Filtration in the brewery (Part 1): an overview

HIGHEST BEER QUALITY | Modern process engineering and automation are optimizing processes in the breweries. When it comes to quality, taste and beer shelf life, it pays to take a closer look at filtration, as it has a major impact on the entire brewing process. This is the first of a five-part series on the filtration process in the breweries. We start with an overview of the process steps before covering the topics of clarification and trap filtration, fine filtration, and membrane filtration in detail in the following parts. The series will conclude with special filtration solutions for craft beer production.

TODAY, beer production is very different from the handcrafted image of 100 years ago. Brewing beer is a highly technical food process shaped by standardized procedures, automation and process optimization.

Filtration, in combination with stabilization, plays a crucial role in the quality management of premium beers. Employed at different stages of the brewing process, filtration is important for the quality of the beer as well as its preservation. It removes beer-spoiling microorganisms and turbidity and lays the foundation for professional stabilization that is adapted to the process. For end consumers, this results in practical benefits, primarily in the form of extended shelf life combined with a full-bodied taste. For manufacturers, consistent high quality, time and cost advantages through simplified logistics and flexibility are added in sales.

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Process optimization in the filtration cellar

After the young beer has matured, various filtration methods and optional stabilization techniques are used at different stages of the process. In detail, these include:

- Centrifuge (optional);
- Clarifying and precoat filtration, or crossflow filtration;
- Trap, fine and microbial removal filtration;
- Alternative stabilization;
- Fine and microbial removal filtration;
- Membrane filtration or flash pasteurization (HTST) before bottling.

The first step in the multistage filtration process usually involves the use of a centrifuge to remove yeast and other particles causing turbidity from the young beer once it has matured. The remaining finer particles and yeast are filtered out of the beer during the next step as part of the clarifying and precoat filtration process, or alternatively, the crossflow method. Optionally during this phase, initial steps can be taken to stabilize proteins and phenols. Otherwise, this step is done just before bottling.

To achieve a high level of purity, it is important to perform a further filtration step for particle reduction after each stabilization process. This is usually performed using filter cartridges. The retention rates of the filter media become finer and finer from filtration step to filtration step to remove any kind of turbidity and undesirable microorganisms. This also stabilizes the beer against microbiological aging processes. The final step in the process is membrane filtration. Membrane filter cartridges developed specifically for the brewery industry are used to remove the last remaining microorganisms that could spoil the beer. This is done right before bottling to obtain the longest shelf life as possible with high quality.

Alternatively, the HTST method can be used to kill off microorganisms. However, this increases the system's energy require-

Fig. 1 The membrane in the filter cartridge has been designed specifically for beer filtration and features an asymmetric design to reliably remove microorganisms

Photo: Eaton

ment and can result in slight changes to the color and taste, potentially making a final trap filtration step necessary before bottling.

Three methods, one objective: premium-quality beer

While the individual process steps on the way to filtered, stabilized beer are generally the same in most breweries, the methods used in the filtration process differ. Essentially, there are three methods commonly found on the market that improve the beer quality and guarantee the longest possible shelf life: classic beer filtration (precoat filtration), crossflow filtration and 1- or 2-step depth filtration without diatomaceous earth.

The process chosen depends on the needs of the system operator and the profile of the brewery. Those with more expertise of the process knowledge may end up with differing results than operators with a strong desire for automation. Investment and operation costs can also play a critical role, along with the purchase itself. Breweries must factor in maintenance costs, as well as water and energy consumption.

