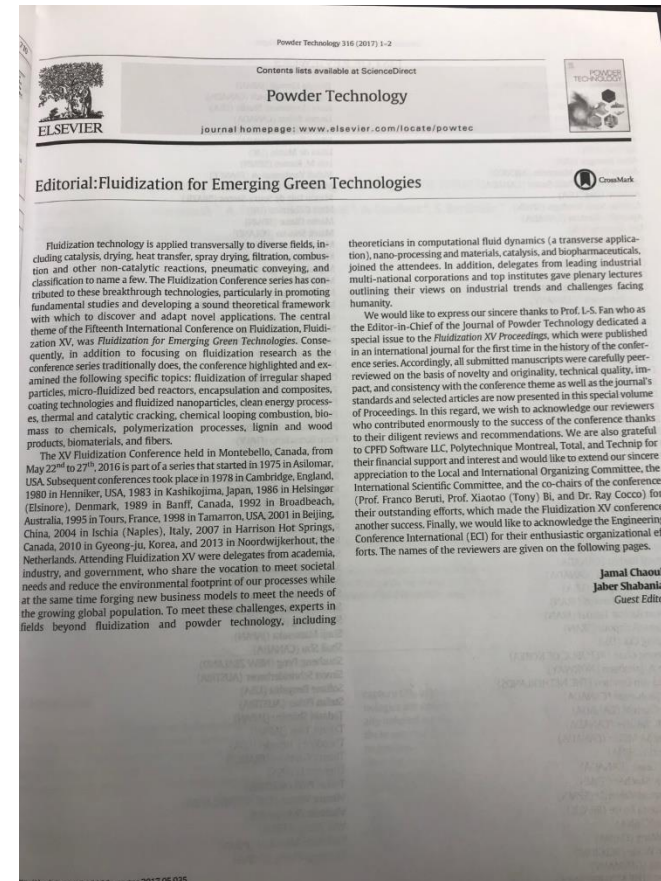
Prof. Yi Cheng, **Integrating Plasma Physics & Chemistry with Multiphase Flows in Fluidization Engineering**

Jose Manuel Valverde (Universidad de Sevilla), **Fluidization of fine powders: Cohesive versus dynamic aggregation**

# Fluidization Conference Proceedings XV

Conference	Year	Location	Chair/co-chairs
XV	2016	Montebello, Quebec, Canada	Jamal Chaouki, Franco Berruti, Xiaotao (Tony) Bi, Ray Cocco
XVI	2019	Guilin, China	Chi-Hwa Wang, Wei Ge

## Fluidization XV



# Fluidization Conference XV & XVI Topics

Conference	Year	Location	Chair/co-chairs
XV	2016	Montebello, Quebec, Canada	Jamal Chaouki, Franco Berruti, Xiaotao (Tony) Bi, Ray Cocco
XVI	2019	Guilin, China	Chi-Hwa Wang, Wei Ge

## Fluidization XV

Guangwen Xu, **A few recent developments in fluidized bed technology applications for fuel conversion**

Olivier Simonin, **CFD in fluidized beds: The state of the art**

Piero Salatino, **Mixing and segregation in fluidized bed thermochemical conversion of biomass**

Leslaw Mleczko, **Fluidized bed chemical reactors – Old and new applications**

Thierry Gauthier, **CLC, a promising concept with challenging development issues**

Liang-Shih Fan, **Chemical looping gasification and reforming – A perspective and prospects of novel circulating fluidized bed systems**

Ludvik Martinu, **Surface engineering and vapor phase technologies for coating and functionalizing complex objects and small particles**

Guangxi Yue, **CFB reactor to CFB combustor - The R&D of CFB combustion in China**

## Fluidization XVI

J.A.M. Kuipers, **Recent Advances in the Multi-Scale Simulation of Mass, Momentum and Heat Transfer in Dense Gas-Particle Flows**

Qingshan Zhu, **Fluidized Bed Mineral Roasting: From Fundamental to Application**

