Panel on Future of Chemical Engineering, Biosystems and Process Systems Engineering (August 21, 9:15-10:00)

Moderator: Ignacio Grossmann.
Panelists: Soledad Diaz, Mike Doherty, Angel Irabien
Rapporteur: Soledad Diaz

1. How important is PSE for the future of ChemE?

Mike Doherty: It can be stated that "Chemical Engineering is Process Systems Engineering", as PSE requires an integrated application of chemical engineering knowledge and concepts.

Angel Irabien: The future of Chemical Engineering may be based on the new research trends (nanotechnology, biotechnology, and sustainability) leading to new developments, and innovative processes and/or products, where PSE may have a leading role due its ability to develop computational tools for decision making, including the anticipation of uncertainties. The ability of PSE to be applied to multiscale (length and time) processes and products is one of the major strengths for the future of PSE.

Soledad Diaz: PSE is a part of the central core of Chemical Engineering. It is also an area of interdisciplinary research with areas such as computer science, operations research, applied mathematics, materials and life sciences. And this particular characteristic of PSE allows adapting to new challenges in Chemical Engineering.

Ignacio Grossmann: A major challenge for the PSE area is in claiming its fit with the rest of the chemical engineering academic community given the strong trend towards science and move away from engineering. Process Design courses in the US are increasingly taught by retired industrial people and not by faculty as they deem the course to be not only very time-consuming, but also "too practical" and with no science content. Furthermore, Process Control in many universities is no longer a required course for chemical engineering. On the one hand it is clear that the Process Design course provides not only the experience of solving a complex engineering design problem, but it also offers the opportunity of integrating all the knowledge that students have acquired in previous courses. Process Control is also a basic subject that is central to the understanding of chemical process operations and dynamics of natural phenomena. On the other hand, we the PSE community may have perhaps failed to communicate with the rest of our colleagues. For instance in Process Control by overemphasizing the mathematics, and in Process Design by not emphasizing the systematic procedures and approaches to design.

Mike Doherty: The curriculum of Process Design does not have to be modified in essence because a rich methodology to address problems has been developed over the last 30 years. It will require adaptation to the design of new emerging processes. Moreover, as chemical engineers are a link between science and industry, these courses that strengthen this relationship should not be lost.

Ignacio Grossmann: Regarding ways of integrating academy, industry and government to address challenging problems such as energy systems and new technologies, there are current joint efforts carried out in USA. There seems to be no such policies in Latin America.

2. What are new major directions and intellectual challenges that need to be addressed in PSE?

Ignacio Grossmann: The topics that have been discussed throughout in his meeting cover main challenges that need to be addressed in PSE. It is important to note that the particular feature of PSE that combines mathematical modeling, optimization theory and algorithms and insights derived from existing operation, mainly on the chemical and petrochemical industry, can be now redirected to address current challenges on energy systems, process design for sustainability, biosystems engineering, multiscale design of new materials and enterprise-wide optimization.

Angel Irabien: Basic developments related to algorithms and computer sciences need to be introduced in engineering applications related to nanotechnology, bio and sustainability demands. All Chemical Engineering areas, where innovation is expected are promising areas for PSE research. Water, Energy and Food seem to be three major areas of future developments. The ability to integrate interdisciplinary and multiscale instruments and methods in PSE research may be the main point.

Mike Doherty: Regarding product design as a new emerging area, I have to say that in my experience it is usually chemists who have performed this task in industry. Therefore, the perceived importance of product design is perhaps overstated. Chemical engineers are best suited for process design, and that is our real strength as a profession. Furthermore, there are plenty of major challenges left in this area.

Soledad Diaz: Managing complexity remains an important challenge in PSE, not only in modeling aspects but also in algorithmic and computational aspects. It is specially related to multiscale modeling, both in time, as in enterprise wide optimization, and in space, in molecular product design and engineering. Uncertainty handling and dynamics are also sources of complexity that remain a continuous challenge in PSE.

3. What would you advise to a young Assistant professor who wants to pursue research in PSE?

Mike Doherty: A young assistant professor could engage in any of the promising areas just mentioned, in which he/she can make important contributions. However, it is also advisable to also engage in topics of regional or national interest from which there are examples of current joint work of great interest.

Ignacio Grossmann: To follow on Mike Doherty's remark, it is likely that in the future topics of social interest such as water, food and health will become increasingly important. The IChemE in the UK has produced an interest roadmap that emphasizes

these areas for future research (http://www.icheme.org/roadmap2007.pdf). Another area worth considering for a young professor is process intensification as it offers the possibility of radically changing the footprint and look of chemical plants.

Angel Irabien: The core of PSE is probably going to be restricted (may be reduced) to elementary courses but innovative topics with a PSE scope are going to grow. New knowledge-based instruments: software, applications, demonstrations, etc are going to increase in the next future.

Soledad Diaz: It is also advisable that a young professor keep in mind that he/she must consolidate a solid background in PSE approaches and methodologies, which are numerical analysis, mathematical programming, systems and control theory, computer science and even management science.

4. Is bio likely to continue to grow as a major area in ChemE?

Angel Irabien: Bioprocesses/Bioproducts are now and probably are going to be an important point of growth for PSE because health and food demands are growing. Innovative Biomedical Processes/Technologies/Products and innovative food technologies are key areas for the future of Chemical Engineering and PSE.

Soledad Diaz: Biosystems engineering has received increased attention within PSE. In this meeting there have been presentations on protein folding, de novo protein design, matabolic and regulatory networks and biomedical applications, which are representative of the intense activity that is taking place in this area. There is currently a huge amount of information available, which allows increasing knowledge of biological systems as well as their organizational principles and interactions at different scales. Combining this information with PSE methodologies makes possible to suggest modifications that could lead, for example, to the overproduction of a desired product, interception of targeted molecules in therapeutic interventions, enzime engineering, etc. As a result, the combination of PSE, computational biology and systems biology will continue to grow, addressing important questions in biology and biomedical applications.

Ignacio Grossmann: While bio will continue to be an important area, it is very likely that energy will become in the future the major focus of PSE.