Water Treatment - Ultrafiltration

Pumps and their role in Ultrafiltration.

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Introduction:

In many water treatment applications, the removal of particles is the key component in order to provide clean water for subsequent use. An ultrafiltration plant removes effective particles down to a size of 0.01 µm, such as bacteria, suspended solids, etc.

The pressure range for ultrafiltration is from 1 - 10 bar. The size of ultrafiltration plants can vary from small-scale systems, e.g. water supply in remote areas with only a few consumers, up to big industrial parks, which use ultrafiltration to process water, and water supply for thousands of people.

Purpose:

The purpose of this white paper is to inform about the role and configuration of typical ultrafiltration pumping equipment.

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Background

In general, the feed water is pumped through the membrane. Optional in the feedline is a dosing pump, to pump flocculent into the feedline in front of the membrane. After the membrane there is a set of backwash pumps to clean the membrane with filtrate or enhanced with cleaning chemicals. These, too, are dosed via dosing pumps.

A general set-up of an Membrane System can be seen in the picture below.

Variable frequency drives (VFDs) are nothing new to membrane filtration units. The most typical use of an external VFD on pressure pumps for reverse osmosis (RO) or ultra-filtration (UF) systems is to account for variability in flow. However, most end-users see their application as having a constant flow requirement, such as treating water for a boiler system or a constant flow process; the majority of membrane systems are supplied with fixed speed pumps.

Challenges

Major challenges in the ultrafiltration applications can be:

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

These challenges must be handled and solved by a modern set-up, in a reliable and smooth 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.

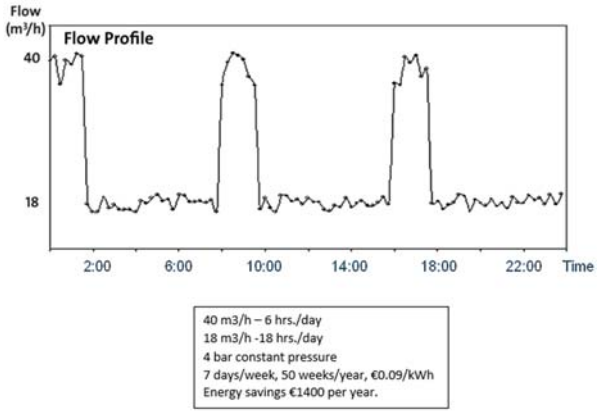
Flow variability, pressure stability

The pump system must account for variability in water supply requirements for an 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).

Save energy

The basic affinity laws for pumps and motors shows 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 is 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 is 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.



Example:
A 7.5 kW fixed-speed CR pump that is 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 €1400 per year.

Standardisation

A pump and drive solution can dramatically reduce the number of different pump designs used to manage different RO/UF system sizes. This standardization 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.

Dual Frequency

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 save in the complexity and cost of different power variants for membrane systems for North American or export use.

Membrane wear

Moreover, a smart booster pump softens the start-up and shut-down of flow. This eliminates powerful water forces that can, under some circumstances, increase wear of membranes in a system.

Membrane degradation

All membranes will foul eventually 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 account for pressure changes easily, allowing them to operate for longer between cleanings without a loss in production flow - provided that the filtered water continues to meet quality requirements.

Plan for the future

Choosing the right drive and pump selection can help the end-user to plan for future system enhancements. This could include changes to the skids, 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 performance solutions.

Think integrated

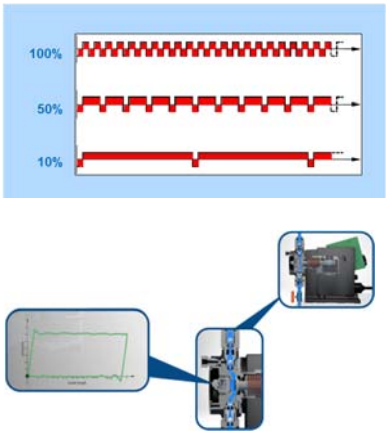
Newer pump products include integrated drives, where a drive is optimised for, mounted on, and works together with the pump motor. This can lead to pumps with smaller motors, optimized performance and ensure that the pump is protected. End-users should also look for a pump-designed drive. Many drives 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.

Chemical Dosing in Pre-Treatment & Backwashing

Precise Dosing:

Ultrafiltration requires extremely accurate dosages of chemical additives. Modern digital dosing pumps, such as those incorporated in systems provided by Grundfos can deliver the required chemicals with 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, one can see the nearly continuous dosing flow, which is provided by the motor technology of the stepper motor, even with small volumes.



Picture 1: Flow monitor principle and dosing flow diagram

Conclusion:

Traditional solutions for UF and RO systems have used fixed-speed pumps, with throttling valves to control the flow rate. This has often been very wasteful in terms of energy, extra wear and maintenance, thus making the system less cost-efficient. New pump drive and digital control technologies allow end-users to keep a closer eye on the operation of their system, and control the required flow and dosing in an energy-efficient and more economical way.

Sources:
Harland Pond: Using pump Variable Speed Drive Solutions in Membrane Filtration

: *"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*

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

Simple Dosing:

In addition, the SMART Digital range will provide modular pumps for easy system integration. The clear menu structure and the plain text provide information about the status of the Pump system, helping operators in the 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 PLC.