Whitepaper

Intelligent Flow Control in Micro- and Ultrafiltration

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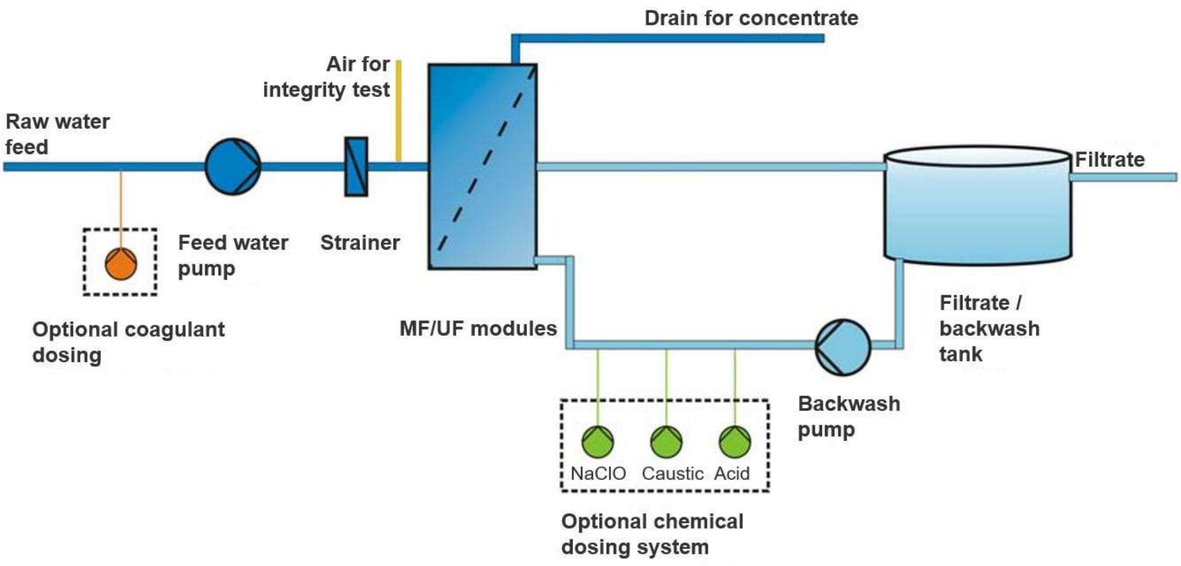
Introduction

In many water treatment applications, removal of particles is the key component to provide clean water for subsequent use. A micro- or ultrafiltration plant effectively removes particles down to a size of 0.01 µm, such as bacteria, suspended solids, etc.

The pressure range used in those filtration types is between 0.2 and 10 bar. The size of membrane filtration plants can vary from small-scale systems, e.g. water supply for only a few consumers, up to big industrial parks to treat process water or large water utilities for thousands of people.

Background

In general, the feed water is pumped through the membrane. Suspended solids are removed by the filter effect. An optional dosing pump in the feedline injects flocculent in front of the membrane. A set of backwash pumps is additionally installed to clean the membrane using filtrate water or enhanced with cleaning chemicals.



Graph 1: General set-up for a membrane filtration system

Variable frequency drives (VFDs) are recommended to be used for pumps in membrane filtration units to account for the 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. Still, many membrane systems are supplied with fixed speed pumps in a static design and with that the flow control components.

Challenges

Major challenges in micro- and ultrafiltration applications can be:

- Changing conditions in raw water (e.g. turbidity variations) or system (e.g. membrane ageing)
- Fluctuating demand on the clean water side
- Requirements on optimized system operation regarding energy, chemical and water usage

These challenges must be handled and solved by a flexible set-up, in a reliable and smooth way. Components should be easily integrated and changes in flow rates must be handled. At the same time, the process must be energy efficient and economic with low environmental impact. This requires connectivity and remote-control abilities for most components in a membrane system.

Flow variability, pressure stability

The pump system must account for variability in water supply requirements. Seasonality, process fluctuations or even water supply restrictions can cause variations. Common design in the past was the combination of fixed speed pumps with throttling valves to control the water flow. Nowadays, frequency-controlled pumps enable simple constant-pressure control for the membrane system even under changing conditions. In combination with that, valves help to ensure the optimized process flow. Besides simple open/close tasks, valves must also be able to regulate the liquid flow. This concerns the water to be treated as well as the chemicals for conditioning and cleaning.

