"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2012
Brasov, 24-26 May 2012

MEMBRANES PROCESSES USED IN BEER FILTRATION

Mariana Geta TOMESCU (cas. Cismarescu)*, Carol CSATLOS**

*Faculty of Food and Tourism, "Transilvania" University of Braşov, Braşov, Romania
** Faculty of Food and Tourism, "Transilvania" University of Braşov, Braşov, Romania

Abstract: *The purpose of this paper is to demonstrate that the membranes and separation process through membranes are used considerably in industrial processes, because there are much more efficiency and more economic than conventional tehnics. Separation processes through membranes are neconventional technologies names „clean technologies" and there are regarded as technologies of the future.*

Keywords: *filtration, membrane, microfilters, nanofilters, cross-flow.*

1. INTRODUCTION

The purpose of filtration is to make beer so stable that no visible changes occur for a long time and so the beer looks the same as when it was made.
Filtration is a process in which a turbid liquid (unfiltered liquid) is separated by a filter into a clear filtrate and a filtered residue or filter cake is left behind. The driving force for this is always a pressure difference between the filter inlet and filter outlet. The pressure at the inlet side is always greater than the pressure at the outlet side. The greater the pressure difference the greater the resistance with which the filter opposes filtration. It rises greatly towards the end of filtration.

2. SEPARATION MECHANISMS

Filtration is a separation process in which the yeast cells and other turbidity-causing materials still present in the beer are removed from the beer. At the same time substances are removed which would, in the course of the next few weeks or months, themselves precipitate and make the beer turbid.
A distinction is made between the following separation mechanisms (Fig.1):

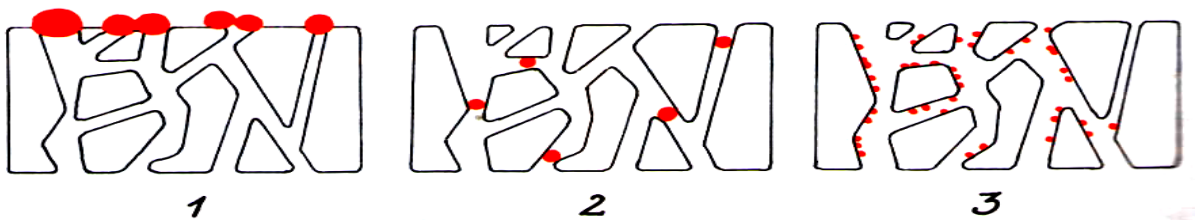

Fig.1: Filtration mechanisms
1- surface filtration; 2 depth filtration (particles are retained mechanically); 3- depth filtration with adsorption of particles

Sieving or surface filtration (1) - the particles cannot pass through the pores in the filter medium and are retained in a layer which becomes continuously thicker.
The filtration becomes increasingly fine but the volume flowing through decreases continuously.

Cross-flow filtration belongs to this type of filtration. It is discussed in more detail later.
Depth filtration -increasingly, separation media are being used which consist of very porous materials and which as a result of their very large surface and labyrinthine structure compel the liquid to take a very circuitous path.
- The particles are thereby held back by a mechanical sieving effect because of their size. They gradually block the pores (2)and thereby decrease the flowrate through the filter, or
- Fine particles are fixed by adsorption (3). This adsorption occurs because of differ ences in electrical charges between the filter and the material retained. Sieving and adsorption effects usually occur together.

2.1. Filters

Filters include**:**
- **Sieves** of all kinds, e.g. metal sieves, slotted sieves or parallel arrangements of wedge wire in candle filters.
Metal or cloth tissues-they are, however, not used for beer filtration because they can not be sterilized so well.
- **Filter sheets** made of cellulose, cotton, kieselguhr, perlite, glass fibres or other materials (asbestos, however, is no longer used on health safety grounds). Filter sheets are now very widely used and are available for very different filtration cut off limits down to sterile filtration.
- **Membranes**. These are made of polyurethane, polyacrylate, polyamide, polyethylene, polycarbonate, cellulose acetate and other substances. The membranes are very thin (0,02 to 1 μm) and are therefore applied on large-pored support layers because they would otherwise tear. They are manufactured by impregnation, spraying or deposition. The pores themselves are made: by incorporating

salts which are later dissolved out again to form pores, or by etching. Because of the different manufacturing materials, nowadays membranes with any desired pore size can be made and they can correspondingly filter out materials of any chosen molecular size because these filters contain very fine pores, one speaks of:
- microfilters when the μm range is concerned (10^{-1} to 10^{2} μm) and of;
- ultrafilters or nanofilters when the nm range is concerned (10^{-3} to 10^{-1} μm).

