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Intelligent saving of resources on membrane plants

Part 1: New concepts – the ALPMA driving assistant



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Responsible use of everything that is taken from nature is currently one of the most important tasks facing humanity. The need to conserve resources does not need to be explained or justified in 2025. It is common knowledge that our world is being used too wastefully. And that this process is finite.

What can be done to give this process a different, positive direction? Saving the world in one fell swoop – it would be nice if that was possible. However, the rescue must consist of many pieces of the puzzle. Regulations need to be changed on a large scale. And on a small scale, every company and all specialists must do what they are able to do in their own area.

Our area of expertise in the Membrane Filtration department of ALPMA's Division of Process Technology are membrane filtration systems. What can be done here - what resources can be saved and by what means? To answer this question, we will first look at the resources used by a membrane filtration plant, see Figure 1. It can

be seen that there are involved different groups of resources. One group of resources is required in the operation of the plant; the other group of resources is already utilised in the construction of the plant. The third group is the product itself, which is to be produced with the plant. The topic of product yield is focussed on from an economic point of view and also from an ecological point of view.

All resource groups are influenced by the size of the system. These include the consumption of steam to heat up a certain volume of plant, the mass of stainless steel used in the plant, the mass of copper, which depends on the size of the motors used and more. The first task is therefore to design the system exactly to the point so that it can fulfil the task set, but does not have any excessive size reserves beyond

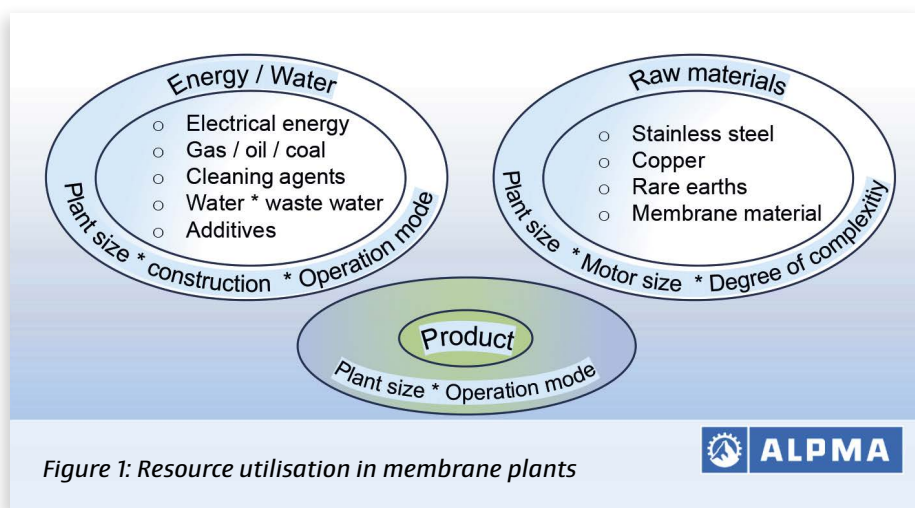


Figure 1: Resource utilisation in membrane plants

this. At ALPMA, the design is carried out on the basis of a special design tool and using data from the installed base (see Fig. 2). Alternatively it can be determined via pilot tests in the Technical Centre for membrane filtration (see Fig. 3).

The operating mode of the system has a further, very significant influence. This can be used to control the consumption of resources for the ongoing production and for the CIP processes.

ALPMA has developed the 'Energy^{SAVE}', 'Aqua^{ECON}' and 'Aqua^{SMART}' energy- and water-saving modules, partly together with its cleaning partner Horpovel. Figure 4 shows the amounts of electrical energy and water that can be saved.



Figure 2: Design of the plant size based on real values from the installed base



Figure 3: Design of the plant size based on tests in the Technical Centre Membrane filtration

