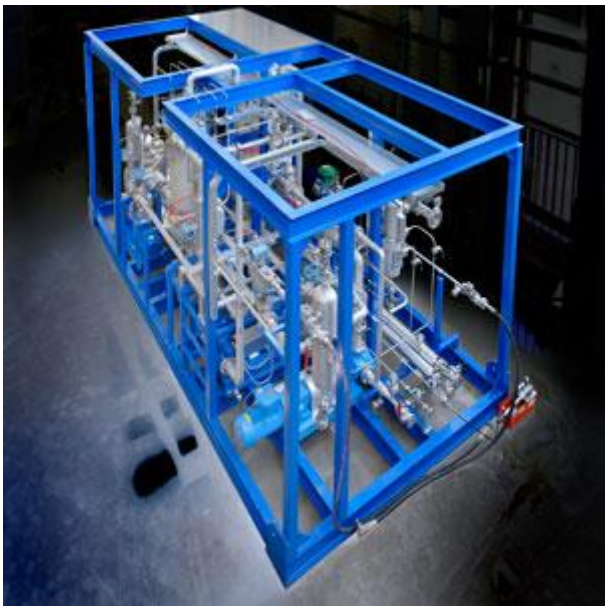
Process intensification: A balance between product and process innovation

Martijn de Graaff of TNO and Pieter Swinkels of TU Delft discuss the challenges of implementing process intensification in new product and process innovation.
The Delft Product & Process Design Institute at Delft University of Technology in the Netherlands (TU Delft) has seen over 100 case studies on product and process innovation that PDEng trainees solve for industry as part of their post-MSc designer traineeship. And, although efficient processes, minimal energy use and less waste are essential to addressing the needs of a growing world population, process innovation is often considered to be secondary to product innovation.

An important challenge for implementing more efficient processes in this context is the value and performance of existing assets. Especially when the industry is shrinking or moving to developing countries, there is less economic incentive to implement costly process innovations in existing assets.

Process innovation is generally only done when large energy savings have been proven, the manufacturing capacity of new process routes is expanding, such as in the gas-to-liquid business, or the controllability of the process is crucial. In these cases, health, safety and environmental legislation and cost reduction are the main drivers. However, all these observations refer mainly to the commodities business, where the balance of R&D is about 80% process innovation to 20% product innovation.

In the experience of the Process Intensification (PI) business line of TNO, the Dutch research organisation, interest in PI and process innovation in general depends on the industry. In fine and speciality chemicals, much more money is spent on innovation, but the 80:20 ratio of process to product innovation is reversed. New products are the core business of these companies, so this is where we find the highest competitive advantage, added value and incentive to innovate.



Hydraulic wash column for ultra-pure products

Although speciality chemicals companies mainly invest in product innovation, process technology remains very important to them. These companies test, buy and optimise equipment for their products in order to improve product properties and specifications, without disclosing their chemistry or starting to rely on an equipment supplier to understand the process.

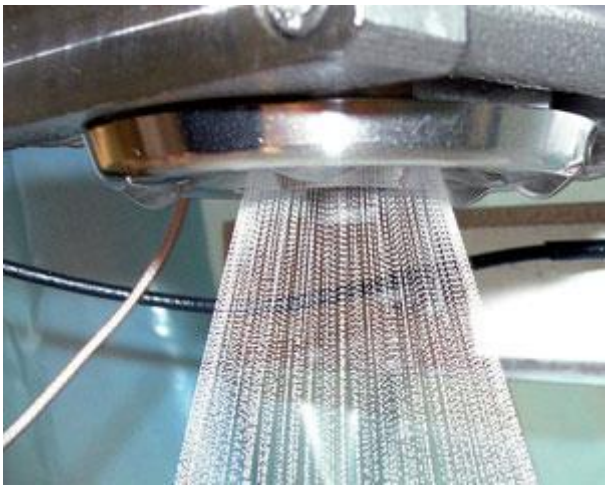
Process innovation models

The missing link and delaying factor in this approach to process innovation is the business case for the equipment supplier. If a process is directly linked to a product, chemicals companies prefer to develop it in an exclusive relationship with the equipment manufacturer. But once the technology is delivered, the collaboration is over. This is why the suppliers have no incentive to co-invest upfront.

