INDUSTRIAL WATER REUSE:

GRUNDFOS OFFERINGS FOR INDUSTRIAL WATER REUSE

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EASY INTEGRATION

OPTIMISED PROCESSES

REDUCED OPEX

GRUNDFOS iSOLUTIONS

PUMP CLOUD SERVICES

Introduction

Water is such a fundamental necessity for life that it is simply taken for granted. In modern industrial societies, tap water is expected to be pure and drinkable without a second thought. However, the background is, of course, much more complicated. Mankind is becoming increasingly aware that fresh water is a rarity, and that the process of water treatment is of vital importance to us all. The water consumption in the industrial area contributes a lot to the global water situation and therefore Grundfos is putting special focus on this.

Purpose

The purpose of this white paper is to introduce the topic of industrial water reuse and to describe the processes in this specific area of water treatment. Also Grundfos offerings and the visions for the future are shown.

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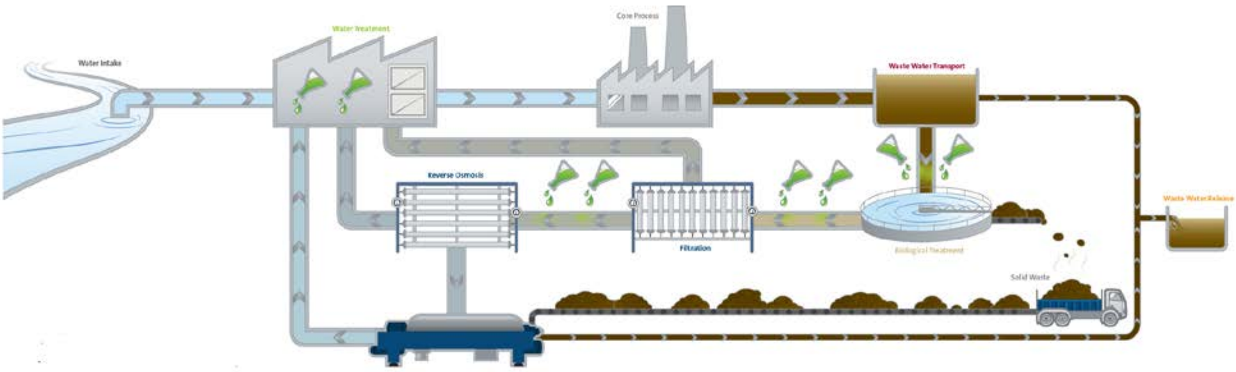
Background

In industrial markets, water plays an important role as a solvent, cooling liquid, wash and clean liquid, and more. Whenever we use water, we also change the content and with this the water quality. In many countries, water needs to be treated after use to avoid contamination of the water cycle by industrial substances. A general cycle of water usage and treatment is shown in Picture 1.



Picture 1: Industrial water cycle

To reduce water consumption and contamination in industry, many companies are looking into the field of water reuse. Reuse is defined as when already-used water is treated up to a quality where it's possible to either use the water in different utility processes, like cooling or wash and clean processes, or even to a quality where it can be used in the core process of the respective industry. Depending on the industrial area, the contamination and treatment steps vary. In Picture 2, we can see a generic water reuse process.

Reuse Process

The process generally consists of the following stages:

Water Treatment	Waste Water Transport	Biological Treatment	Waste Water Release	Chemical & Physical Treatment	Concentrate Treatment	Water Quality Measurement and Controls

Picture 2: Generic water reuse process

Wastewater Transport

After the different usages of industrial utilities or processes, the water is transported towards the treatment facility. Depending on the water chemistry and the particle content, different transport pumps are used and are available with Grundfos. Also, depending on the water condition, different materials have to be chosen. For example, when high chloride content is present, stainless steel should be used.

Biological Treatment

As in municipal wastewater treatment plants, the industrial area of biological treatment with bacteria plays an important role in treating wastewater. In this step, the nitrogen content, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), are treated to lower the concentration of N and P values. Sometimes this step is combined with a physical step to separate particles out of the water. Membrane Bioreactors are used, for instance, if some of the water isn't reused but released to the environment.

Wastewater Release

As described above, after this step, some wastewater can be released according to local regulations. Very often, it's released in a river or another surface water source. In some areas, a disinfection step also happens in this part of the process, depending on local laws and regulations.

