Integrated Multiscale Process Units with Locally Structured Elements

IMPULSE NEWS N°1 November 2005

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EDITORIAL

Welcome to IMPULSE, Europe's flagship research and development initiative in chemical production technologies !

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This **first IMPULSE Newsletter** highlights the scope and goals of the IMPULSE consortium's research efforts, launched in February 2005 with the support of the European Union's 6th Framework Programme for Research and Technological Development (FP 6).

IMPULSE's groundbreaking research in the totally new area of structured multiscale design is directly targeted at maintaining a sustainable and competitive 21st century manufacturing base in Europe. The 20 industrial and academic partners from 8 European countries in the IMPULSE consortium are committed to responding to the challenges of eco–efficiency and global competitiveness, by developing the technological underpinnings for a step–change in quality, safety and cost–effectiveness for innovative industrial production.

Following a rapid presentation of the structured multiscale design concept, this first Newsletter will offer a forum for presentation of the major goals and business drivers retained by the industrial leaders in the three commercial sectors selected by IMPULSE : pharmaceuticals, specialty chemicals and consumer products. Future Newsletters, issued twice a year, will follow developments and progress of the research over the four–year duration of the project up to completion in February 2009.

IMPULSE User Group

To enhance dissemination and promote communication among stakeholders beyond the IMPULSE partners, the consortium has decided to initiate a User Group of interested parties for information exchange, input and feedback. In particular, chemical producers, equipment manufacturers and users of structured equipment should benefit from the User Group through rapid access to public-domain research results, methodologies and tools intended to represent future technological standards in chemical engineering.

We are looking forward to a fruitful and enriching dialog with all concerned stakeholders, and would be very happy to welcome you as a member of the IMPULSE User Group.

Michael Matlosz,
IMPULSE Project Director

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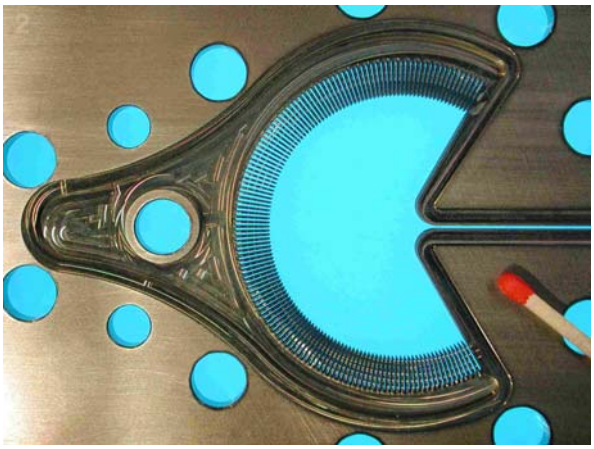
IMPULSE – the future of chemical manufacturing



Courtesy of IMM

Sustainable development requires radical innovation in production methods and completely new paradigms for industrial manufacturing. The chemical process industries, representing more than 12 % of total added value for the manufacturing sector in Europe, have a special responsibility in this connection and must play a major role in driving the industrial innovation necessary for society's future. Intensified chemical process components, such as microreactors and thin-film devices, offer tremendous opportunities for substantially higher efficiency, smaller volumes, reduced transport and inventories, and lower energy and solvent consumption. To tap into these new sources of technological opportunity calls for effectively targeted methodologies, design tools and performance criteria, based on carefully chosen industrial examples.

Structured multiscale design: a whole-process approach

Enabling true performance enhancement for complete process systems, and not simply individual unit operations, requires an integrated, whole-process approach that is presently unavailable for process intensification. IMPULSE addresses this urgent need head-on through a revolutionary vision that reverses completely traditional chemical engineering practice : rather than the classical method of adapting process operating conditions to equipment limitations, IMPULSE proposes a new paradigm that takes advantage of new technological opportunities to adapt process structure, architecture and equipment to the needs of the most eco-efficient physico-chemical transformations. A key feature of the resulting **structured multiscale designs** is local process control through integrated sensors and actuators, leading to step-change improvement in global process performance and to highly promising perspectives for the sustainable chemical manufacturing facilities of the future.

Business drivers in three industrial sectors

The technological benefits of structured multiscale design, such as **flexible** process devices, «**programmable**» reactors and **portable** process equipment, offer possibilities for **novel business models** for industrial economic growth. The business drivers for IMPULSE generally concern increased flexibility and reactivity to changing market conditions, as indicated in the table below.

Business Drivers	*Industrial Sector*	*IMPULSE Industrial Leadership*
o on site, on demand manufacture o distributed, delocalized production o variable, modular throughput o mass customization of product properties	Pharmaceuticals Specialty Chemicals Consumer Products	GlaxoSmithKline Degussa Procter&Gamble

To investigate the specific economic implications of the IMPULSE approach, the application-oriented research work concentrates on three major high-added-value industrial sectors: **pharmaceuticals**, **fine & specialty chemicals** and **consumer products**.

