PREFACE

Chemical engineering science has played an important role in modern civilization in the provision of energy, the making of materials and the protection of environment. However, its current knowledge base is still insufficient to support future development of economy and society. Although it is still difficult for us to quantitatively design and optimize conventional chemical processes, we have come to face new challenges of depletion of fossil and non-renewable energy resources and difficulties in coping with chemical processes related to nano-, bio- and other emerging technologies. We need to think how to better serve society by adapting ourselves to these new developments in science and technology. We need to ask what the bottleneck is in upgrading our knowledge base, and what breakthrough is needed.

Gradually we have come to recognize that understanding of the spatio-temporal multi-scale structures in various chemical processes is essential for upgrading our ability. In fact, as much as we know about macro-scale chemical processing, e.g., radial and axial profiles, and what happens at micro-scales, e.g., chemical reaction and even molecular structures, we really know little about what happens at the meso-scale in between. That is, meso-scale is the key to understanding multi-scale structures. This is the bottleneck!

Stimulated by this recognition, multi-scale analysis and simulation have received unprecedented attention in recent years, as shown by the dramatic increase in related publications. However, measurement technology focused on multi-scale structures, particularly, on meso-scale phenomena, has not been sufficiently tackled. Without breakthroughs in this aspect, theories and simulations could not be verified and validated, and upgrading the knowledge base for chemical engineering would be futile.

Recognizing this problem, *Advances in Chemical Engineering* decided to organize the present thematic issue on *"Characterization of Flow, Particles and Interfaces"* to alert the chemical engineering community to this challenging issue. We selected the following six meso-scale measurement technologies.

1. ***Ultrasound-based Gas-liquid Interface Detection in Gas–liquid Two Phase Flows*** (by Prof. Yasushi Takeda *et al.)* introduces two ultrasonic-based detection methods for gas-liquid interface of gas-liquid two-phase flows in horizontal pipes, based on ultrasonic velocity profiler (UVP) measurements. One approach using ultrasonic peak echo intensity information to predict gas-liquid interface has wider application range and has been validated. Another approach based only on liquid velocity information is a relatively new technique and is still at intermediate stage of an ongoing development.
2. ***Micromanipulation in Mechanical Characterization of Single Particles*** (by Prof. Zhibing Zhang *et al.)* reviews a number of micromanipulation-based techniques and their applications for measuring mechanical strength of single particles, particle-particle interaction as well as particle-surface interactions. Among the techniques introduced, AFM, optical trapping and diametrical compression are more attractive, and the description of models for extracting intrinsic mechanical property information from compression testing data is useful.
3. ***Particle Image Velocimetry Techniques and Its Applications in Multiphase Systems*** (by Prof. Koichi Hishida *et al.)* reviews particle image velocimetry (PIV) technique and describes the progress in applying this technique from single phase flow system to two-phase flow system, such as liquid-liquid two-fluid flow, gas-liquid two-phase flow and particle-fluid flow systems, providing whole-field velocity profiles based on the captured images of seeded particles.
4. ***Positron Emission Imaging in Chemical Engineering*** (by Prof. J. P. K. Seville *et al.)* reviews the state-of-the-art positron emission particle tracking (PEPT) technique and its extensive applications in chemical engineering, demonstrating its versatile features, that is, the capability to track tracer particles down to about 60 μm in size, moving at up to 10 m/s, yielding locations to within ± 1 mm at frequencies better than 100 Hz, and also revealing its application prospects such as development of multi-particle PEPT, applications in liquid-phase-continuous systems, in validation of computational codes, as well as in situ large-scale use of mobile PEPT at industrial sites.
5. ***Electrical Capacitance, Electrical Resistance, and Positron Emission Tomography Techniques and Their Applications in Multi-Phase Flow Systems*** (by Prof. L.S. Fan and Prof. Richard Williams *et al.)* reports three tomography measurement techniques of capacitance (ECT), resistance (ERT) and positron emission (PET), with ECT and ERT being electrical modalities and PET radioactive modality. Their applicability in imaging multiphase flow dynamics

of industrial processes are exemplified by widespread applications, including fluidized beds, pneumatic solid conveying, slurry bubble column, hydrocyclone, oscillatory baffled reactor, stirred tank reactors.

6. ***Time-Resolved Laser-Induced Incandescence*** (by Prof. Alfred Leipertz *et al.)* introduces an online characterization technique (time-resolved laser-induced incandescence, TIRE-LII) for nano-scaled particles, including measurements of particle size and size distribution, particle mass concentration and specific surface area, with emphasis on carbonaceous particles. Measurements are based on the time-resolved thermal radiation signals from nanoparticles after they have been heated by high-energetic laser pulse up to incandescence or sublimation. The technique has been applied in *in situ* monitoring soot formation and oxidation in combustion, diesel raw exhaust, carbon black formation, and in metal and metal oxide process control.

We hope the publication of this issue would stimulate the application of these measurement techniques in chemical engineering and further our understanding of multi-scale structures. I thank Prof. Guy B. Marin, the editor-in-chief of this book series, for his advice in selecting the present topic and, Prof. Zhuyou Cao and Dr. Jiayuan Zhang, for their contributions made in editing this issue. Thanks are also extended to reviewers and authors for their efforts and time.

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