Beneficial system for beer recovery

A white paper on GEA **rotoramic**

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1. Introduction

Sustainability is now a universal process criterion. The brewery industry is also intensively concerned with conserving natural resources and launching green products, with a high level of environmental responsibility. Cost saving is also a big issue in breweries, leading to the constant exploration of new technologies in order to increase the efficiency of the processes.

The main reason for installing a beer recovery system is to improve cost-effectiveness. Nevertheless, the beer quality will always remain most important feature for the brewer.

If a brewery has an annual output of 1M hl , the annual volume in the tank bottoms is around 4 %, or 40,000 hl. Approximately 50 % of the volume can be recovered as beer, so assuming a value of approximately EUR 10 per hl, every year it is possible to generate an additional EUR 200,000.

The ceramic membranes form the centrepiece of this cross-flow filtration. The material is absolutely food-neutral and can be regenerated again at any time in the filtration system. The service life of the membrane is at least 10 years. The result: purest beer quality – brewed in a way that is sustainable and reduces costs. The following report considers the technical background and explains the basic principles and features of the process.

2. Principles of cross-flow filtration using ceramic discs

In cross-flow filtration the feed is passed across the filter membrane tangentially. It has to have a positive pressure relative to the permeate side. The material, which is smaller than the pore size, passes through the membrane as filtrate, the rest is retained on the feed side as retentate. A turbulent flow at the membrane surface creates shear forces which help to avoid fouling of the membrane. The advantage keeps the pressure low and helps to save more energy compared to traditional filtration methods.

2.1. Ceramic discs

Advantages of ceramic membranes in cross-flow filtration:

- Completely inert material
- Freedom to choose the right pore size for an optimum filtration
- Operationally safe
- Long life time of the ceramic membranes
- High temperature range (135 °C), can be sterilised with steam
- High mechanical stability
- Very good cleanability
- Full pH range 0 – 14
- Standard cleaning agents: NaOH, NHO3 and booster
- Cleaning times approximately two hours
- Higher flux rates compared to tubular membranes
- Acid and base-resistant, solvent-resistant
- Can be regenerated
- Wear-resistant
- Robust against pressure and temperature
- Constant flux rate of filtrate over the complete lifetime cycle

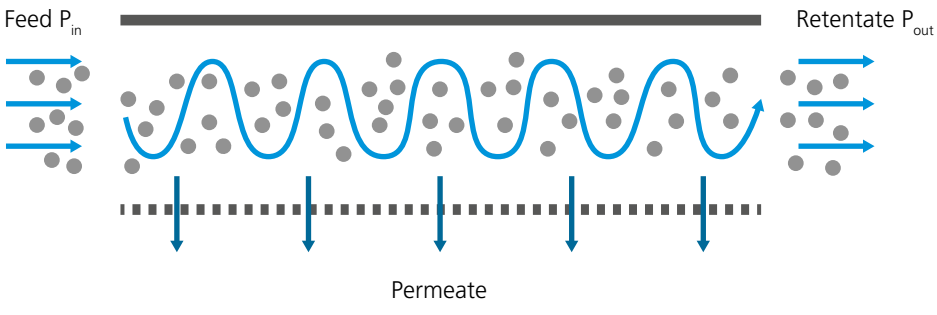

Figure 1 – Principle of cross-flow filtration

2.2 Manufacture and characteristics of ceramic membranes

The ceramic discs, which are the core components of GEA **rotoramic** are produced by GEA. GEA ceramic discs are sintered as a single part. The requirement for maximum mechanical and chemical stability with minimum flow resistance has been met by using a substrate with a macroporous structure made of pure aluminium oxide(α-AI_2O_3). A flat surface ensures low vibrations and long lifetimes for use in a rotating system.

At the final sintering temperature of approximately. 1800 °C the aluminium oxide crystals begin to fuse together and form the solid and stable ceramic disc. The now porous base body has a pore size of between 10 and 15 µm. The final pore size is sintered on the outside of the discs and available in sizes from 20 nm to 1.4 µm.

