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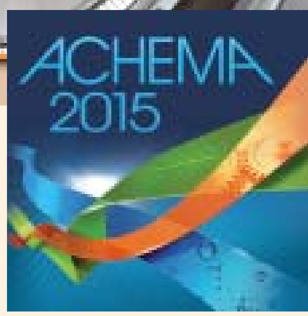


REPRINT

Each process step has to be put to the test

Reprint for Alfa Laval

Efficient scale-up of bio-based chemical production

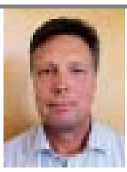
Each process step has to be put to the test

The transition from a pilot plant to full-scale production requires a thorough investigation into the opportunities and pitfalls that a larger scale entails. As shown by the example of bio-based chemical production, taking a broad view of the entire plant and how the various stages interconnect can shed light on new ways to improve operations.

When scaling up from pilot to full-scale production, the balance between investment and operating costs often shifts dramatically. Operating costs are rarely an issue in a pilot plant, where the main focus is on demonstrating that the process works. When building a full-scale plant, it is important to pay close attention to the operating costs and carefully consider all possible savings. The capital investment in a full-scale plant is often lower than the total cost of operating and maintaining it over its entire lifetime. This means that investing in equipment which reduces operating costs and increases production yield is generally good for business in the long run, even if it means a higher initial outlay. Transitioning from demo plant to full-scale production provides an opportunity to examine the production process and see if it can be simplified by combining individual steps. Taking a broad view of the entire plant and how the various stages interconnect can shed light on new ways to improve operations.

Tests with the new cell removal system using a high-speed separator and cross-flow membranes have been conducted at Alfa Laval's research centre in Nakskov, Denmark

Authors



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Reversed process order

When a producer of organic acids scaled up from demo plant to full-scale production, Alfa Laval's engineers proposed a cell removal system that improved the yield and cut both the installation and the operating costs. Alfa Laval already supplied the equipment which was used in the demo plant. A fermentation broth is processed there in two steps. First of all, it passes through a high-speed separator, where the cells are removed. It is then purified in a second step using cross-flow membrane filtration. The obvious choice would have been to simply scale up the existing process, which would have resulted in a major investment and high operating costs.

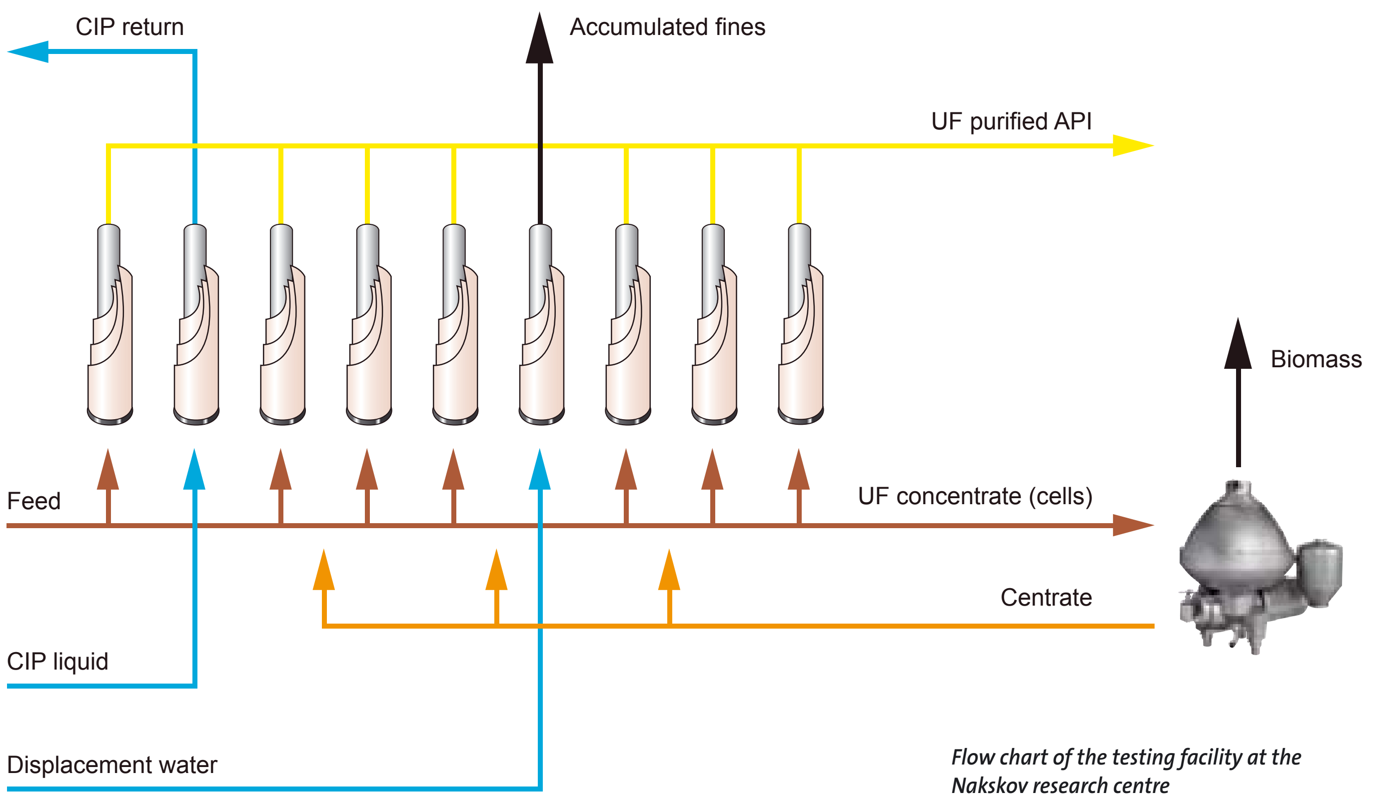
Alfa Laval's engineers proposed a solution for the full-scale plant in which these two steps were combined into one. The new set-up also uses a high-speed separator for cell concentration and cross-flow membranes for purification and recovery. The key difference is that the order is reversed. In the new set-up, the broth first passes through an ultrafiltration (UF)