Membrane wear and degradation

Changing flow streams could cause quick pressure changes. This might have a negative impact on the membrane lifetime. Intelligent pressure pumps soften the start-up and shutdown of flow. With that, switching of valves must be coordinated in a MF or UF membrane system. Feedback signals on valve status and remote settings by the system controller are therefore required to ensure optimum operation.

All membranes will foul and eventually clog, thus require cleaning. Membrane performance can also drop during ageing. These dynamic changes must be handled in the pressure management to achieve a constant flow rate. The pump and valve setup must be able to adapt to the changing conditions, allowing them to operate for longer time between cleanings without a loss in production flow.

Connectivity and controls

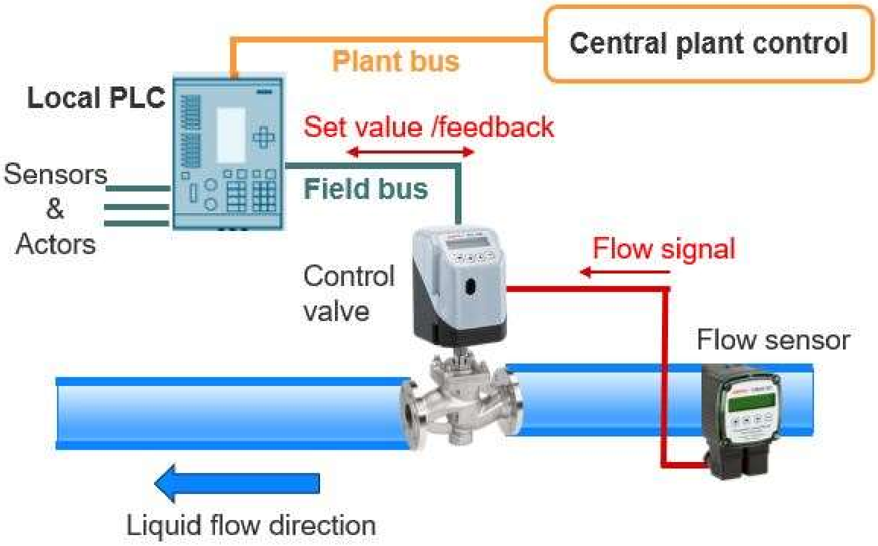
Stable and reliable operation in combination with optimization of the membrane system output is only possible with suitable system components. Choosing the right pumps and valves can help the end-user to plan for future system enhancements. This could include changes to the trains, newer low-pressure membranes or different process flows. This flexibility will make retrofits cheaper in the future, enabling the end-user to take advantage of new green and high-performance solutions.

The selection of suitable ball, membrane or globe valves depends on several factors. Generic criteria as type, flow rate, material or connection diameter are system depending. The degree of connectivity or regulating abilities are subject to control requirements for the membrane system. Non-critical valves (e.g. for drainage) can be manually controlled, whereas system-integrated valves should be able to be connected to the control system.

The first level of connectivity for all valves would be a position indicator to send the status (open/closed) as electric signal to the system controller. It does not allow to send feedback signals. Pneumatic or motorized valves are commonly used in water treatment systems to control the flow through the pipes. This is the second level of connectivity allowing to switch those valves by a local PLC, e.g. for changing the flow from filtration mode to backwash mode.

In some places of the filtration system, a simple on/off switch might not be sufficient. MF or UF systems are more and more often subject to be optimized by flexible operation modes or new control algorithms. This requires different ways to control the liquid streams. Regulating valves build the third connectivity level and are needed e.g. for dosing and mixing of chemicals in the pre-treatment or chemical enhanced backwash. Changing demand can be caused by fluctuating intake water quality and/or if chemical consumption shall be minimized. Globe valves with a long stroke are ideal for control tasks, as they are capable of precise regulation for different type of liquids under varying conditions. Also diaphragm or ball valves are used for flow regulation.

The amount of data generated by different actors and sensors within a filtration system is growing fast with increasing control demand. Subsystems could help to reduce data processing tasks in the local PLC or superior control. E.g. valves with integrated process controller and connected flow sensor are able to act as decentralized control loop for liquid flow, just with a given set value from the PLC.



Graph 2: Example for a subsystem flow control

Companies like GEMÜ can deliver the wide range of different valves including connectivity and control functionality, which is needed to build state-of-the-art membrane filtration systems. An example would be a globe valve in combination with the intelligent positioner and process controller GEMÜ 1436 cPos. Such solutions are prepared for the future control of micro- and ultrafiltration systems.

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