Chemical & Physical Treatment

If a more detailed treatment is needed, the next step is a chemical or physical treatment. In this step, the water is conditioned in terms of pH, and all particles are removed to prepare the water for the last step: the concentrate treatment.

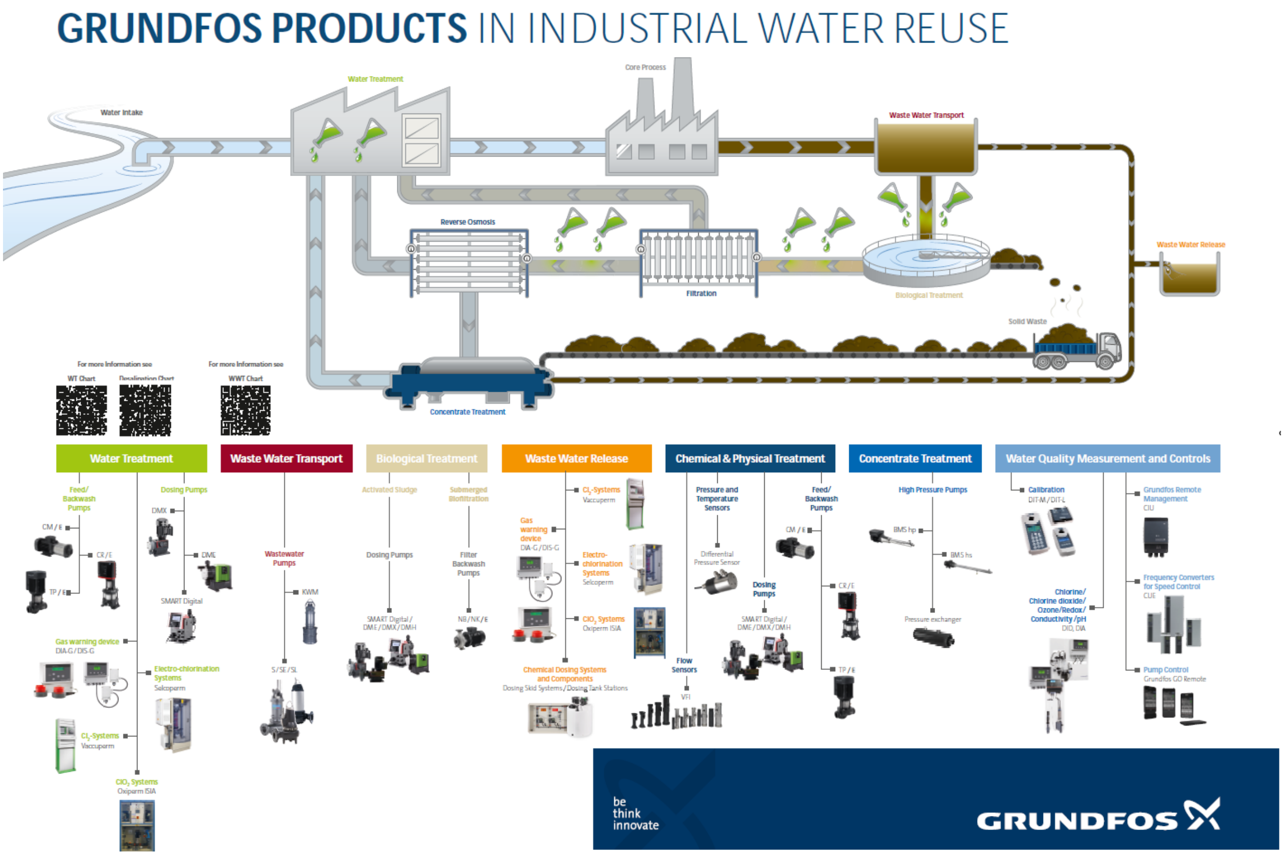
Concentrate Treatment

Concentrate treatment is a challenging water treatment process to the very end. High energy demand and high ion concentrations are the two main challenges combined with a relatively small amount of water. This step is often done via a crystallisation step or Reverse Osmosis (RO) with up to three stages. Challenges for RO are the high pressure and water chemistry, which can be demanding for the membranes but also for other components, such as pipes, valves and pumps.

Control Systems

Throughout the whole process, different measuring and control functions providing reliable results are needed. Typically, hydraulic parameters, such as temperature, flow, and pressure or chemical parameters, including pH, turbidity, conductivity and Total Organic Carbon (TOC), are measured online. BOD COD, Phosphate and Nitrogene parameters are the most important ones when it comes to wastewater regulations.