Fig.2. shows the size ranges of particles and pores which must be dealt with here. It must be remembered that each division covers a range only one tenth that of the division to its right. Thus these membranes contain very fine pores. Naturally, beer can not be passed, as in static filtration, at right angels throught these thin layers because:
- the membrane rapidly becomes coated and,
- the pressures difference would tear the thin membrane.

Consequently the beer is passed over the membrane and washes it continuously so that only a very limited layer can build up. Microorganisms and impurities remain behind as retentate or non-filtrate, whilst the permeat or filtrate passes through the pores of the membrane. This type of filtration is called cross-flow filtration. Because only part of the liquid passes through the holes in the membrane and a very large part flows along the membrane, a very large membrane surface area is needed.

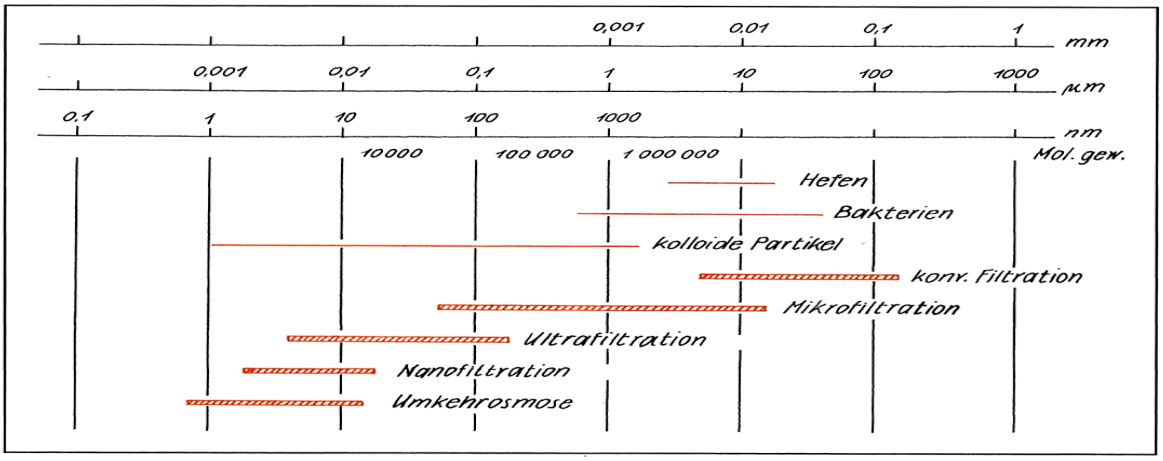

Fig. 2. Particle and filter pore size ranges

So as not to have to work with such large filter surfaces, the membranes are usually coiled. For this two membranes, bound together by porous supporting material, about 0,7 mm thick and stuck together on three sides, with an (0,5 mm) intermediate layer as spacer, are rolled up. Such a rolled combination of membranes, supporting material and intermediate layer is know as a spirally wound module (fig.3.)

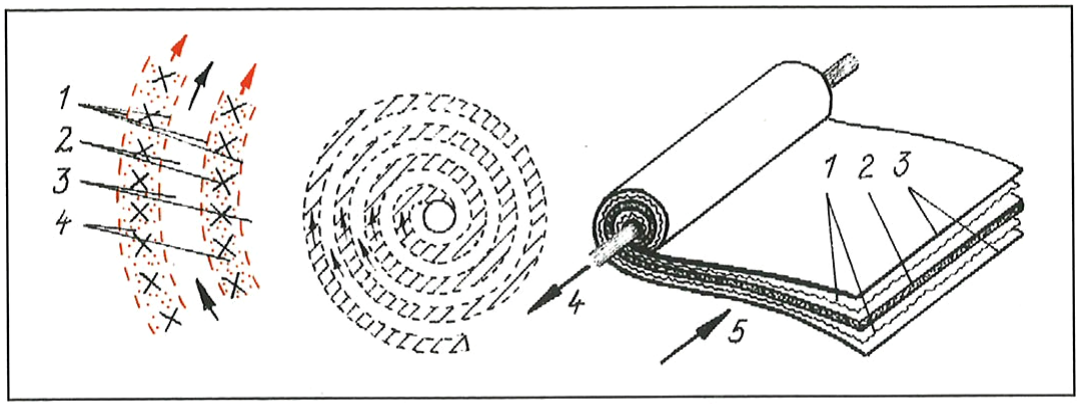

Fig.3: Spirally wound module (principle)
1-membrane; 2- porous support material; 3- intermediate layer as a spacer through which the unfiltered liquid flows; 4- nitrate outflow.