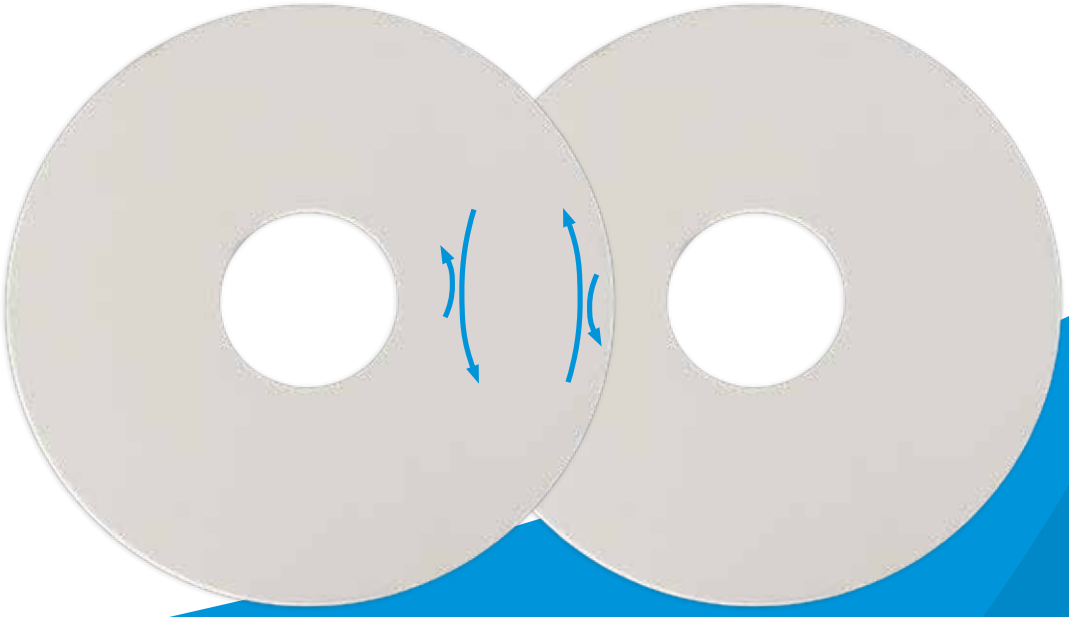

Figure 2 – Overlapping of the rotating ceramic discs

Ceramic membranes are standard in yeast beer recovery as well as fruit juice filtration. The oldest systems for yeast beer recovery have been in use for over 20 years with the first set of membranes. Because of their extreme durability, ceramic membranes can be cleaned at high temperatures and with aggressive chemicals, while the initial installation condition can be reproduced over and over again. Furthermore, expensive enzymatic cleaners can be compensated for with high caustic temperatures. Sodium hypochlorite or peroxide is used as the oxidative component for cleaning.

2.3 GEA **rotoramic** – the multishaft filter

The ceramic discs are mounted on two hollow shafts which rotate in the same direction. Shear effects between the discs, on the surface where the discs overlap help to prevent fouling.

Spacers and gaskets between the discs maintain the correct distance and prevent a mixing of filtrate and unfiltrate. The rotation speed of the shafts is creating the cross-flow speed. This filter unit is assembled in a housing, e.g. a tank.

The high quality construction of the membrane to the usual GEA standards reliably connects the components with a 100 % seal. Particular attention has been paid to the rules of hygienic design which are of utter importance when flow speeds are low as specified here.

Figure 3 – Filtration unit with two shafts

3. Layout of the GEA rotoramic for beer recovery

The GEA **rotoramic** filtration unit is mounted in a tank (see Figure 4)

Typically, the filtration unit is fed by a screw pump due to the high viscosity of the yeast. As soon as the filling process starts the discs start rotating. The pressure, which is necessary for the filtration, comes from the feed pump. To maintain the capacity, the filtrate outlet is controlled by a regulating valve.