Overall process control is important for every treatment application. Normally, a PLC samples all measured signals from the different process steps and controls the process to secure the success of the treatment. Standard data communication, such as Profibus and Ethernet, is normally used. Today, an advanced process control system could include cloud solutions and automated remote management. A direct link from the process step to the required pump solution is shown in Picture 3.



Picture 3: Link from process to pump and pump system

Grundfos iSOLUTIONS in Water Reuse:

As described above, chemical and physical treatment is important in a water reuse process. Very often, it's the particle removal step which is the heart of the process, as proper pre-filtration is key to a sustainable and reliable operation of the following process steps.

Grundfos is able to deliver a row of pumps and pump systems to make your ultrafiltration (UF) system not only state of the art when it comes to reliability and cost effectiveness but also future ready for increasing demands in your water reuse process.

The following chapter describes what Grundfos in particular can offer with Grundfos iSOLUTIONS.

Challenges

Major challenges in an ultrafiltration application include:

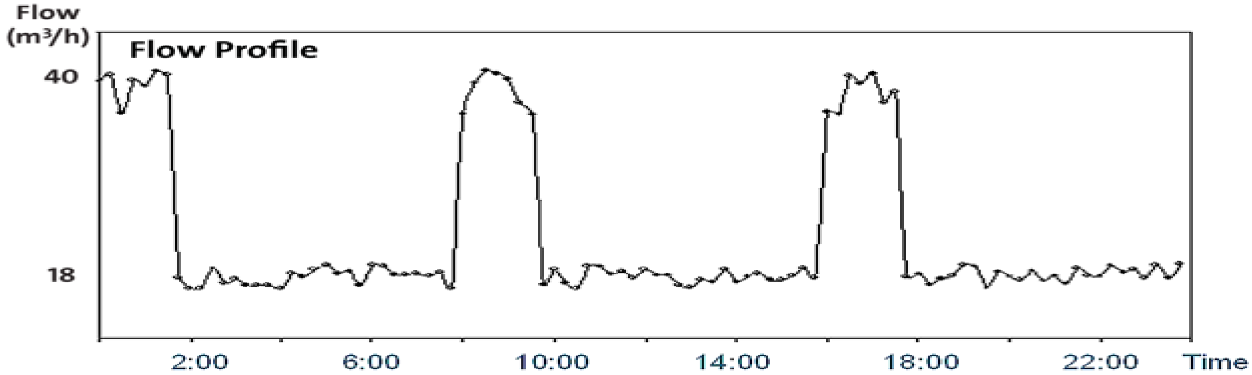
- Changing raw water conditions (e.g. turbidity increase)
- Changing demand on the clean water side

These challenges must be handled and solved by a modern set-up in a smooth and reliable way. This requires a system in which components can be easily integrated and which quickly gives reliable information on water quality. Changes in flow rates must be handled flexibly. At the same time, the process must be energy efficient, economic, and have no detrimental effect on the environment.
The pump system must account for variability in water supply requirements for a UF system. A good deal of variability could take place despite these being 'fixed-flow units'. Seasonality, process fluctuations or even water supply restrictions can cause variations. The right drive on a pump can help to control flow

without wasting energy (e.g. with a throttling valve). Additionally, a drive can enable simple constant-pressure control for the membrane system, regardless of changes in water supply or discharge pressure (variability).

The basic affinity laws for pumps and motors show that by reducing motor speed you decrease energy consumption to the third power. End-users often use a throttling valve to decrease flow on a fixed speed pump. This wastes large amounts of energy and money – a problem that's worsened when pumps are over-sized during the design phase.

Furthermore, throttling will move a pump down the efficiency curve, so not only is the pump's power draw higher, it's also less efficient. A drive can allow you to dial in the exact flow and pressure requirement and save large amounts of energy at better efficiencies.



40 m3/h – 6 hrs./day
18 m3/h -18 hrs./day
4 bar constant pressure
7 days/week, 50 weeks/year, €0.09/kWh
Energy savings €1400 per year.

Figure 1: Flow profile of a pump in an ultrafiltration system

Example:
A 7.5 kW fixed-speed CR pump that's engineered to deliver 40m^3/h of flow in a system with 4 bar is sometimes controlled by a throttling valve. This increases pressure (to nearly 7 bar) and moves performance down both the flow curve and the efficiency curve. A CR pump in this application will require 5.5 kW.