Stefan Heinrich, Title: TBA

Hamid Arastoopour, **Fluidization and Fluid Particle Systems Research Contribution in Creating a Pathway to Sustainable Society**

Marc-Olivier Coppens, **Innovations in Fluidization, Inspired by Nature**

Fei Wei, **A Multistage Fluidized Bed Reactor: Stability Analysis, Suppression of Back-mixing and its Application in Heterogeneous Catalysis**

Jamal Chaouki, **Hydrodynamics of High Temperature Gas-Solid Fluidized Beds**

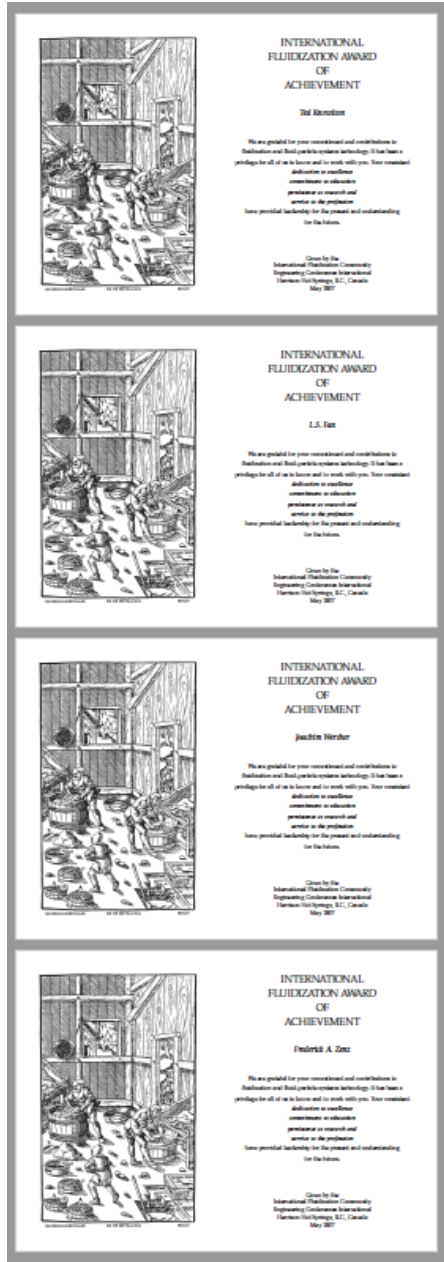
Benjamin Glasser, **Scale-up of Fluidized Bed Drying: Hydrodynamics, Mixing and Heat and Mass Transfer**

# Sample Topics in Heated Discussion

- Bubble or Jets
- Density to be used for the buoyancy force of suspended particles
- Cluster definition, shape, formation mechanism
- Naming of fast fluidization
- Scale-up criteria
- Modeling and computation: restitution coefficient, solids stress and pressure and kinetics theory, granular temperature, and drag force
- Etc.

# International Fluidization Award of Achievement

- Selected by an International Covert Committee, convened by Dale Keairns on behalf of the Engineering Foundation
- The initial Awards Team agreed with using the wood cut from Agricola's 1556 book, viewed by many as an initial reference to fluidization, as the background for the Award Certificate, along with the Steuben Glass as the Gift



# **Awardees**

## **International Fluidization Award of Achievement**

- **John Davidson (1989)**
- **Moonson Kwauk (1989)**
- **Peter Rowe (1989)**
- **Daizo Kunii (1989)**
- **John Grace (1998)**
- **Fred Zenz (2007)**
- **Ted Knowlton (2007)**
- **Joachim Werther (2007)**
- **L-S Fan (2007)**
- **Octave Levenspiel (2011, awarded at 10<sup>th</sup> CFB Conference, in cooperation with this conference series)**



