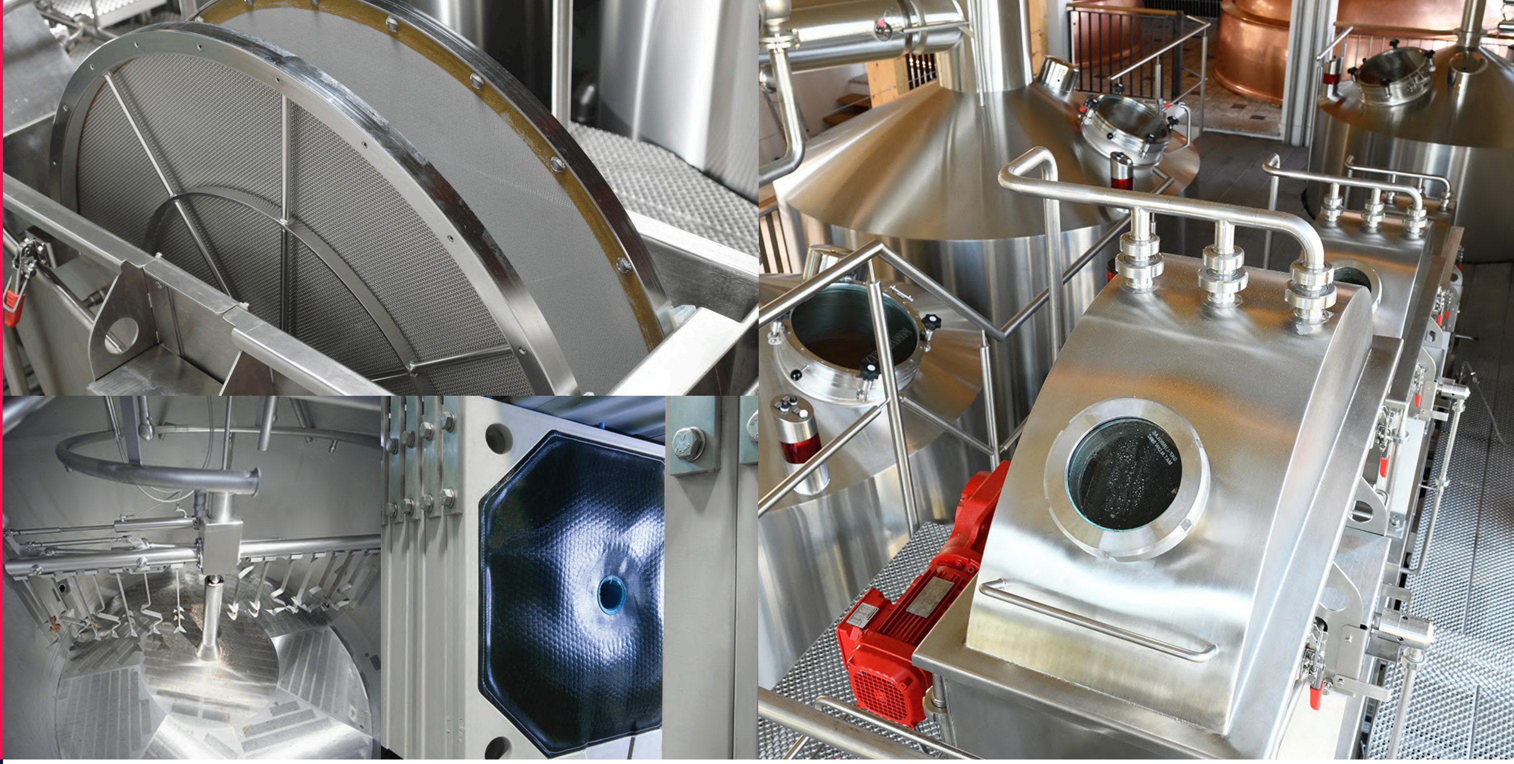

The lautering process in breweries with lauter tun, mash filter and continuous mash filtration system

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Ziemann Holvrieka

Contents

Introduction

The lautering process is the solid/liquid separation of wort and spent grains as well as the determination of the extract yield. For this process, the international brewing industry currently uses predominantly lauter tuns, mash filters and a continuous separation system.

From a process-technological point of view, the lauter tun and mash filter systems, are static filtration systems. More precisely, this process is a combination of screen filtration and depth filtration, with the subsequent extraction, and particularly in the lauter tun, the depth filtration predominates. The continuous separation system uses a dynamic filtration to separate the solid and liquid phase and enables simultaneously further extraction. The separation systems are technically highly developed and have been specialized for the brewing technology.

The following White Paper provides an overview of the status quo of the lautering technology in terms of design and performance as well as its influence on the beer production. The central questions regarding the selection and use of one of the three lautering processes are answered in a comprehensive and practical manner.