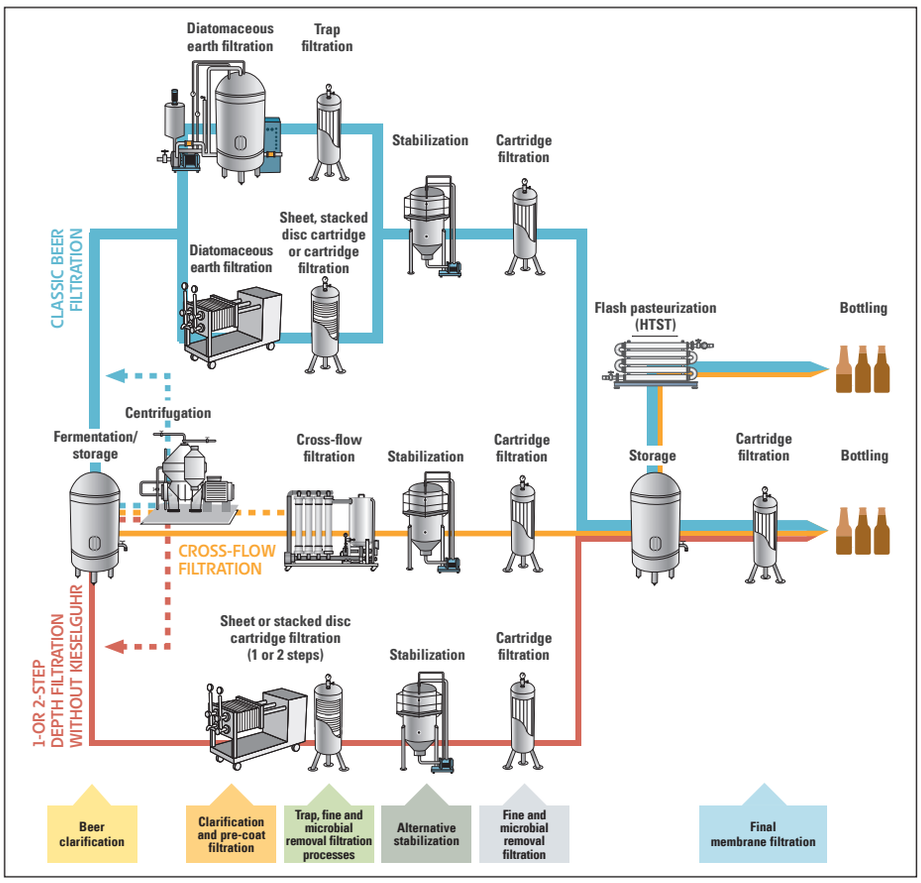

Fig. 2 The process steps of the three most common production methods in beer production
Photo: Eaton

Precoat filtration

The classic beer filtration method is precoat filtration. This process uses natural filter aids such as diatomaceous earth, perlite and cellulose as precoating material. First, they are deposited on a rather coarse sifter so that a fine filter cake is formed. The beer then passes through, and suspended solids such as yeast residue are filtered out.

Precoat filtration using diatomaceous earth has been a tried and tested process in breweries for decades. This process is well established. The choice of filtration systems and media available on the market is vast. Any changes are rather minor, such as reduced water consumption or extended filter media service life – key factors in the brewing process. The particularly gentle filtration process helps to ensure that valuable ingredients, colour and flavours are very well retained.

To secure the high filtration quality needed, precoat filtration is followed by microbial-reducing depth filtration using filter sheets, stacked disc cartridges or filter cartridges. Trap filtration is another method growing in popularity due to the rising requirements for efficient processes. It has been used in brewing for some time and is being utilized more now, due to changes in specification profiles. Trap filtration is ideal for breweries that use other technical aids for filtration. Aside from diatomaceous earth, these also include the stabilization agent polyvinylpolypyrrolidone (PVPP). This filtration method ensures that the filter aids are safely removed again after use.

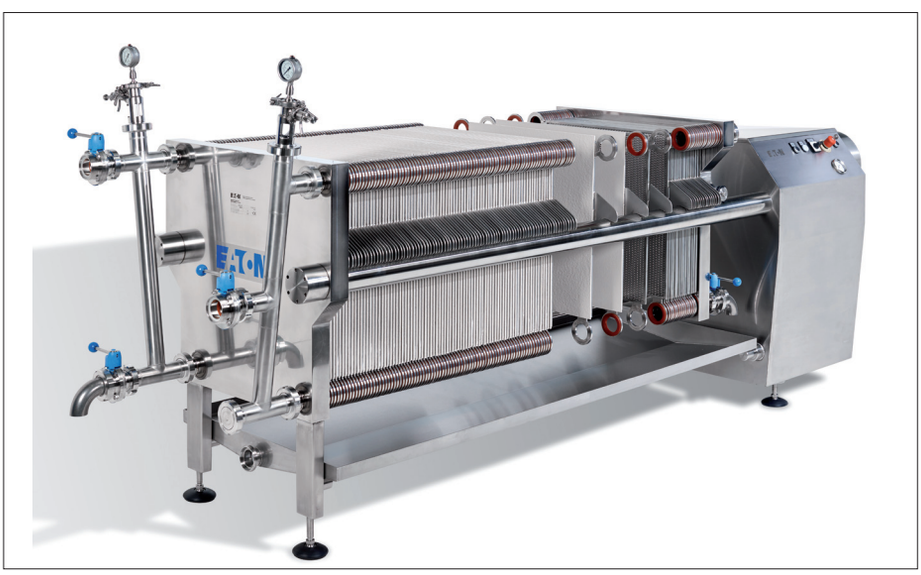

Fig. 3 During classic precoat filtration, plate and frame filter provide a high degree of flexibility by simply adjusting the filter surface
Photo: Eaton