# Awardee

## International Fluidization Technology Leadership Award



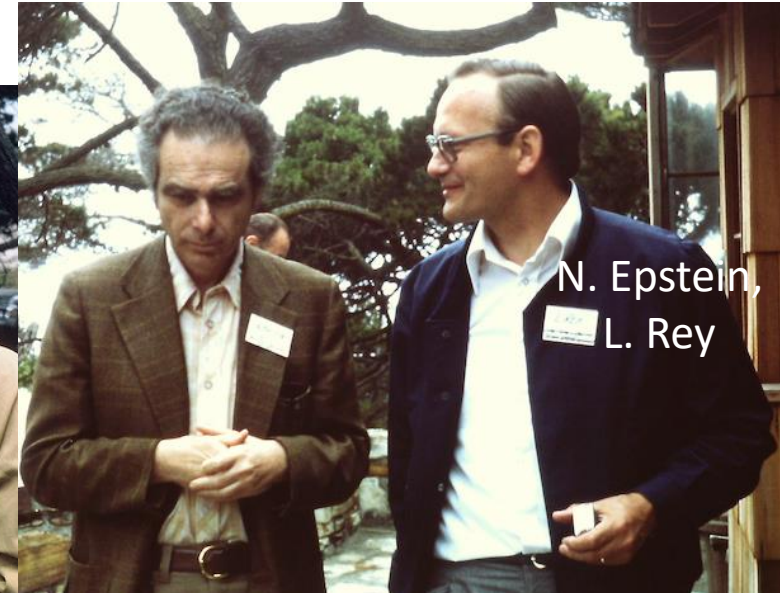
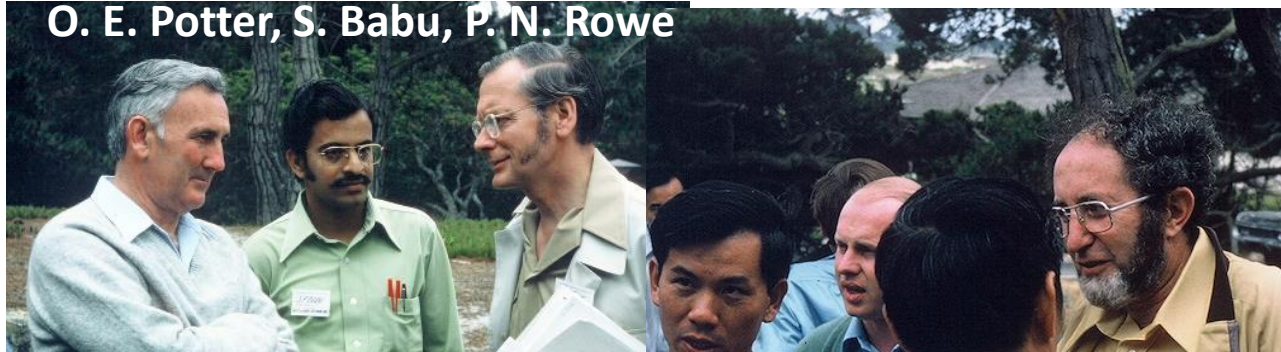
- Dale Keairns (2011, awarded at 10<sup>th</sup> CFB Conference, in cooperation with this conference series)

**Awardees**  
**Fluidization Conference**  
**Organizing Committee Award**

- **Owen Potter (Gold Coast/Brisbane, 1992)**
- **Maurice Bergougnou (Tours, 1995)**
- **J.S.M. Botterill (Tours, 1995)**
- **Derek Geldart (Tours, 1995)**