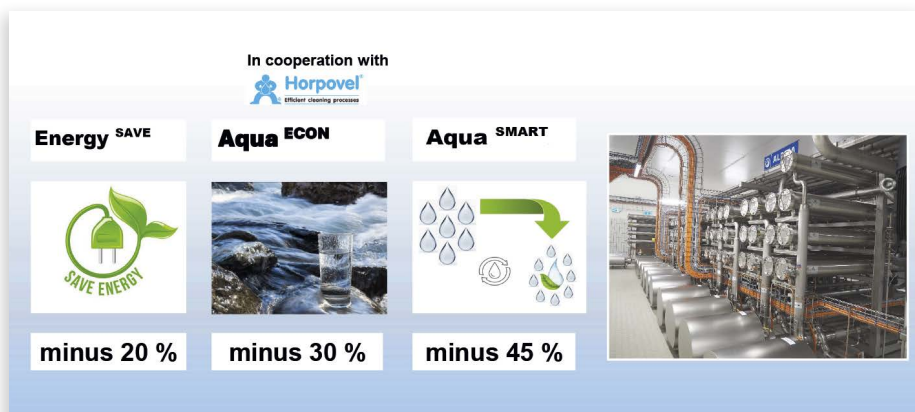


Figure 4: Operating mode – saving water and electrical energy

It is important not to save blindly and thus generate increased expenditure elsewhere by not operating the membranes appropriately, which may initially appear to save a little, but would necessitate premature membrane replacement. This would mean saving too much. What is needed is an optimisation process between desirable savings and essential expenditure for stable and safe system operation.

This includes knowing which savings are sensible and effective for which type of system in conjunction with which product. One example is the applied amount of crossflow over the membrane modules by means of the stage pumps. Standard values exist for this, from which it is possible to optimise downwards. As the crossflow is essential for controlling the fouling, the fouling potential of the product must be considered. In RO systems for UF permeate, for example, this is low as long as no calcium precipitation occurs. UF permeate contains neither fat nor casein nor whey protein as surface layer-forming substances, and the RO membrane has no pores that could become blocked. The situation is completely different with a ceramic microfiltration membrane for skimmed milk. Skimmed milk contains all the proteins found in milk. Casein has different structure-forming properties to whey proteins, which are also more effective in generating cover layers. In addition, ceramic microfiltration membranes have pores inside which deposits can build up.

In order to take this distinction properly into account, ALPMA categorises saving measures into specific clusters according to the type of system and the product's relevance to the formation of surface layers, within which the same or similar measures should be taken, see Figure 5. The less complex the system is and the lower the proportion of potentially surface-layer-forming substances in the product, the higher the savings potential.

To further ensure that the correct, i.e. the optimum operating mode is used, the 'response of the system' to the operating mode used is 'queried'. The ALPMA driving assistant can be used for this purpose. In many discussions, the terms Industry 4.0 or AI are used in an almost inflationary manner. Instead of repeating these terms, the ALPMA driving assistant offers a concrete solution to urgent questions.

The driving assistant is aimed at anticipatory driving. In car terms, this means - staying in lane - avoiding accidents - recognising problems in good time and taking countermeasures - driving in a fuel-efficient manner while ensuring that the destination is reached on time. This can be guaranteed by the ALPMA membrane experts and can also be realised electronically.

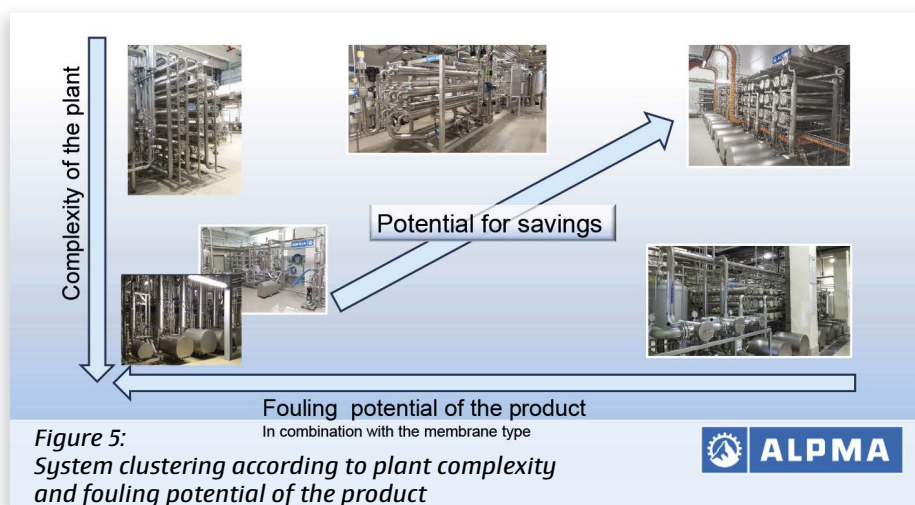
For example, a sensible CIP is configured on the basis of analysing the previous production data. This ensures that no over-cleaning takes place, which would take up more resources than necessary. On the other hand, deficient CIP is not selected, which would lead to losses in subsequent production performance and even prematurely required membrane replacement. The cleaning status can also be checked by regular maintenance as part of the ALPMA membrane service package (see Fig. 6).