During filtration, the concentration of the retentate also increases as a result of the torque of the shaft. There are two options to prevent the shafts sticking:

1. Fresh yeast (with a lower percentage volume needs to be fed constantly. The retentate also needs to be constantly transported back to the feed tank.
2. Instead of fresh yeast it is also possible to feed degassed water. The effect of reducing the concentration is much higher than with the fresh yeast. In this case, the extract will also be diluted.

To increase the yield, it is recommended to perform a diafiltration before emptying the unit and starting a CIP. Diafiltration is limited, depending on the dilution limit set by the brewery. Due to lower concentration in the losses, it also increases the yield from yeast washing/alcohol extraction.

The filtration pressure is stated as transmembranepressure (TMP), this value is calculated by subtracting the pressure in the tank and the pressure of the filtrate site. Unlike traditional cross-flow filtration, the transmembrane pressure is very low and does not cause stress to the yeast cells.

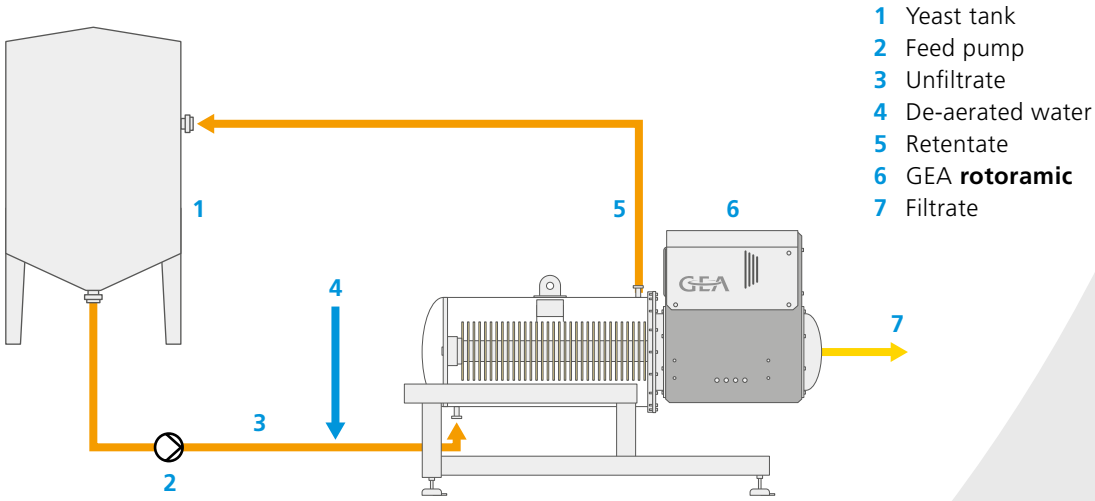

*Figure 4 – Flow chart of the GEA **rotoramic** beer recovery*

4. Use of ceramic membranes in beer recovery

The quality of beer recovery is only as good as the yeast supplied from storage. With suitable preparation of the tank bottom yeast, beer recovery with GEA **rotoramic** can be optimised in terms of production and cost:

- Maximum storage period 48 h, better 24 h
- Maximum of 4°C

This helps to maintain the quality of the recovered beer. The beer can never be better than the surplus yeast it comes from.

4.1 Work sequence of cross-flow filtration

Work sequence:

- The cleaned system is filled with de-aerated water and emptied under CO_2 pressure
- The discs starts rotating and the control valve starts the flow of filtrate
- As soon as a specific torque is reached, the product will be diluted by new product or de-aereted water
- After the batch is finished or a predefined TMP has been reached, the system will shut down
- In the case of a shutdown, the system empties the retentate and starts by flushing for the CIP.

4.2 Cleaning sequence

During flushing, foam residues and the retentate are rinsed out and the system temperature is set to the range of the caustic solution temperature in the stack tank. The temperature should jump by no more than 20 K in the case of a change of medium. For the caustic cleaning booster, a 2 % caustic

soda solution is used at a temperature of at least 85 °C. The rinsing water accrued can be collected. It is then neutralised with acid, the system is rinsed, and the temperature is set. The cleaning takes around 2.5 h. Following the CIP, the pressure resistance of the elements can be checked with water under standardised conditions (temperature, flux, cross-flow) and the success of the cleaning can thus be determined.