# Fluidization I - Asilomar

O. E. Potter, S. Babu, P. N. Rowe



N. Epstein,  
L. Rey

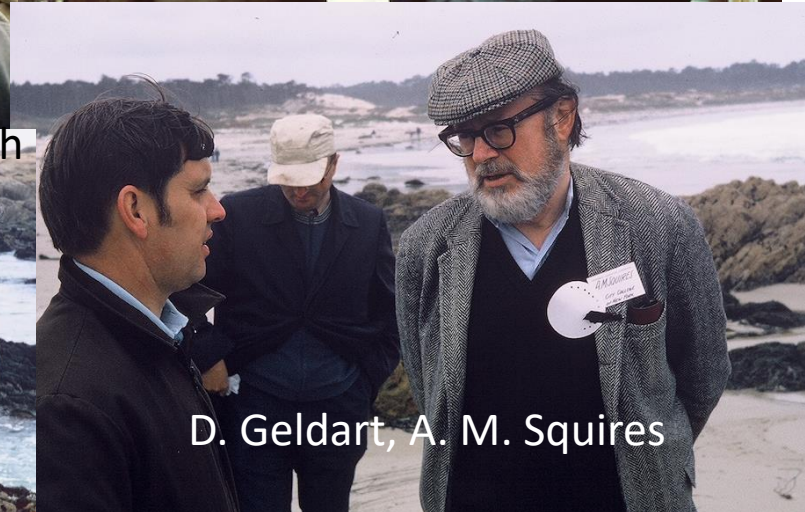


L. S. Leung, J. Werther,  
A. M. Squires



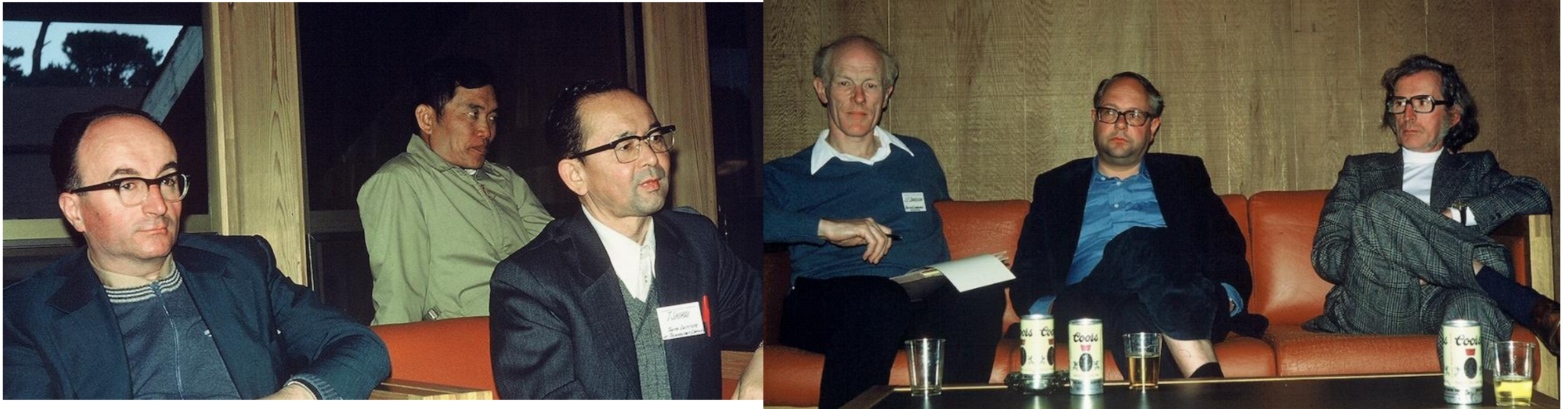
J. S. M. Botterill, O. E. Potter, T. Heath

