Filtration in the brewery (Part 2): clarifying and trap filtration

FEWER PARTICLES, IMPROVED QUALITY | Suspended solids, filter aids, tannin-protein complexes: A wide variety of particles can affect the shelf life and brilliance of beer. Clarifying and trap filtration remove unwanted components and increase beer quality. This is the second installment of a five-part series on the filtration process in breweries.

CLARIFYING FILTRATION plays a key part in the brewing process. There is scarcely a better way to increase a beer's shelf life. But it can do much more than that. Aside from preserving the beer, it gives the beer clarity and brilliance – two of the most important things customers look for in beer. Only a few specific, cloudy specialty beers and craft beers, which are usually consumed locally within a short time, are able to forgo the process.

Trap filtration is an additional process that is required after performing clarifying filtration. While clarifying filtration is aimed at removing larger suspended particles, solids and insoluble solids, trap filtration is used to remove fine particles and yeast that have survived clarifying filtration.

Clarifying filtration for removing suspended solids

After fermentation, yeast harvesting, maturation and sedimentation, beer must undergo clarifying filtration to remove the coarse suspended solids that have resulted from the brewing process. These are mainly yeasts and fermentation byproducts, but also other suspended solids such as malt and hops residues that have appeared during sedimentation or fermentation and subsequent storage.

During sedimentation, some coarse suspended solids sink to the bottom of the fermentation tank and can be separated before clarifying filtration using a centrifuge. In some breweries, the sediment is also drained through a controlled tank opening. Subsequent filtration removes suspended particles that do not form sediment during maturation and storage.

Clarity and shelf life for a brilliant beer

In large breweries whose products are not just sold and consumed locally, but also nationally or even internationally, clarification is primarily required to achieve a longer shelf life and brilliance, as many suspended

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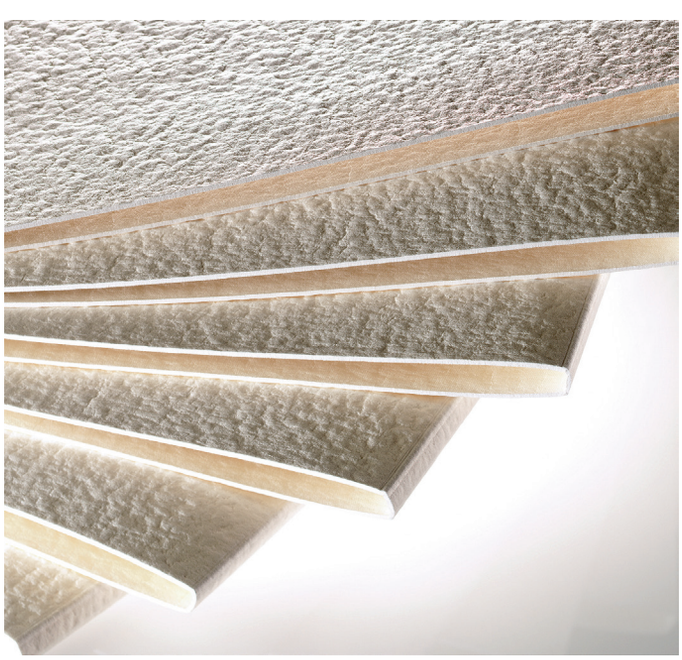

Fig. 1
Diatomaceous earth filtration with reusable support sheets offers a long service life and high levels of strength

solids remain active and contribute to the aging of the beer: After a few weeks, unfiltered, unpasteurized beer ages more quickly than filtered beer. Shelf life and clarity go hand in hand. Clarification filtration enables breweries to produce a beer that meets current market and consumer expectations for clear, hazeless beers. Consumers only expect cloudiness in craft beers or naturally cloudy specialties such as wheat beer, "Kellerbier" or "Zwickelbier," which is why these kinds of products are sometimes specifically advertised as unfiltered.

Another advantage of clarifying filtration is that it can also be used to remove young yeast that is still active. This forms a sediment after the fermentation process and, once the yeast has been successfully harvested, it can be used again for another fermentation process. Harvesting this yeast not only saves breweries money, but also ensures consistent quality. The number of fermentation processes that can be carried out using the harvested young yeast depends on several factors specific to the yeast and the applications in question. In general, however, use in at least three fermentation processes is possible.

In brewing, clarification filtration is typically based on one of two filtration technologies: crossflow filtration or pre-coat filtration using filter aids such as diatomaceous earth, cellulose and perlite. Since the crossflow process can be implemented while keeping personnel costs low, demand for this process has been growing for several years. However, it is mainly used in large breweries due to its high investment costs. Despite some instances of filtration being carried out using exclusively cellulose and perlite as filter media, the most common method in businesses of all sizes remains pre-coat filtration with diatomaceous earth (fig. 1). The process, which has been widely used since the 1960s, has undergone a series of improvements and offers breweries today a variety of advantages in terms of quality and efficiency, including the use of cellulose, perlite or diatomaceous earth in combination with stabilization aids for protein and phenol stabilization.