stage, where the product is purified and recovered. This is possible thanks to the relatively low concentration of cells in the broth. The UF concentrate (cells and fluid) is then transferred to a high-speed separator, where the cells are removed. The high concentration factor in the separator minimises product loss.
The high-speed separator in the proposed set-up is specially designed for handling liquids with a high concentration of cells. A model with intermittent discharge, suitable for low cell content, was used for the demo plant. For the full-scale facility, Alfa Laval's engineers instead suggested a high-speed separator with continuous discharge.

Results		
	Traditional process with separate steps	New process with combined steps
High-speed separators (HSS)		
Required number of HSS	10	2
HSS energy consumption	100%	20%
HSS service cost	100%	20%
HSS price	100%	22%
Ultrafiltration system (UF)		
Number of loops in the system	7	8
UF area	100%	110%
UF energy	100%	80%
UF service cost	100%	90%
UF CIP cost	100%	100%
UF price	100%	100%
Overall yield	≈97,5%	≈98,4%

Controlling the accumulation of fines

The clear fluid from the separator – the centrate – is returned to the membrane stage for further product recovery and the removal of fines. These fines are various colloids, such as cell debris, that are not removed in the separator stage. If the fines are not eliminated, they will accumulate over time in the loop through the cross-flow membrane and separator stages, leading to lower performance.
To avoid this, the ultrafiltration stage is designed to remove fines automatically. The centrate is fed back to the cross-flow membrane stage through a special distribution system while a control system monitors the fines concentration continuously. If required, the control system stops the centrate flow and starts a displacement process that washes out the fines, thereby maximising performance and yield. The loss of product due to the displacement process is minimal. In displacement mode, the product molecules left in the membrane pass through it as normal, but with a little added washing water. The amount of water added is relatively small thanks to the low hold-up volume of the sequential displacement loop. The total displacement volume with fines will typi-

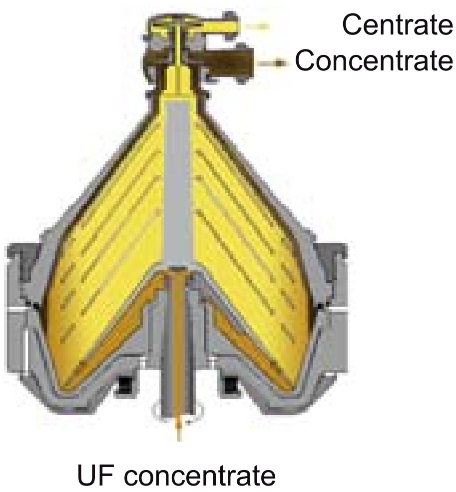


Flow chart of the testing facility at the Nakskov research centre cally be 0.1 % of the product feed, depending on the composition of the broth.

The control system also automatically initiates CIP (cleaning in place). One feed line and one CIP line lead into each membrane section, enabling sequential CIP and the removal of fines in each loop without having to interrupt production. The new system proposed for the full-scale plant offers a higher yield.

Successful results

The managers of the organic acids plant found the proposed solution very interesting and tests conducted at Alfa Laval's research centre in Nakskov, Denmark, have confirmed that the design works. These tests also included an analysis of product quality. Improved retention profiles were to be expected since the ultrafiltration stage operates with an overall lower cell load. The data from the analysis did not show any significant differences, but there was an indication of slightly better colour and nitrogen retention. The next step will be to perform full-scale runs at the customer's plant later this year.



High-speed separator with continuous discharge, suitable for high cell concentrations

The key benefits of the new set-up are significantly lower investment costs and energy consumption as well as increased yield. The highly concentrated biomass resulting from centrifugation also eliminates the need for a diafiltration water system in the ultrafiltration stage, which further minimises the investment and operating costs. As this example shows, there are many new opportunities to be discovered when scaling up from demo plant to full-scale production. Taking a broad view of the entire production process when designing the individual steps and keeping an eye on lifecycle costs represents a good starting point.

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