4.3 Protecting against membrane breakage

If it ever happens, membrane breakage is a drastic event; with ceramic membranes membrane breakage can be virtually eliminated. This can be monitored using an in-line measurement of turbidity.

5. Product Result

Trials of GEA **rotoramic** in various breweries show (see Figure 3) a constant recovered beer flow is possible with a simultaneous low transmembrane pressure (TMP). This ensures the product is subjected to low forces.

Figure 6 shows the increasing torque and the discharge of the concentrated yeast due to the increasing concentration of the yeast in the tank. At the same time, dilution by adding new yeast can take place. Another option is to dilute using degassed water.

Compared to the traditional cross-flow filtration, the energy consumption is really low. The cross-flow is created by rotation of the discs and not by pumping the product (see Figure 7).

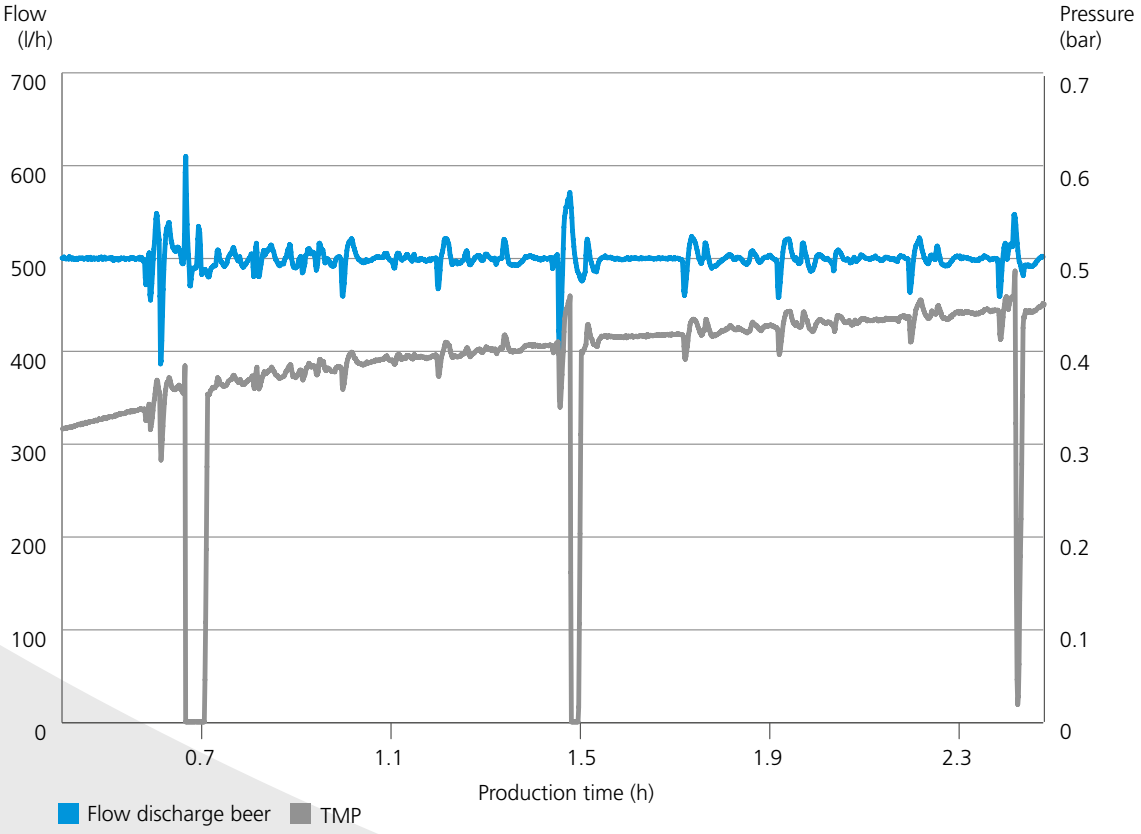

Figure 5 – Flow and pressure in relation to production time

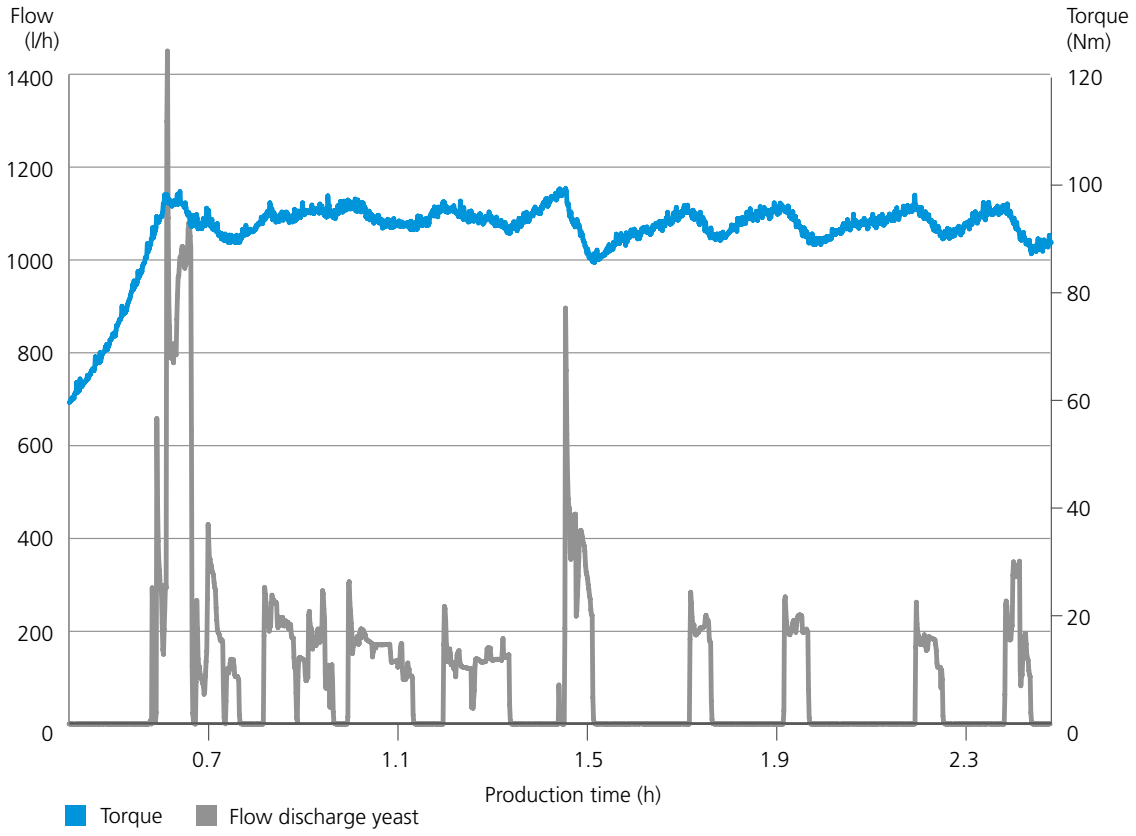

Figure 6 – The effect of torque on the discharge flow of yeast

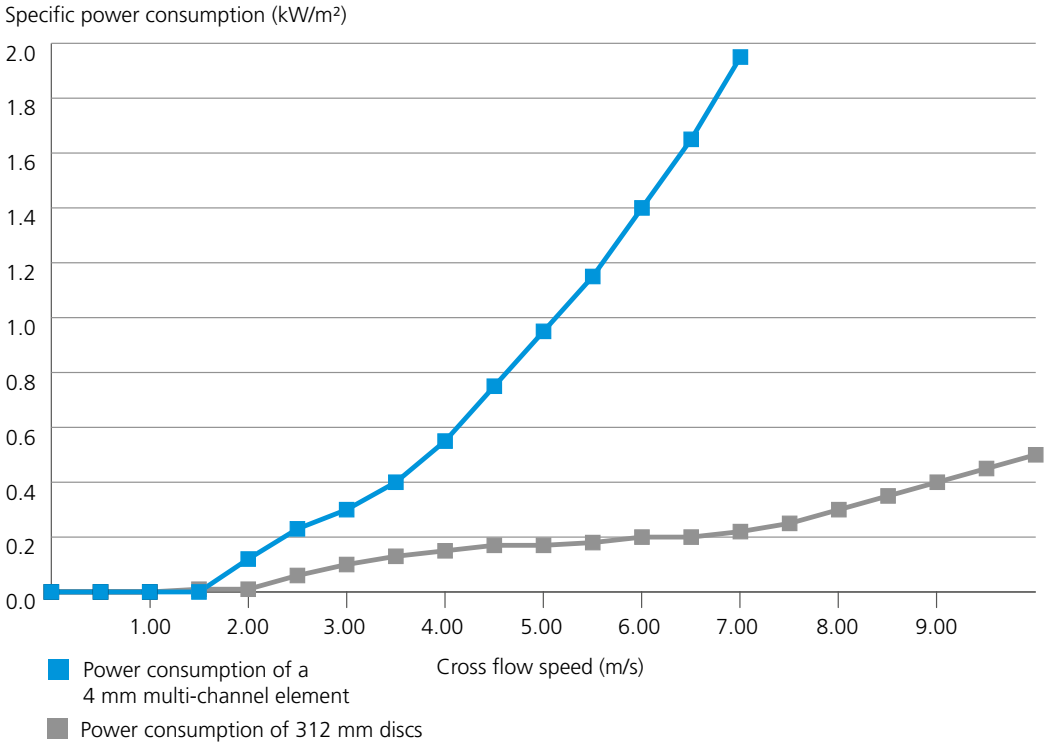

Figure 7 – Comparison of energy consumption

6. Summary