A similar approach is used to optimise the saving of electrical energy. With a few exceptions, the largest consumers of electrical energy in membrane filtration systems are the loop pumps. This is where the greatest saving potential exists. At the same time, the loop pumps have one of the most important tasks within a membrane system - namely to control the formation of the surface layer. Here, too, the reaction of the system to the saving measure must be analysed and taken into account. This is done by adapting the crossflow to the analogue actual values of the system, i.e. only reducing it to the extent that the formation of the surface layer is still justifiable and can be cleaned economically.

In the future, the ALPMA driving assistant may be integrated into a cloud-based solution. The ALPMA Eco Clean system is

already available in the ALPMA Connect cloud solution. This is an optimised operating mode for the dairy plant CIP that was developed by our colleagues from ALPMA France.

The following article by Horpovel presents the optimisation and solution of a complex cleaning task on an ALPMA nanofiltration system with diafiltration at Brixen-Milch.



Short-, mid-, long-term Review

Optical cleanliness

Microbiology

Verification of organic substances

Figure 6: Monitoring of the long-term cleaning status by the ALPMA service team in collaboration with Horpovel



			INT	Vorspülen	EXT	CIP	Temp.	Leuge	Säure	Puffer	Enzym								
1				0 s	0 s	1800 s	48,0 °C	0,0 l 240 s	15,0 l 120 s	0,0 l 120 s	0,0 l 360 s								
2			INT	1020 s	120 s	EXT	90 s	CIP	48,0 °C	Leuge	0,0 l 0 s	Säure	0,0 l 0 s	Puffer	9,0 l 120 s	Enzym	0,0 l 120 s		
3			INT	Vorspülen	EXT	0 s	0 s	CIP	2700 s	Temp.	48,0 °C	Leuge	0,0 l 0 s	Säure	0,0 l 0 s	Puffer	0,0 l 0 s	Enzym	4,5 l 120 s
4			INT	550 s	120 s	EXT	2400 s	CIP	48,0 °C	Leuge	10,5 l 120 s	Säure	0,0 l 600 s	Puffer	0,0 l 360 s	Enzym	0,0 l 600 s		
5			INT	Vorspülen	EXT	0 s	0 s	CIP	49,0 °C	Leuge	0,0 l 600 s	Säure	0,0 l 600 s	Puffer	0,0 l 360 s	Enzym	0,0 l 360 s		
6			INT	Vorspülen	EXT	0 s	0 s	CIP	15,0 °C	Leuge	0,0 l 600 s	Säure	5,0 l 360 s	Puffer	0,0 l 360 s	Enzym	0,0 l 360 s		

Analyses of production

Evaluation

CIP-configuration

Dynamic adjustment

Figure 7: Driving assistant, configuration of the optimum CIP



Difficult cleaning tasks

Part 2: Customised solution using the example of mozzarella whey



Author: Martin Patzelt, Head of Application Technology and Sales, Horpovel

Good cleaning is results-orientated, cost-effective, reproducible and achieves a stable result. For this reason, Horpovel® GmbH has developed application-specific cleaning concepts. These concepts are used both in the field of general CIP cleaning and in membrane cleaning.

This article presents a customised solution to a difficult cleaning task using the example of mozzarella whey as well as the application-specific cleaning concepts at a customer.

Both the general procedure and the influencing factors of cleaning optimisation are presented in order to concretise the adapted cleaning solution using the example of cleaning optimisation of a 4-stage nanofiltration system for mozzarella whey. Using the example of the nanofiltration system to be optimised, the customer's existing standard cleaning process was adapted on the basis of the findings from the previous analysis.

The customer's initial situation was as follows:

The desired end product was mozzarella whey with maximum dry matter and demineralisation.

The resulting consequences were

- » Difficult filtration process due to the shift in salt balance.
- » Calcium precipitation on the membranes.
- » Faster tendency to clogging.
- » More difficult adjustment of stable pH values, especially in the acidic purification steps.
- » Cumulatively, this led to a shortened membrane service life.

Nanofiltration plant for mozzarella whey (ALPMA) at the customer's site



The customer's existing cleaning process initially involved the following steps:

1. enzymatic cleaning
2. acidic cleaning
3. alkaline cleaning

The customer preferred a customised cleaning concept that was cost-effective, reproducible and, above all, stable. There was therefore a need for action.