J. Yerushalmi,  
K. Ostaardgard



D. Geldart, A. M. Squires

# Fluidization I - Asilomar



M. Bergougou, CY Wen, T. Shirai

J. F. Davidson, O. Molerus, P. LeGoff



L. Massimilla, H. Angelino

# Fluidization II - Cambridge



# Fluidization III - Henniker



Working Party Meeting

# Fluidization III - Henniker



# Fluidization III - Henniker



John and Sandy Matsen; John and Sherrill Grace



Henniker, Matsens,  
Botterill, Levenspiel



Henniker, CYWen, Keairns



T. Thompson, F. Zenz, D. Well, T. Knowlton



# Fluidization IV - Kashikojima



Working Party Meeting

# Fluidization V - Elsinor



Working Party Meeting

# Fluidization V - Elsinor

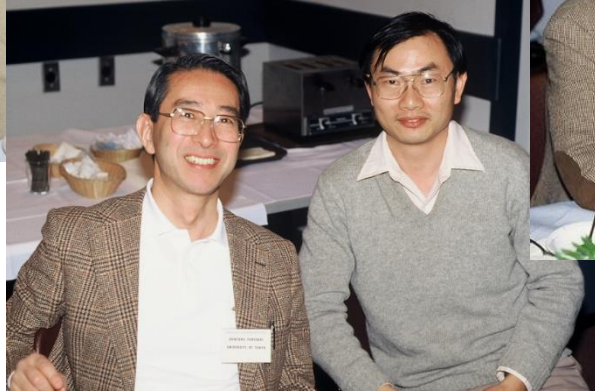


# Fluidization VI - Banff



Working Party Meeting

# Fluidization VI - Banff



## Fluidization VI - Banff



# Fluidization VII – Gold Coast



Working Party Meeting

# Fluidization VII – Gold Coast





# Fluidization VIII - Tours



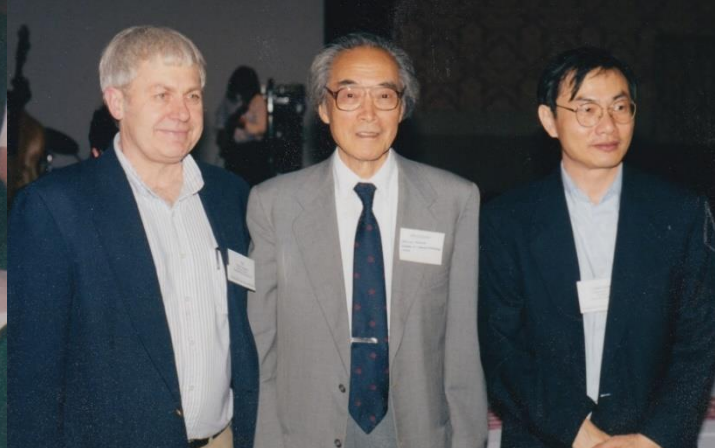
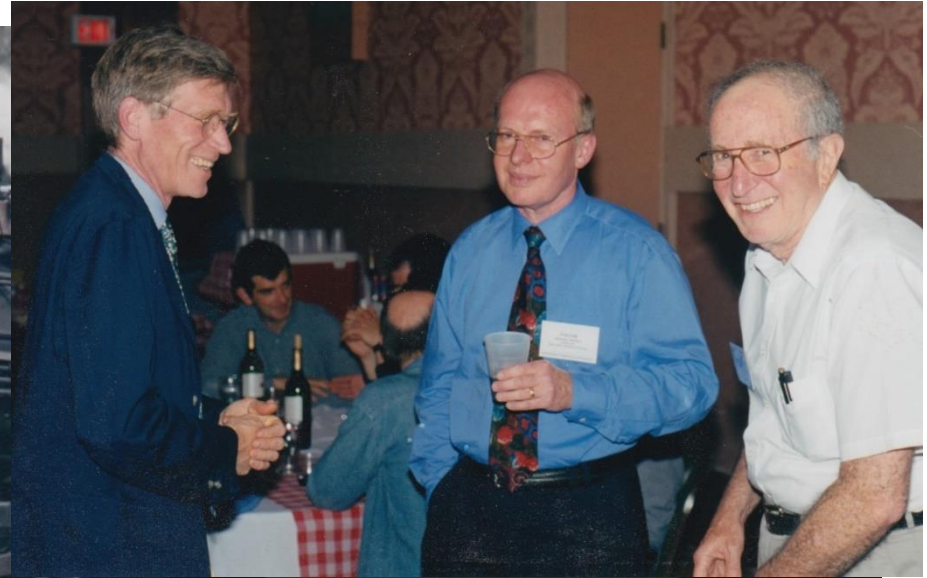
Another unique conference dinner experience