To increase the throughput of the filter several of these modules must be connected in parallel.
A micro-flow filtration unit therefore always consists of a series of such modules. A special type of membrane is the hollow fibre membrane.

The membranes have wall thicknesses of 10 to 25 μm, a diameter of 50 to 200 μm and are up to 3 m long. Hollow fibres can only be used with completely clean liquids because they are easily blocked.
Hollow fibres will be considered again when describing the dialysis process for the

production of alcohol free beer. Hollow fibre modules, which can be linear or U-shaped, make it possible to provide 20,000 m^2 of membrane surface/m^3 space.
Instead of membranes, ceramic material with very fine channels are often used for microfiltration (Fig. 4.).

In the case of the multi-channel element module shown it can be seen that each channel is surrounded by ceramic material containing very fine pores, on the fineness of which the sharpness of filtration naturally depends. Using a parallel connection of many elements and modules large throughputs can be obtained.

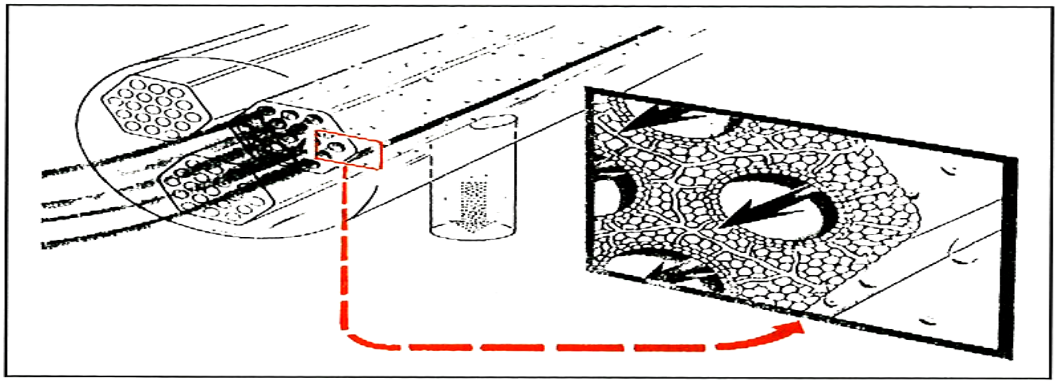

Fig. 4 Tangential flow filtration

2.2. Cross-flow filters

The delicate membranes are manufactured and used on a porous support layer to increase their mechanical stability. These membranes are used in a cross-flow process in which the liquid to be filtered is passed under pressure over the fine pore membrane. Some of the liquid passes through the membrane and all particles are thereby removed from it. The remainder of the liquid, the retentate or concentrate, which is now enriched in trub material is left behind and is led away.
But since the retentate still contains a large amount of the liquid wich can still be filtered out, the liquid is now recirculated (Fig.5).

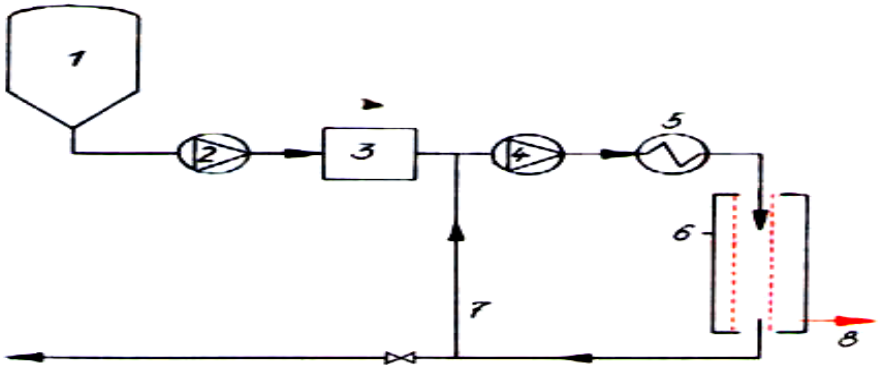

Fig. 5. Cross-flow filter (operating principle)
1- buffer storage tank; 2-feedpump; 3-prefilter; 4-circulation pump; 5- heat exchanger; 6-membrane filter; 7-circulation pipes; 8-filtrate outlet pipe.