Crossflow filtration

Crossflow filtration was first used in breweries in the 1990s. Also known as tangential-flow filtration, it extensively avoids the formation of a filter cake. The beer to be filtered is transported in parallel to a membrane and the filtrate removed across the direction of

Fig. 4 During trap filtration, depth filter cartridges reliably remove particles *Photo: Eaton*

flow. In the unfiltrate cycle, the suspended particles, solids and insoluble solids to be removed accumulate. Regular rinsing and cleaning cycles are needed during filtration to prevent a cover layer forming on the membrane and an associated drop in performance. The frequency of these regenerations is based on the particle content in the unfiltered beer.

Originally, crossflow filtration was mainly popular with larger breweries and corporations with a very high annual output. The procedure is highly automated and, as a highly technical solution, enables remote operation and maintenance. Even the cleaning process for a crossflow filtration system can be performed fully automatically. In contrast, it comes with high investment costs and higher energy and water costs, as crossflow systems must be cleaned more frequently and for longer than other filtration systems. Breweries with high production volumes aiming for a high degree of automation, and not concerned about the costs and challenges of the technology, can benefit from a lower amount of work.

1- or 2-step depth filtration without diatomaceous earth

During sheet filtration after the centrifuge, depth filter sheets are placed between a variable number of plates, which have a feeding and a filtered side. The filtration mechanism combines mechanical and adsorptive removal. In the plate and frame filter, the depth filter sheets are pressed on hydraulically so that they seal each other. In addition to providing mechanical stability, modern cellulose depth filter sheets almost entirely eliminate drip losses. In the compact structure of a stacked disc cartridge, filter sheets can be used alternatively after the centrifuge.

To achieve the highest degree of clarity possible, depth filtration can be performed using filter sheets or stacked disc cartridges in two consecutive steps. During the first step, larger particles are initially removed from the beer. During the second step, much finer filter media are used to remove even the smallest harmful particles and microorganisms from the filtrate. Depth filter sheets made of high-purity cellulose are especially

ideal for this, as no mineral components are added.

For small or medium-sized breweries, it's recommended to use 1- or 2-step filtration depth filter sheets or stacked disc cartridges. This is a lower investment cost as it is a simple setup and straightforward operation. It has been an insider's tip for craft beer brewers for some time, and today is a favourite option. But even some large breweries successfully rely on the 2-step filtration process.

HTST or cold-sterile filtration

The recommended filtration method is primarily determined based on operational aspects, such as annual output and energy management. But the philosophy of the master brewer also plays a role. The same applies when it comes to the choice of performing HTST or cold-sterile filtration as the last step before bottling. Due to the growing significance of factors such as carbon footprint and energy consumption, breweries need to consider the advantages and disadvantages of each procedure regarding the consumption of resources and energy. The brewhouse already has a high thermal energy requirement. Until now, this has practically always been met with fossil fuels. Breweries wanting to save costs and cut carbon dioxide emissions can use cold-sterile filtration to reduce their thermal energy costs.

Fig. 5 Value-preserving premium depth filter sheets made of high-purity cellulose and stacked disc cartridges do not require any mineral components, even for microbial removal filtration *Photo: Eaton*

Another factor regarding costs and environmental sustainability is water. Water is required for cleaning and sterilization during membrane filtration. Initial approaches have already been made to capture process water, treat it and feed it back into the filtration cycle. This promotes environmental sustainability and reduces water consumption. In turn, it impacts energy costs. When in doubt, the ultimate deciding factor can be the costs of energy or water, based on the local circumstances.

Spoiled for choice

Whether in Germany, Europe or around the world, with a few regional exceptions, breweries today face high investment requirements. Against this tense background, the choice of filtration process not only contributes to a product having a perfect taste and high quality, but it can also have a crucial impact on costs and resource expenditure. There is no one solution for operators. Each of the three variants presented has its merits and needs to be evaluated and compared. These factors depend on the operational and economic circumstances of the brewery, including throughput, investment opportunities, personnel expenses and requirements for automation. At a time when competition is constantly on the rise, breweries need to gear their processes toward profitability and quality.

Those who can identify the right filtration solution for their operation can benefit from stable, reliable processes and a high-quality product that wins over the market in the long term. In the brewing of beer, filtration procedures are essential factors for quality, taste and shelf life – characteristics that are always worth taking a second look at. ■