# Fluidization IX - Durango

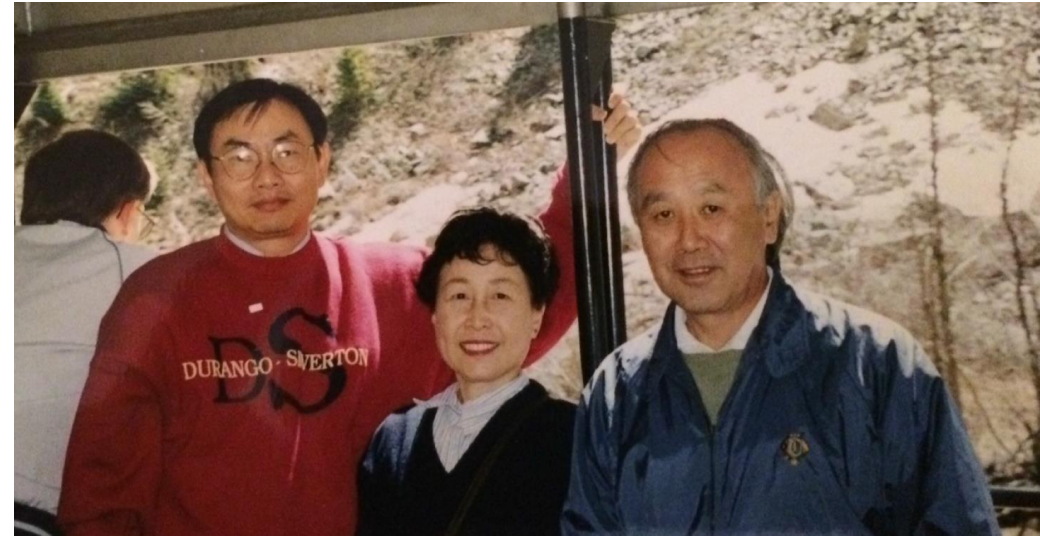


Working Party Meeting

# Fluidization IX - Durango



# Fluidization IX - Durango



# Fluidization X - Beijing



Working Party Meeting

# Fluidization X - Beijing



# Fluidization X - Beijing

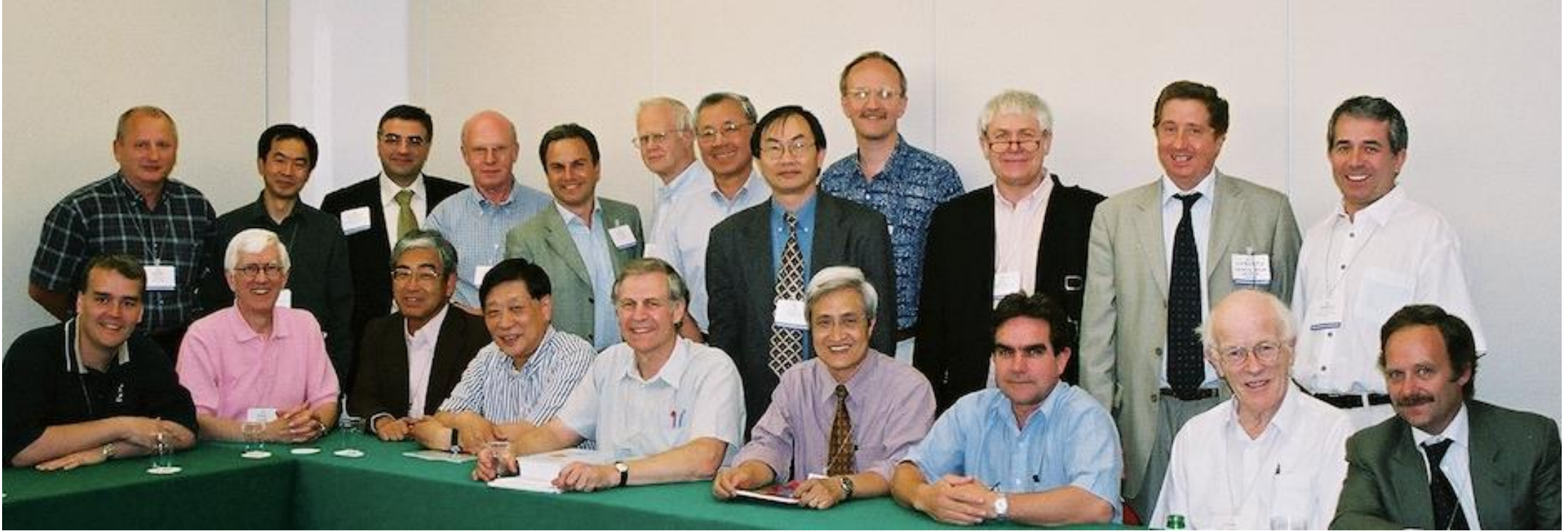


# Fluidization X - Beijing





# Fluidization XI - Ischia



Working Party Meeting

# Fluidization XI - Ischia



# Fluidization XII – Harrison Hot Springs



# Fluidization XIII – Gyeong-Ju



Working Party Meeting

# Fluidization XIV – Noordwijkerhout

FUNDAMENTALS TO PRODUCTS



## Fluidization XIV

May 26-31, 2013  
NH Conference Center Leeuwenhorst  
Noordwijkerhout, The Netherlands

### A Tribute to Professor Derek Geldart (1931-2012)



*"He kept six serving men  
(Who taught him all he knew)  
Their names were What? And Why?  
And When?  
And Where? And How? And Who?"*

*R Kipling*

## Tributes

\* Professor Derek Geldart



\* Professor Mooson Kwauk



### Condolence of Prof. Mooson Kwauk (1920-2012)



科学做事

Working on everything  
scientifically

悉心育人

Teaching youth  
elaborately

Prof. Mooson Kwauk passed away on Nov 20, 2012

## Fluidization XV – Montebello





# Comments by Ted Knowlton Who Attended the meeting most times, 15/16

- Greetings to everyone attending Fluidization XVI – especially to all my friends and colleagues.
- I am extremely disappointed that I cannot attend Fluidization XVI. It is due to circumstances beyond my control.
- I have attended all of the Fluidization Conferences except for this one, and in my opinion, they have been exceptional.
- For me, the Conferences have always been 1) the best place to learn of new advances in the Fluidization field, and 2) to see old friends and colleagues working in the field. I looked forward to Every One.
- The Fluidization I Conference in Asilomar, California was different Than the Rest of the Conferences in that it Had a *Rapporteur* format, where one person would report on/discuss/criticize each paper in a session.