Fundamentals of lautering

In the brewhouse of a brewery, the malt enzymes convert the starch into fermentable sugar. In this process, a suspension of a sugar-containing liquid and undissolved solids is formed. The solids, known as spent grains, are separated to continue with the process of beer production. Afterwards, the clarified wort is mixed with hops and is boiled. The solid/liquid separation of wort and spent grains is known by brewing technologists as lautering. The lautering process consists of two stages: the first one is the run-off of the wort in a filtration process. This stage is followed by the washing out of the remaining wort in the spent grains and the embedded sugar molecules by means of hot water: sparging.

The aim of the lautering process is to achieve the highest possible yield as quickly as possible and with the least amount of sparging water. In addition, in the last few years the parameter "turbidity" has become more and more important with regard to the assessment of the lautering quality. Here brighter wort types have been demanded. However, Philipp Heiss (1812 – 1860) wrote more than 150 years ago in his textbook [1]: „The lautering of the wort shall be carried out as quickly as possible. It is a completely erroneous opinion to believe that the complete brew should run off clear." Numerous recent scientific studies confirm this empirical brewing knowledge of many generations. They report an improvement in the yeast condition and an acceleration of the fermentation on turbid worts in comparison to clear worts [2, 3, 4].

A possible reason for this is the increment in long chain fatty acids, which are present in turbid worts. In addition to the lipids, zinc, which is also found in turbid wort, significantly contributes to the improvement of the fermentation [4]. In the future, it will possibly be more important not to lauter the clearest wort, but the wort which is nutritionally most suitable for the yeast.

The lauter tun

The lauter tun is equipped with a second, perforated bottom, which can be positioned above the actual bottom of the lauter tun (figure 1). The undissolved and solid components of the mash settle on this false bottom. A filter bed, which is formed by the spent grains is required for the clarification of the run-off wort. Roller mills are commonly used for this process, as they preserve during the grinding process in a substantial way the husks, which are an important part of the natural filter layer.

In the last few decades, the efficiency of the lauter tun increased significantly in reference to the wort qualities, the yields and the possible number of brews. Modern lauter tuns achieve peak values of less than 102 minutes occupancy time (figure 2). The specific false bottom load of a lauter tun is an important parameter for its design, i.e. the grist load weight per square meter of filter area. Depending on which type of milling and preconditioning the malt is subjected to, the result is different in terms of grist load for the same filtration area. This defines the performance of a lauter tun.

Figure 1: This second, perforated false bottom is installed above the actual bottom of the lauter tun

Figure 2: Today's lauter tuns can achieve peak values of up to 14 brews per day.

The modern process control systems in combination with the optimized raking units have contributed in a large extent to these improvements. An important part of this evolution is based on the flow-optimized design of the lauter tulips, the higher distance of the false bottom to up to 25 mm as well as the increased number of run-off openings from 1.0 to 1.4 per m2. In return, these constructive measures result in increased material, manufacturing and cleaning costs. There is also a higher volume of water needed to pre-fill the lauter tun before the mash is pumped in. Due to the current low evaporation rates, this additional water volume can no longer be used as sparging water. Consequently, there is a lower yield particularly when brewing wort types with a high extract content, e.g. for high gravity brewing or very strong craft beers.

Scientific and empirical observations and modern CFD flow analyses (computational fluid dynamics) clearly show that with an optimal design of the "tulip" pipes and the higher false bottom distance, the spent grains are no longer affected by a partial suction effect (figure 3).

Therefore, less run-off pipes are required, since these were so closely located only to avoid compression of the spent grains cake [5].

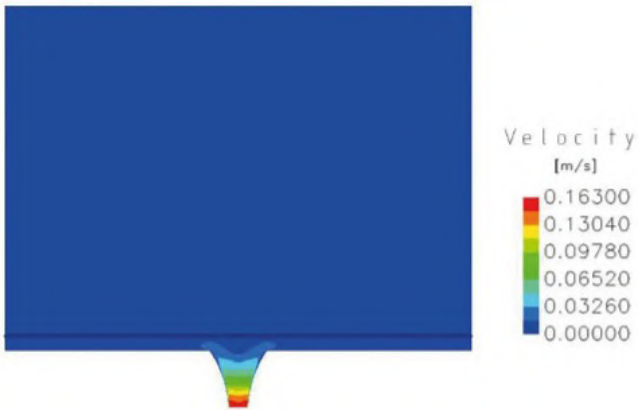

Figure 3: With an optimal design of the "tulip" pipes and the current false bottom distance, the spent grains cake is no longer affected by a partial suction effect.

With the current false bottom distance and the flow-optimized tulip pipes, the collection area per tulip can be increased to 2.5 m2 – without compromising the yield or wort quality (figure 4).

Figure 4: With the current false bottom distance and the flow-optimized tulip pipes, the collection area can be increased to 2.5 m^2 – without compromising the yield or wort quality.

The mash filter

In a mash filter, the entire spent grains volume is divided into many vertical spent grains' cakes with a layer thickness of 3 to 5 cm and a surface, which corresponds to the frame size of the filter element (figure 5). Because of this, the filtration principle is fundamentally different from that of the lauter tun where the entire spent grains forms a single, horizontal depth filter bed with a thickness of 20 to 60 cm. The design of the current mash filters is divided into two types; chamber and membrane filters.