By using a drive to meet the flow requirements, the exact pressure and flow needs are met. The power required drops to 3 kW, allowing for energy savings of €1,400 per year.

A pump and drive solution can dramatically reduce the number of different pump designs used to manage different RO/UF system sizes. This standardisation on fewer pump sizes, each with more flow flexibility, will help system manufacturers reduce complexity and costs while easing design needs. It can also help an end-user with multiple systems or trains, offering additional savings in maintenance and spare-part costs. Some system manufacturers will ship membrane systems to other countries with different power requirements. A drive can allow for 50 or 60 Hz power and still run the standard pump motor. This can reduce the complexity and cost of different power variants for membrane systems for North American or export use.

In addition, a smart booster pump softens the start-up and shut-down of flow. This eliminates powerful water forces that can, under some circumstances, increase membrane wear in a system. All membranes will eventually foul and require cleaning, yet as membranes clog, the pressure requirements to treat water at the same flow rate increases. Without a drive, a system with a fixed-speed pump will begin to deliver less than the rated permeate flow. A modern drive and pump can easily account for pressure changes, allowing them to operate for longer between cleanings without a loss in production flow, provided the filtered water continues to meet quality requirements.

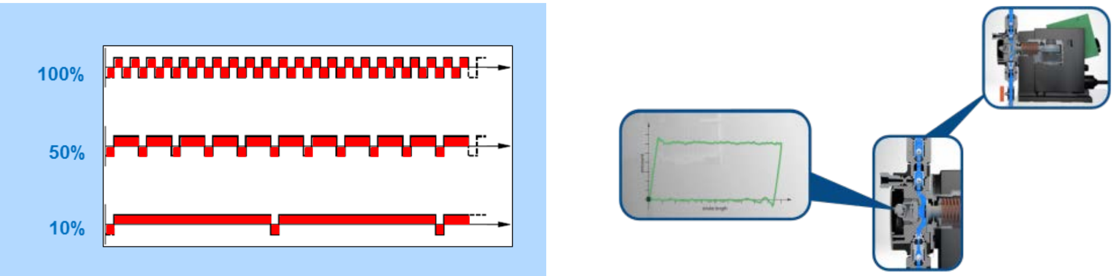
Choosing the right drive and pump selection can help the end-user plan for future system enhancements. This could include changes to the trains, newer, lower-pressure membranes, or process flow changes. This flexibility will make retrofits cheaper in the future, enabling the end-user to take advantage of new green and performance solutions.

Newer pump products include integrated drives, where a drive is optimised for, mounted on, and works together with, the pump motor. This can lead to pumps with smaller motors and optimised performance, and ensures the pump is protected. End-users should also look for a pump-designed drive. Many drives on the market are generic to a variety of motor needs. A drive designed and matched for a specific model of pump can make installation and set-up easier, and increase efficiency. [1]

Chemical Dosing in Pre-treatment & Backwashing

Ultrafiltration requires extremely accurate dosages of chemical additives. Modern digital dosing pumps, such as those incorporated in systems provided by Grundfos can deliver the needed amount of chemicals with high precision.
[Source: *"How good is the Grundfos SMART Digital DDA FCM really?" University of Applied Sciences Weihenstephan-Triesdorf - Institute of food technology*]

Looking at the diagram below (Picture 4), we can see the nearly continuous dosing flow, which is provided by the motor technology of the stepper motor, even with small volumes.



Picture 4: Flow monitor principle and dosing flow diagram

An integrated flow monitor controls this flow, which is able to give feedback about the actual flow in comparison to the set point.

In addition, the SMART Digital range will provide modular pumps for easy system integration. The clear menu structure and plain text menu provides the needed information about the status of the pump and eases the lives of system operators in their daily work.

Communication with this pump is no longer a challenge in the system integration. By connecting via the E-Box, we have a plug-and-pump system communicating in many different ways with the overall PLC. [2]

A Glimpse into the Future:

Digitalisation, connected systems, Big Data and autonomous production are themes present in all boardrooms around the globe. In the water treatment industry, the Fourth Industrial Revolution will also impact the way we treat water and how we handle and use of data in the future. This chapter will showcase possibilities with connected systems and the innovative use of data and algorithms to present data from RO systems and optimise anti-scalant usage in RO systems.