Based on these criteria, it is essential to first record and analyse the cleaning problems. On the one hand, it must be determined at this point where and when the problem becomes apparent on the systems and how the membrane system performs during production and cleaning.

This problem analysis is initially carried out in a closed system and the parameters can be recorded non-destructively as follows:

- » Record displayed values.
- » Sampling of the various streams with control of essential chemical parameters.
- » In addition, by circulating an indicator in the system, the deposits that do not pass directly into the liquid phase can be recorded and detected (e.g. organic deposits, which may be encapsulated in places).
- » Disadvantage: Only what passes into the liquid flow can be measured.

The problem analysis in the closed system did not initially lead to the desired result, which is why a membrane replacement was unavoidable. Following the membrane replacement, an autopsy of the blocked membranes was carried out.

An autopsy can provide indications of mechanical damage, deformation or deposits, for example. In addition, an FTIR examination of the surface (direct comparison of a new and a used membrane) can be used to analyse detected deposits in detail.

When analysing the deposits in the customer's nanofiltration system, it was clearly established that they were calcium compounds. Observing the reaction of the calcium compounds to temperature and various cleaning agents led to a change in the cleaning process. Calcium compounds tend to precipitate with increasing temperature and increasing pH value. For this reason, a cleaning step with cold acid was placed before the enzymatic step in order to react to the calcium problem before further cleaning steps were carried out.

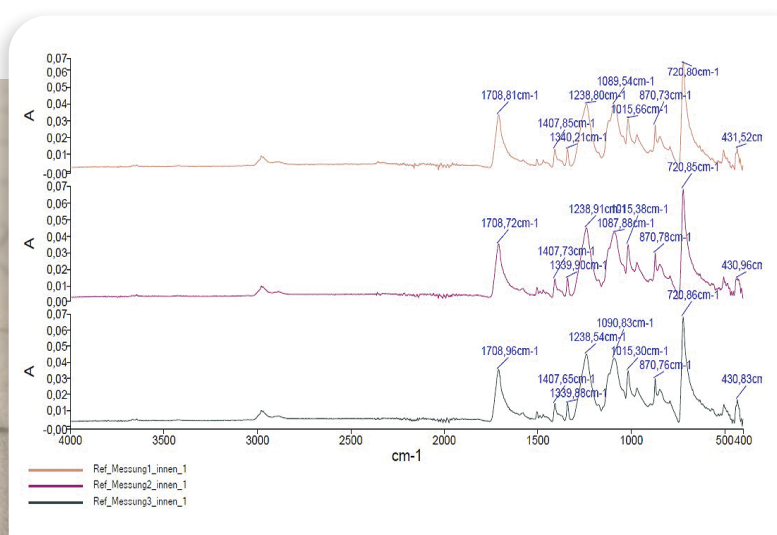
This was followed by an analysis of the current status of the production processes based on the relevant aspects:

- » How does the calcium behave during production?
- » What is the rinsing behaviour of the calcium before cleaning?
- » How successful is the rinsing result of the calcium after the first cleaning step?

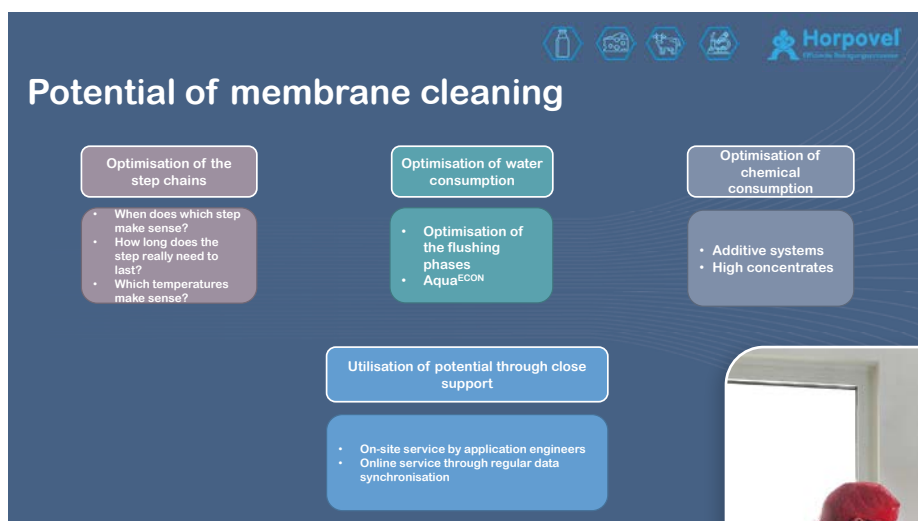
Together with ALPMA/LTH Dresden and the customer, the individual steps were observed, monitored and optimised. In this context, the filtration process and the existing cleaning concept were adapted in order to reduce the precipitation of calcium compounds. By removing the calcium before the enzymatic cleaning step, it was possible to stabilise the pH control in the cleaning steps and significantly extend the membrane service life.