Triple-layer filter cake

Classic pre-coat filtration with diatomaceous earth involves using a triple-layer filter cake: a first and second pre-coating along with subsequent, continuous dosing of product filtration. The first pre-coating is initially performed using coarse diatomaceous earth with an average permeability of 1.3 to 1.5 darcy and produces a stable filter cake on the support sheets or the metal or plastic sieves of the filtration systems. If metal sieves are used, cellulose or perlite are usually added along with the diatomaceous earth, as these boast better separation behavior during the cleaning process.

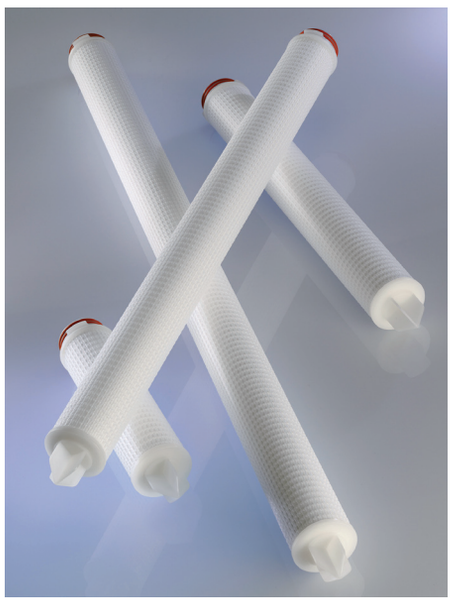

Fig. 2 During trap filtration, fleece-wrapped depth filter cartridges reliably separate 3- to 10-µm particles depending on the process requirements

The efficiency of the pre-coating is affected by various parameters, with the flow rate being of particular importance: If this is too slow, the filter aids are distributed unevenly, which may result in the beer filtration not yielding the desired result under some circumstances. This comes with the risk of leaks and some cloudiness developing. A system pressure of at least 29 psi (2 bar) is usually recommended, along with double the rate of the subsequent product filtration. If, depending on the system, 0.11 to 0.17 gal/ft²/h (4.5 to 7 hl/m²/h) or more is used for pre-coating, the beer filtration should be between 0.07 and 0.12 gal/ft²/h (3 and 5 hl/m²/h).

The second pre-coating is carried out using finer diatomaceous earth with an average permeability of 0.2 to 0.3 darcy, which creates the second layer of the filter cake. The subsequent dosing of the beer filtration often takes place in a very similar way to the second pre-coating; silica gel or polyvinylpolypyrrolidone (PVPP) should only be optionally added if the beer requires protein or phenol stabilization. These stabilization agents have a positive effect on filtration performance and can reduce the dosage of diatomaceous earth when used correctly.

Diatomaceous earth dosing for clarifying filtration usually varies depending on different filtration systems and process parameters. Users can use the following typical recommendations as a guide for dosing: 0.13 to 0.16 lb/ft² (600 to 800 g/m²) coarse diatomaceous earth, 0.13 to 0.16 lb/ft² (600 to 800 g/m²) fine to medium-fine diatomaceous earth; for continuous dosing 0.67 to 1.34 lb/100 gal/h (80 to 160 g/hl/h) diatomaceous earth in the same way as the second pre-coating and an additional 0.25 to 0.75 lb/100 gal/h (30 to 90 g/hl/h) silica gel and/or 0.08 to 0.33 lb/100 gal/h (10 to 40 g/hl/h) PVPP.

One method, three common filtration systems

Several established systems are available on the market for clarifying filtration: disc filter cartridges, centrifugal horizontal filters (CHF) and diatomaceous earth frame filters with support sheets. Disc filter cartridges and CHFs are based on metal or plastic sieves, which help to localize and bind the filter cake. Diatomaceous earth frame filters with support sheets have been used for over 50 years and remain widespread in breweries today.

Trap filtration for removing particles

Breweries that opt for classic diatomaceous earth filtration after fermentation and storage often follow this with trap filtration using filter cartridges. This is used to remove small, fine particles, and is so named because in a sense, it sets a trap for the particles. Trap filtration can be used after process steps that lead to unwanted particles in the beer, such as after storage, diatomaceous earth filtration and flash pasteurization (HTST). Precipitations can arise during storage, particles in the form of filter aids can build up during clarifying filtration with diatomaceous earth, HTST promotes the precipitation of tannin-protein complexes and thermal deposits (burn-off) can result in browning.