This process necessitates a circulation pump to maintain the circulation, and a plate cooler since the use of pressure warms the liquid. In the course of filtration the surface of the membrane gradually becomes blocked (Fig.6).

Filtration must then be interrupted and the surface of the membrane first rinsed with water and then treated with warm nitric acid or caustic. From this it should be clear that, as a rule, a membrane filter is installed as the final

filter so that premature blocking of the filter surface is prevented.

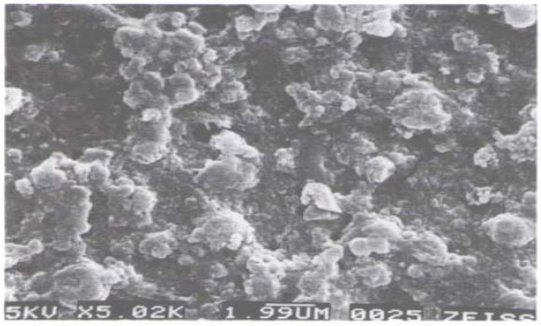

Fig.6. Particulate material deposited on the membrane surface

For prefiltration kieselguhr is almost always used. However, because of its cost and, increasingly, in many countries because of the increasing costs of disposal of the used guhr, use of kieselguhr is becoming less desirable. Recently therefore there have been more and more attempts to find replacements for kieselguhr prefiltration.

In the first place yeast removal by separators is possible. By parallel connection of several separators it is possible to obtain good preclarification of the beer and this can be followed by a further fine filtration using a module or cartridge filter.

Recently a combination of separator and cross-flow filtration has been suggested for clarification (Fig.7). The unfiltered beer (1) is here preclarified by a high performance separator (2)and the preclarified beer is conveyed by a frequency controlled feed pump (3) to tne membrane filter which performs the clarification. In this way it is possible to avoid the use of kieselguhr and also problems with its disposal.

Another possibility is to replace the kieselguhr by a filtration mass which can be regenerated consisting of cellulose, fibrils and fibres of various plastics and PVPP .

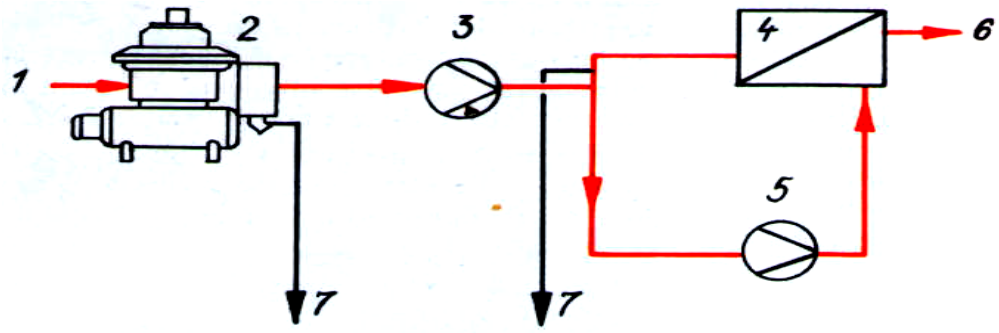

Fig.7: Combined preclarification separator and microflow filter
1-supply of unfiltered beer; 2- high performance separator; 3-frequency regulated feed pump; 4- microflow filter; 5-circulation pump; 6-filtered beer; 7- discharge.

3. CONCLUSIONS

Membrane filters are used nowadays for reverse osmosis for water purification and the production of low alcohol beers, as dialysis filters for the manufacture of low alcohol beers, as microfilters for the recovery of beer from yeast, and rarely for the final filtration of beers. The main advantage of the membrane processes is ability to separate and concentrate thermolabil compounds.

REFERENCES

1. Banu C., [2006], *Tratat de industrie alimentara*, Bucuresti, Editura ASAB.
2. Banu C., et.al.(1992), *Progrese tehnice tehnologice in industria alimentara,* Bucuresti, Ed. Tehnica.
3. Wolfgang, K., [1996],*Technology brewing and malting*, Berlin, VLB Berlin.