- The Rapporteur for my paper in Fluidization I was Professor Peter Rowe from University College London who was known to be very exacting and as a young engineer I was a bit worried. Fortunately, my Paper “Survived” his scrutiny.



 **Comments by Ted Knowlton Who Attended the meeting  
most times, 15/16 (cont.)**

- One other memory that I have from **Fluidization I** was that there was a Workshop where Fast Fluidization was debated as to whether it was really a separate Fluidization Regime! It was a very spirited debate! The Consensus was that it was a different regime.
- For me, all of the Conferences have been extremely good, but I especially remember **Fluidization I**, **Fluidization II** (in Cambridge), Henniker Conference (it was hot with no air conditioning), Banff Conferences, **Fluidization IX** (that I Co-Chaired With Professor LS Fan) in Durango, and **Fluidization X** (in China)
- My overall remembrance of the Conferences is that they have always represented quality and opportunity. Above All, However, what is remembered is the sense of shared purpose, collegiality and friendliness.
- I would like to wish all of you a very enjoyable time in China and an extremely successful conference.

# Closing Thoughts

- A strong sense of personal gratitude to the field of fluidization—it has been the focus for a research and teaching career characterized by lifelong friendships, supportive colleagues, a harmonious research community, and stimulating intellectual environment. It is imperative on all of us to **maintain this tradition and culture**
- We are entering a period marked by a new generation of scholars, new problems, new approaches, new excitement, and new leadership, but we should not forget the foundation of the work from **those on whose shoulders we stand**
- There remains a new 30 years and more of **fluidization history to be written**