

DEAD-END ULTRA-FILTRATION

Membrane technology for optimized hygiene and economical water treatment

In the past years, it has become clear that drinking water deserves increasingly attention because it is a decisive and the most important raw material and auxiliary agent in terms of quantity for the beverage industry. Drinking water is remarkable for the hygienic and safety standards as well as for its costs. Membrane technologies can make significant contributions to both topics in water treatment in the beverage industry. The following two examples are to demonstrate the manifold applications: improvement of microbiological safety standards of water without the use of chemicals and reduction of costs for water softening/desalination.

Drinking water is microbiologically harmless – this was and is still true today to a large extent. However, again and again there are exemptions from this rule in the daily papers. This is also due to the emergence of new and partly pathogenic germs which cannot be completely removed by the current sterilisation methods that are used for the treatment of drinking water.

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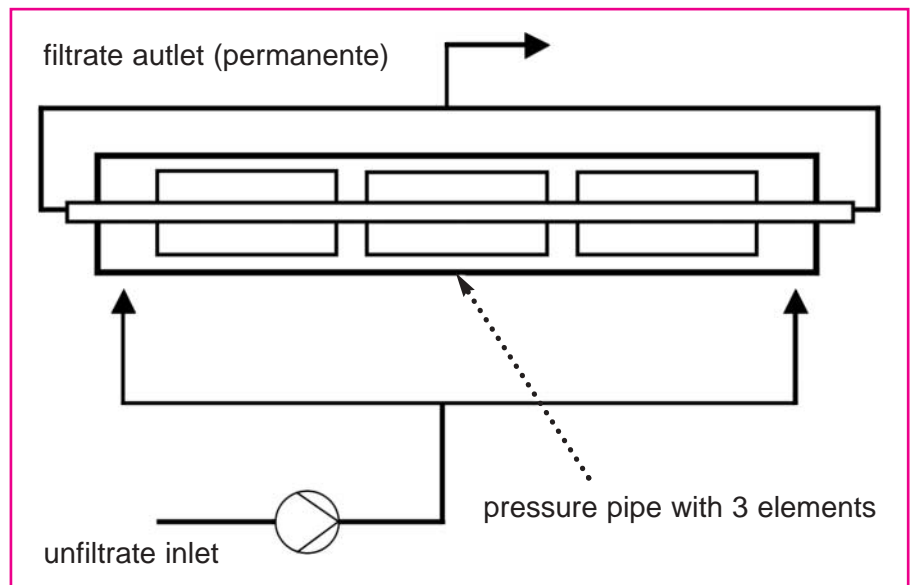


Fig 1: Principle of dead-end operation.

Stubborn Cryptosporidia

Epidemics of infectious diseases are commonly triggered by bacteria, viruses, protozoa and parasites. In 1993, for instance, 400,000 people in Milwaukee were infected with *Cryptosporidium parvum* whose oocytes are extremely resistant to chlorine [1]. Literature even shows that a safe inactivation of *Cryptosporidia* by chloride-based disinfectants is not possible under the German legal requirements [2]. The German Federal Environmental Agency assumes that only one to ten *Cryptosporidium* oocytes can trigger diarrhoea diseases [3].

Improved filtration method

Therefore, the beverage industry has to find possible countermeasures for the hygiene safety. A safe conventional method, however unreasonable for technical applications, is to sterilise the water by boiling. Possible, however not yet completely examined, is the UV sterilisation as an alternative

to chemical disinfection in the inlet to critical points of usage. Here, however, arises the question of verification of the success of disinfection which furthermore depends strongly on a possible sludge contamination of the water.

What remains is mechanical separation, i.e. filtration. Often membrane filter candles with a cut-off of 0.1 μm to 0.2 μm are used. The problem of this process are the required cost-benefit calculations: an improved retention leads to disproportionately increasing costs for filter media.

This problem can be solved by changing the used filtration method: instead of gradually minimising the pore size in microfiltration it is necessary to achieve considerably higher separating capacities: towards dead-end ultra-filtration. Thus, several problems can be solved simultaneously:

- Removal of all particles and suspended matter exceeding a molecular weight of about 250,000 Dalton (that equals roughly a cut-off of 0.01 μm)

- Reduced membrane locking as most particular and microbiological contamination in the drinking water is greater. Thus, these particles are separated on the membrane surface and not in the depth of the membrane structure.
- A much better separation of viruses
- No chemical dosage gets into the used drinking water
- If necessary, a combination process allows for a simultaneous water deferrisation as the flaked ferrous hydroxide is separated in one step with the other sludge.

The process is relatively simple to carry out. The use in the treatment of drinking water out of surface water is therefore already carried out on a grand scale, that means in production units of several thousand m³/h. For hygiene-critical applications in the beverage industry, capacities of 10 to 40 m³/h are absolutely sufficient in this extensive treatment of drinking water. As far as well water is concerned, especially that from areas which are intensively used for agriculture, it is recommendable to purify the entire water flow, especially in order to remove particles and suspended matter which favour the formation of biofilms in drinking water networks.

Dead-end operation

In the dead-end operation the unfiltrate is not pumped through the cycle as with the traditional cross-flow filtration process, but it is directly pumped from the concentration side to the permeate side without circulation (Fig 1). Depending on the plant size several modules are connected in series and parallel. As the sludge concentration increases during filtration and thus the difference in pressure between the unfiltrate and the filtrate, the concentrate is periodically discharged and the membranes are backflushed with filtered water from the filtration side.