The GEA **rotoramic** filtration unit is a very simple and easy system to control. The special design enables us to run the system at low TMP values even at high viscosities. Compared to traditional cross-flow filtration, cross-flow filtration with ceramic discs requires four times less energy. This is because the ceramic membrane is rotated instead of the product. As a result, this system has a really low stress effect on the product.

A small unit volume also means lower CIP consumption and lower CIP costs.
The process of beer recovery is also reducing the amount of waste water in a brewery. Ceramic membranes are food-neutral, so there is no risk of contamination of the product. A modern design keeps the oxygen pick-up to a minimum level.

The recovered beer by GEA **rotoramic** is yeast free and depending on the yeast management it has a good quality. A good yeast management is the foundation for beer recovery.

GEA: proven partner to the brewing industry

Breweries have been working with equipment from GEA and plant planned by GEA for over 100 years. Worldwide, every second litre of beer flows through GEA components.

Beer is one of the most multifaceted consumables created by human society. Unlike wine, the taste of which is dependent not least on the climatic conditions of the respective vintage, the beer consumer expects their preferred brand to always taste exactly the same. Consistent quality down to the finest flavour nuances is therefore the principal aim of such production. To permanently guarantee this stability, breweries all over the world have been working with equipment and technologies from GEA for generations.

GEA is one of the largest suppliers of process technology and components for the food and energy industries. As an international technology group, the company focuses on sophisticated production processes. Based on its decades of experience, the company has acquired great brewery expertise, which is equally valued by regional craft breweries and by large industrial business of world famous brands.

The mature process technology of the company, innovations in equipment technology and customised solutions make significant contributions to achieving an economic process and consistently high product quality.

GEA **rotoramic** seamlessly continues this series of innovations:
Ceramic membranes are already well known in the food industry.

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GEA is a global technology company with multi-billion euro sales operations in more than 50 countries. Founded in 1881 the company is one of the largest providers of innovative equipment and process technology. GEA is listed in the STOXX® Europe 600 Index. In addition, the company is included in selected MSCI Global Sustainability Indexes.

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