The central problems of a membrane filtration system are, in addition to the restrictions on the cleaning agents used, the specifications in the membrane data sheets (physical possibilities limited

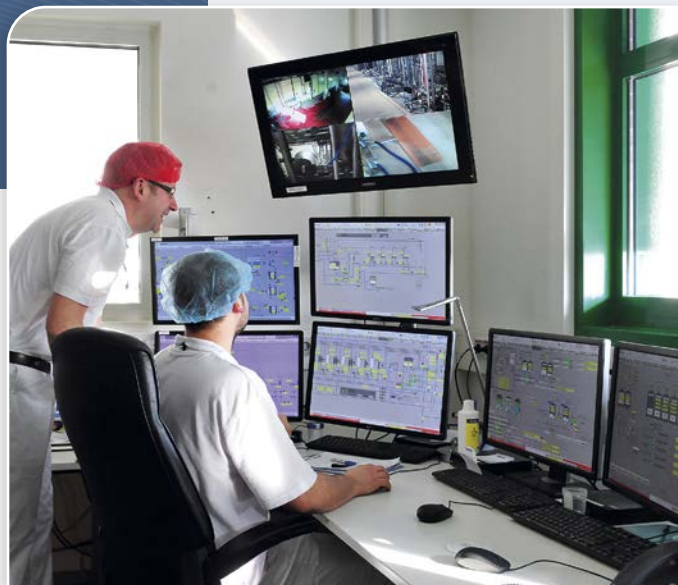
Blocked membrane of the customer



Membrane autopsy on blocked membrane



Plant monitoring/plant inspection



Optimisation potential of a cleaning system

by temperature and flow rate) and existing customer and regulatory requirements. In addition, the nature and quality of the functionality of the membranes changes over the length of the operating time and the natural fluctuations in the starting products used. This results in a repeated need to adjust the cleaning parameters during the service life of the membranes.

In order to achieve an extended membrane service life, close monitoring is essential. This is where Horpovel comes in, creating the right cleaning concept for each application and adapting it to the customer's specifications. This is done either in advance through appropriate pilot tests on our own laboratory plant at the Bochum site, or directly at the customer's plant through a precise analysis of the existing system.

In addition to purification concepts for dairies, concepts for plant-based product lines (such as pea/soy/oat/potato proteins and concentrates from carrots) have already been developed in this way. The control of all important parameters on site at the customer's premises, the recording of flow values (crossflow) during filtration and cleaning can be carried out and evaluated using Horpovel's own online system for data acquisition.

In general, with all optimisations and conversions, it must be ensured that the selection of cleaning agents meets customer-specific requirements. A distinction must be made between the simple handling of special, ready-made cleaning agents and the use of additives. Although these initially require more effort to set up correctly, the use of additives can significantly reduce cleaning costs in the long term.

Regardless of the choice of cleaning agent, it should be noted that a cleaning concept that is not optimised always has a negative impact on the service life of the membrane.

Horpovel sees the following optimisation potential for the areas of system performance and membrane service life:

- » Optimisation of the step sequence, exact parameterisation of the circulation and rinsing steps.
- » Optimisation of chemical consumption.
- » Optimisation and adjustment of the cleaning processes by checking for residual organics.
- » Reduction of operating costs while maximising efficiency.
- » Reduced water consumption when cleaning membrane systems with Aqua^{ECON} (developed jointly with ALPMA/LTH Dresden)
 - › Use of optimised Horpovel cleaning agent concentrates.
 - › Enormous savings in fresh and waste water.
 - › Reduction of tank storage capacities.
 - › Improved ecological footprint.

There must be no unpolished concepts in sensitive cleaning processes. Effective products and responsive service are therefore essential. Horpovel's application engineers monitor all parameters during regular and technical inspections of the systems and intervene quickly in the event of deviations - before or when anomalies in production performance are detected. This is done with the help of existing online solutions (such as data loggers, live view, etc.).