Due to the variety of purposes, trap filtration can be carried out multiple times before different process steps and can also be per-

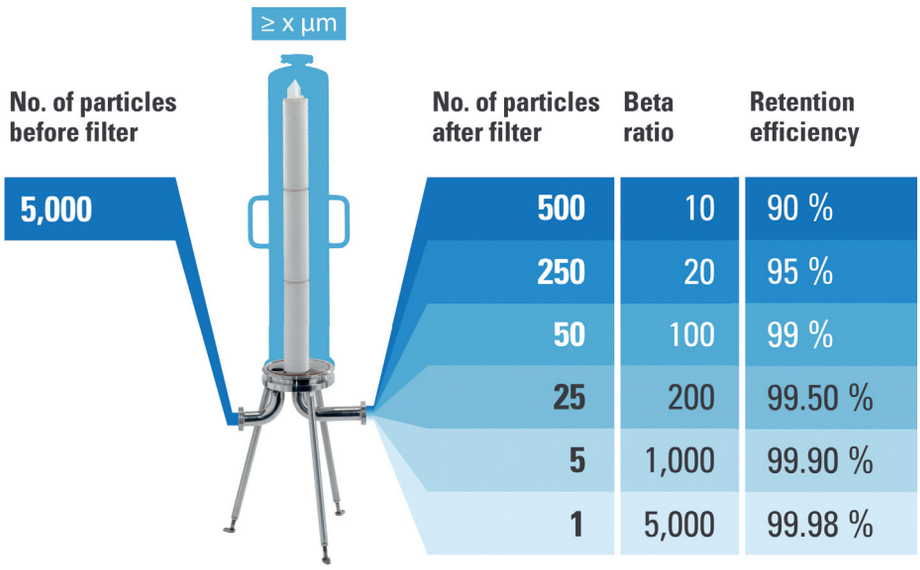

Fig. 3 The beta ratio provides information about the retention efficiency and therefore the performance of a filter cartridge

formed as an optional step before bottling. The procedure also depends on production quantities and individual quality assurance parameters. What producers decide for and against ultimately comes down to brewing philosophy.

Regardless of which model breweries use for their filtration, trap filtration with depth filter cartridges is a proven classic. Over the years, however, retention rates of filter cartridges have become increasingly fine. Until the 1990s, a retention rate of 30 to 40 µm was customary for removing particles. Around the turn of the millennium, a retention rate of 20 µm had already become commonplace, with 10 µm being implemented some 10 years later. Today's industry standard is 3 to 10 µm.

Three types of depth filter cartridges for trap filtration

Three types of depth filter cartridges have become well established on the market: pleated, meltblown and fleece-wrapped (fig. 2). Pleated filter cartridges come with the advantage of a large surface area but are usually only backflushable under certain conditions. This affects cleaning and service lives and makes automating the regeneration process more difficult. Meltblown filter cartridges offer up to four gradations from coarse to fine and can be backflushed. Fleece-wrapped filter cartridges offer advantages in both categories. The fleece is wrapped up to 24 times in graduations and is tighter toward the inside, forming an efficient funnel to retain a wide range of particle sizes. When backflushing using hot and cold water, this design maximizes the success of the cleaning process.

Whichever filter cartridge variant a brewery decides to use, the efficiency of particle retention plays a key role in the quality of the filtration process. In order to ensure that the retention rate corresponds to the efficiency, users have to pay attention to what is known as the beta ratio. As a general rule, a high beta ratio is better for retaining unwanted particles.

The beta ratio is determined under laboratory conditions. This involves applying a defined quantity of particles to the filter and calculating the beta ratio by measuring the number of particles before and after filtration. If, for example, 5000 particles with a size greater than or equal to 20 µm are measured before the filter with a specified retention rate of 20 µm and 500 particles are measured after the filter, the beta ratio of this filter is 10. This corresponds to a retention efficiency of 90 percent. The remaining 10 percent of these particles are not separated and can significantly affect the quality and shelf life of the beer.

Providers of high-quality filter cartridges specify the beta ratio to ensure transparency for users (fig. 3). Fleece-wrapped filter cartridges with retention rates ranging from 0.2 to 150 µm and offering a beta ratio of 5000 are available on the market. The retention rate in these versions is 99.98 percent.

High-quality filtration for top-quality beer

High-volume top seller or craft specialty, regional beer or global brand, brilliant or naturally cloudy – when it comes to brand and product philosophy, breweries today are faced with a wide range of options for meeting their customers' demands for each popular variant. The master brewer's philosophy concerning aspects such as filtration systems, process management or filter cartridge variants also plays a key role in processes such as clarifying and trap filtration.

The crucial factor for a successful brewery is ultimately committing to quality in all of the essential parameters: After all, the quality of the filtration process has a critical impact on the final quality of the beer. For beer with uncompromising quality, a long shelf life, brilliance and an appetizing flavor, high-quality filtration pays off across all steps of the process. ■