The dead-end operation has two advantages. It requires a low energy input of about only 0.2 kWh/m³ of filtered water and it is simple to automate. Depending on the operational situation, the treatment of water can, moreover, be simplified. Sand filters may no longer be necessary and activated



Fig 2: Capillary membranes.

carbon filters may be relieved. The execution of the membrane modulus with inserted capillaries ensures an unobjectionable and checkable separation of unfiltrate and filtrate.

A further increase in separation capacity towards nanofiltration or reverse osmoses with a cut-off of between 50 to 1000 Dalton is only useful if there are traces of pesticides or insecticides in the raw water or if a softening step is to be integrated.

Optimisation of water softening/desalination

An important aspect, apart from product safety, are the costs of water purification processes. An objective is therefore the optimisation of water softening/desalination via reverse osmosis.

For a long time, a standard value for the possible permeate yield of reverse osmosis plants was considered to be at a value of 75 to 80 per cent of the used raw water. For a brewery with an output of 500,000 hl p.a. and a consumption of softened water of 0.3 m³/hl the wastewater would amount to 30,000 to 37,500 m³ per year. With (low) estimated costs of 2 €/m³ this would result in sewage costs of between 60,000 and 70,000 € per year. There are two ways to reduce this cost pool considerably: If there is already a plant in operation, a further unit can be connected to the outlet side. This unit can process the concentrate again with a yield of 70 to 75 per cent by specifically making use of the water-chemical conditions. The amount of sewage arising from the purification of water is thus being reduced to less than 10,000 m³ per year. The required plant will be

amortised over less than two years. The basic concept of this plant circuit is shown in figure 3.

Instead of retrofitting an existing plant a second concentration step can be provided in advance when new projects are planned. This way, there are advantages in terms of automation, the use of CIP facilities and the required space. The specific use of partly oversaturated concentrates leads, of course, to a faster scaling on the membranes. The process control must therefore ensure that the ratio between concentrate and permeate which is essential for an optimal operation remains constant and that the scaling rate always meets the guidelines of the project work. For the same reason it is of essential importance to integrate a CIP station by which certain cleaning steps are triggered off and controlled according to plant capacity.

As experience has shown, such a plant can be operated over years without problems (and without having to replace the membrane) with very high yields. Taking into

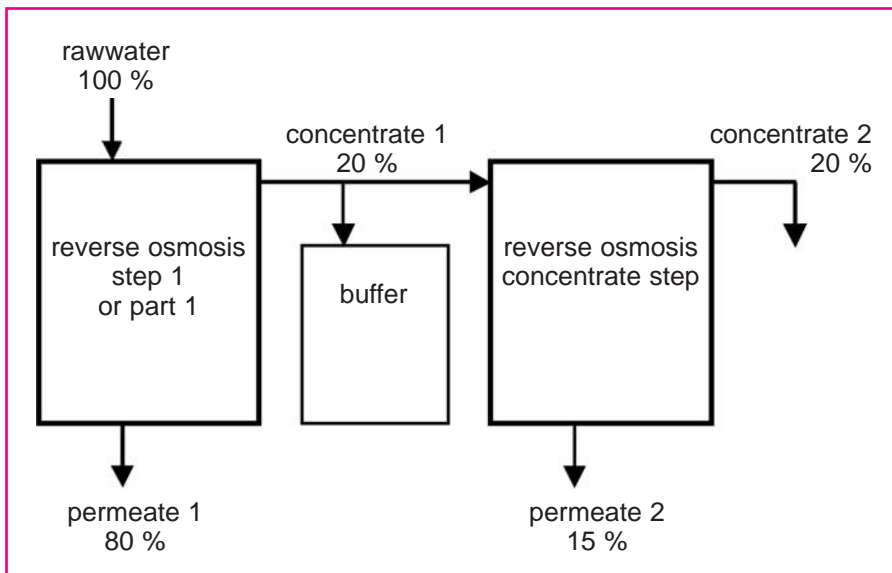


Fig 3: Diagram of a reverse osmosis plant.

account the calculated membrane replace, the costs for cleansing agents and depreciation the achieved cost savings amount to more than 30,000 € per year:

- Depreciation and payment of interest ca. 11,200 € per year
- Calculated membrane replace ca. 4,000 € per year
- Cleansing agents, anti-scaling agents ca. 2,000 € per year
- Total expenditure 17,200 € per year
- Reduction of sewage costs ca. 48,000 € per year
- Cost savings ca. 30,800 € per year

Conclusion

Two examples show the range of application of modern membrane filtration methods in the brewing and beverage industry: the improvement of water hygiene with the separation of pathogenic microorganisms like Cryptosporidia via dead-end ultra-filtration and the reduction of water purification costs by means of an individual and special reverse osmosis with repayment periods of below two years. □

Literature

- [1] Köster, W.; Egli, T.; Rust, A.: Krankheitserreger im (Trink-)Wasser?; EAWAG News 53
- [2] Rohmann, U.; Rödelsperger, M.; <http://www.tzw.de/pages/projekte/proj008.htm>
- [3] Empfehlung des Umweltbundesamtes in einem Brief an den DVGW e.V.; Geschäftszeichen II 4.6 A-53/01 (Recommendation of the German Federal Environmental Agency in a letter to the German Technical and Scientific Association on Gas and Water)