Smart RO works by analysing data from standard sensors (pressure, temperature and conductivity) present in an RO system. The sensors monitor operation and will react to changes in membrane performance. Data from the sensors can be transmitted to and stored in either the dosing pump or a cloud server, and potentially both locations can be used for data storage (local or historical). Smart RO has two main characteristics: 1) Real-time data processing and visualisation, and 2) Digital intelligence featuring decision making for AS dosing. An upgraded version of a Smart Digital dosing pump is used for the implementation of Smart RO. [3]

First results (Figure 2) in field and pilot tests have shown sufficient results, and tests with real customer systems are currently running.

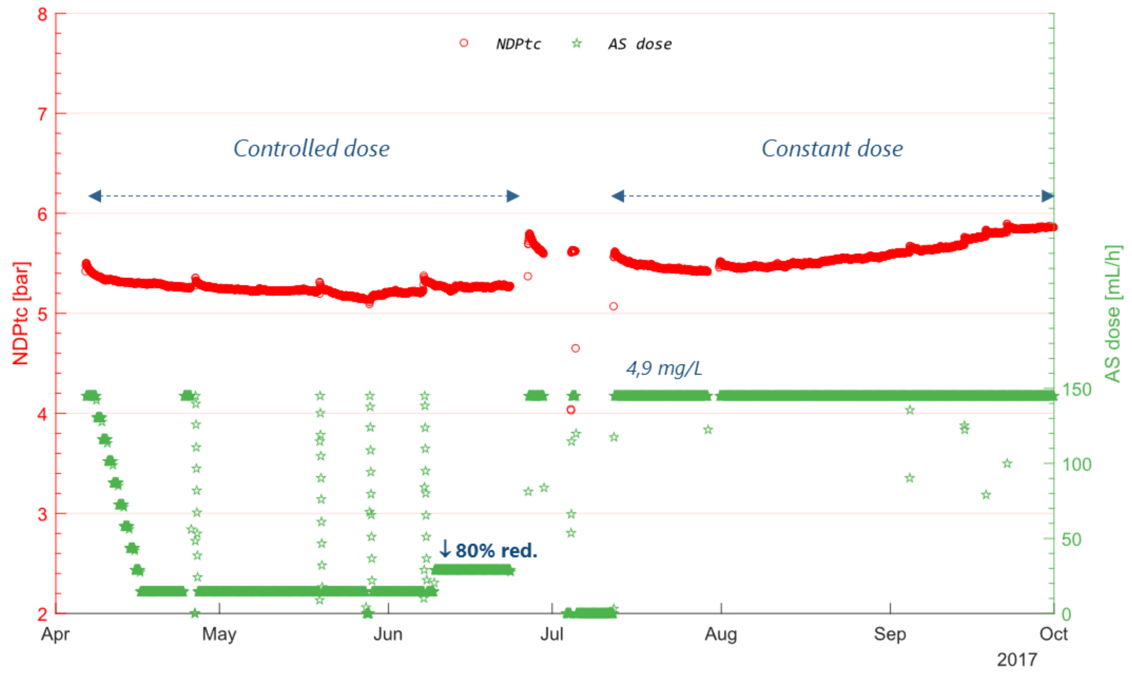


Figure 2: Comparison between system running with Smart RO (controlled dose) and without Smart RO (constant dose)

Conclusion:

This whitepaper is intended to introduce the many elements that constitute the water reuse process. We hope it has answered some of your questions, but there is obviously a lot more to learn. The use of water varies from one industry to another, and there are a number of different applications within water treatment and industrial water reuse in which Grundfos will develop more optimised solutions to make use of intelligent pumps and pump solutions.

As water scarcity becomes greater, the need to recycle water will be increasingly important. Water treatment processes will play their role in ensuring a safe and stable future for the whole planet.

Sources:
[1] Harland Pond: Using pump Variable Speed Drive Solutions in Membrane Filtration
[2] *"How good is the Grundfos SMART Digital DDA FCM really? Comparative study of dosing precision and accuracy between SMART Digital DDA and the mechanical dosing pump DMI" University of Applied Sciences Weihenstephan-Triesdorf - Institute of* food technology
[3] Optimization of RO Systems through Digitalization, Connectivity and SMART Algorithms; Marco Witte, Dr. Carsten Persner, Victor Augusto Yangali-Quintanilla, MSc, PhD,