Equipment manufacturers should start with the collective goals of the industry and develop platform-type equipment, for which no specific chemical process needs to be supplied, just a more general example. Ideally, chemicals companies should get technology suppliers involved early on. However, it is their own responsibility to determine how a modification in their technology might add value to this market.

Both the chemicals company and the equipment supplier can benefit from open innovation models. In shared research programmes, like CoRIAC and Provide! in the Netherlands and the F3 Factory and SPIRE elsewhere in Europe, a setting is created where equipment suppliers interact with chemicals companies and knowledge institutes to obtain information about chemical needs, functionality, business factors, etc. This helps the different stakeholders to play the right role in the innovation eco-system and therefore accelerate innovation.

Thus, process innovation can be done in one-to-one partnerships between the equipment supplier and the chemicals company, as well as in networks of parties involving research institutes solving mutual, general problems. In these networks, other innovative business models can also be explored; think, for example, of using second hand equipment and the leasing of equipment or chemicals, as done by Linde and Air Products.



Multi-nozzle print head for monodisperse powders

Product v. process?

Product and process innovation are often seen as competing with each other. However, in practice, they often go hand in hand with each other. Innovative process technology is often implemented by technology push, while the final product is later discovered to be of much higher quality. Only then do people really get enthusiastic.

Moreover, the implementation of process innovation can lead to additional positive effects, partly due to serendipity. For example, TNO developed a unimodal atomisation process for spray drying towers with a dairy company and an equipment supplier. The incentive was energy savings but the result - and the ultimate business case for implementation - was higher product quality, due to monodisperse particle sizes. The process is also now applied in the pharmaceuticals industry, where product quality is key.

The story is the same for membrane separation. Process technology suppliers should think: 'what is the advantage for my customer and my customer's customer?' The answer to this is in new or improved products, because this is where the higher added value lies.

This product-driven approach to innovation can be a limitation on the long term, however. With product development and scale-up needing to be fast, product formulations that are developed in the laboratory are then imitated at production scale due to lack of equipment innovation.

For example, in the coatings business batch reactors are used in the plant because of batch laboratory set-ups. Ideally, the focus would be the other way round: you would aim to do experiments in the lab, in a down-scaled version of the way you would want to operate the process on a large scale.

Integrated approach

PI implies step changes in ways of thinking, not only on production scale but also in the laboratory. This change is already beginning in the education of chemists and engineers, who have traditionally been product- and technology-focused respectively. In most companies, of course, everything is about the product.

The TNO Helix reactor allows high control of particle shapes

This 'interest gap' continues in chemicals companies, where collaboration between chemists and process technologists is a key success factor for product and process discovery and implementation. For this reason, the joint TU Delft/Leiden University 'Molecular Science &

Technology' BSc programme has for many years been integrating product and process discovery and design. PhD students and PDEng trainees are trained to remove the 'interest gap'.

The type of people required to reach successful innovations are those who are able to integrate, who look at the entire value chain and can make business cases for innovation. This requires a strong knowledge of the company and product portfolio, insight into additional changes that are needed in the plant and the lab, and proper knowledge on the benefits and risks of innovation, i.e. what will happen in different scenarios. In all cases the potential benefits should outweigh the risks to start with an innovation.

Process technology vision

Process innovation should be headed towards ultimate control on a small scale, without compromise. Our dream for the chemicals industry is to be able to envision a product and produce just that. Ideally, for every need, we would have a list of five technological options, with information on whether it has been implemented and whether there are models for it.

Compare this to the semiconductor industry, where a clear vision ('Everything must become smaller') has led to standards for the industry. However, chemical process technology is more diverse. At the moment, every piece of equipment is unique and thus very expensive. We want to move towards smaller, standardised unit operations so that it is not necessary to design each machine separately.

But how do we get there? Are companies innovative enough? Are the right people employed who dare to make the change? The good news is that this future picture is now started to be shared by industry, government and knowledge institutes across Europe. The remaining challenge is the mid-term plan or vision. For this, all parties must work together.