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Addressing challenges in the Pharmaceutical Industry

Pharmaceutical manufacturing has to keep pace with increasing pressure on manufacturing cost, regulatory compliance and environmental impact of processes. Against this background, the IMPULSE Subproject Pharmaceutical Products investigates case studies in continuous hydrogenation, solids handling and integration of primary and secondary processes, which are key issues for the pharmaceutical industry. Shawn Whitfield, Director of Engineering, Technology & Capital Management at GlaxoSmithKline, describes the challenges:

Hydrogenation is widely used in many fields of the chemical industry where the operation is most often carried out in stirred-tank reactors. Moving from batch to continuous micro-structured technology should result in systems that are intrinsically safer than the best conventional technology, while potentially offering better selectivity and yields through operation in the chemical regime.

Solids handling is key to the full implementation of continuous processing into the Pharmaceutical Industry. This research looks at the implications on feed preparation, continuous processing with solids and solids recovery through the use of microstructured process components.

Integration of primary and secondary manufacture is a necessity to reduce costs and process lead-time. The frequent duplication of unit operations within primary and secondary manufacturing is a bottleneck to their integration and the potential for continuous processing. The objective of IMPULSE is to understand the potentially large benefits in supply chain management, flexibility, safety and eco-efficiency of integrating primary & secondary manufacturing operations, and to devise ways of achieving the integration.

Increasing flexibility in the Fine & Specialty Chemicals Sector

Industrial processes for the production of performance chemicals have to deal with issues of **retrofit**, modularity and adaptability for **variable throughput** and flexibility for on-demand process modification and **mass customization**. Around these challenges, IMPULSE R&D work in Fine and Specialty Chemicals is dedicated to three reaction categories, which have been defined on the basis of industrially relevant processes with production outputs in the range of a few metric tons up to several thousand metric tons per year. Henrik Hahn, head of Degussa's Project House Process Intensification, comments on the research work:

Liquid-Liquid alkylation will investigate the transformation of highly exothermic reactions in miscible liquid/liquid systems from batch to continuous operation using structured reactors. Improved product quality and safe/controlled processing with significantly reduced solvents or even solvent-free alkylation are envisioned. This will be exemplified for the production of an ionic liquid on pilot-scale (300 kg/year).

Mini-emulsion polymerisation will address the implementation of a polymerization reaction in a continuously operated structured reactor with modular design suitable for retrofit into an existing plant. The tunable multi-scale reaction system will be evaluated in terms of space-time yield, molecular weight distribution and product purity. In order to demonstrate the multi-scale approach of the new technology, the transfer from lab-scale (< 1 l/h reactant feed) to a pilot scale (60 l/h reactant feed) is intended.

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Electrochemical alkoxylation involves the extension of current thin–gap technology for electro-organic synthesis by adding local current–density controllers through targeted electrode segmentation. The R&D work will focus on optimal design of industrial-scale alkoxylation units with the structured approach and proof–of–principle of the feasibility (construction and operation) of such alkoxylation units on the industrial scale.

Improving the value chain of Consumer Products

Subproject Consumer Products will focus on the use of miniaturized microstructured devices in **distributed production** and radical **integration of production steps** along the value chain. Elimination of energy-consuming transportation of (e.g. hazardous) material may enable production facilities to return to European sites, putting them closer to point of sales where additional high-added-value operations such as formulation and conditioning are involved. IMPULSE will investigate chemical reaction and formulation technologies on the basis of the major processing steps in the industrial production of detergents. Benjamin Sierra, Head of the Process Innovation Group at Procter & Gamble, elucidates the challenges:

Sulfonation and sulfation are major industrial chemical processes used to make a diverse range of products, including dyes and color intensifiers, pigments, pesticides and organic intermediates. The majority of the sulfonates and sulfates are used as surfactants in laundry and consumer product applications.

Encapsulation of solids and liquids is a major enabler to fine-tune the delivery of chemicals in consumer products. Conventionally used technologies are not suitable to provide microspheres at commercial scale with a thin, continuous film around the active core. In addition, batch to batch consistency is difficult to achieve. The R&D effort includes design and testing of a process using structured elements to create shell/core and multi shell (“onion layered”) particles with a highly controlled shell and core geometry.

For **Emulsification**, structured elements should enable much narrower droplet size distributions, which is of utmost importance with regard to product quality and performance. Another common industrial problem is the use of the same equipment to make a variety of different emulsions (e.g., variants of a detergent, cosmetic, silicone, etc.). Downtime and effluent from cleanouts and changeovers should be reduced drastically by using structured elements with minimal internal volume. This will improve industry's ability to do mass-customization and to streamline supply chains through demand-based production.

How to contact IMPULSE

Courtesy of IMM

To receive the biannual IMPULSE newsletter, please subscribe here.

If you or your organisation are interested in joining the User Group, or if you simply have questions or comments on the initiative, please feel free to contact the IMPULSE Support Team (SupportTeam@impulse-project.org) or visit our web-site at http://www.impulse-project.org, where we also announce presentations of IMPULSE results at major conferences in the field of chemical engineering and chemistry.

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