Figure 5: In the mash filter the entire spent grains is divided into many vertical spent grains' cakes.

The chamber mash filter

The frames of a thin-layer chamber mash filter are confined on both sides by means of filter cloths. The wort runs off through these cloths while the spent grains remain in the frame (figure 6). Today filter cloths are made of a polypropylene fabric (PP). Due to the fine-meshed supporting fabric, very fine grist can be used and, since the larger particles are safely retained, the filter layer can be extremely reduced. This results in a very high yield, a high filtration rate and a good clarifying effect.

Thin-layer chamber filters are supplied in medium to large scale, for charges starting from 3 tons to 24 tons of malt equivalent. The malt equivalent is a reference value for the design of the filter load in the form of a specific spent grains' volume. The plates' dimensions are usually from 1,500 mm x 2,000 mm up to 2,400 mm x 2,400 mm (figure 7). The latter is loaded with a malt equivalent of 169 kg per chamber.

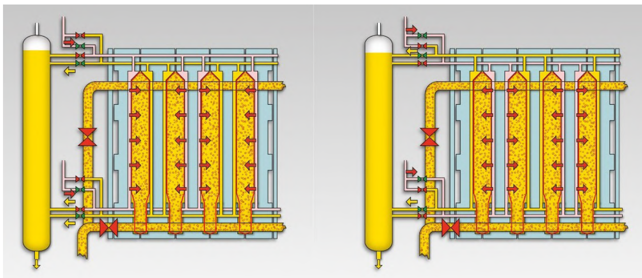

Figure 6: In a thin-layer chamber mash filter, the narrow filter chambers are limited by fixed plates.

A characteristic of chamber mash filters is the simpler design and operating mode compared to membrane mash filters. In practical applications, these mash filters are favourable if a specific sparging water volume of more than 3.2 l/kg is applied. [6]

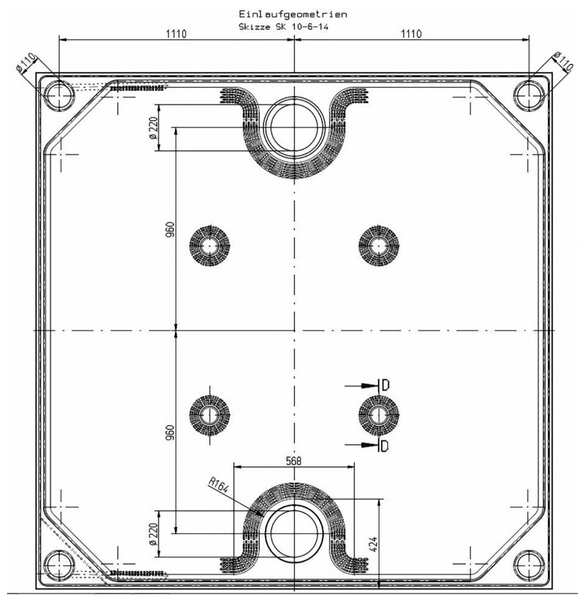

Figure 7: The plates' dimensions are usually from 1,500 mm x 2,000 mm up to 2,400 mm x 2,400 mm.

The membrane mash filter

Membrane mash filters are designed with a so-called ‘mixed’ plate package, where the chamber plates and the membrane plates are alternately arranged (figure 8). The rectangular or square plates are comparable to those of a chamber mash filter.

The membranes are moved with a pressing medium and the wort is pressed out of the spent grains cake from both sides (figure 9). A multiple, repeated and intermediate pressing is possible during sparging. The final pressing dehumidifies the spent grains cake to a water content of less than 70 %. This provides a complete and easy discharge of the spent grains during the spent grains’ removal. For operational and plant-safety reasons, water is used as pressing medium. In addition, water allows a hydrostatic uniform distribution of the mash during the filling of the chambers.

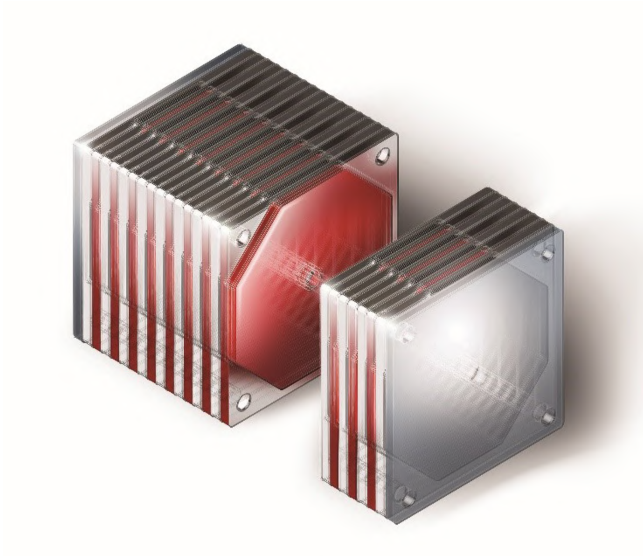

Figure 8: Membrane mash filters are designed with a so-called ‘mixed’ plate package, where the chamber plates and the membrane plates are alternately arranged.

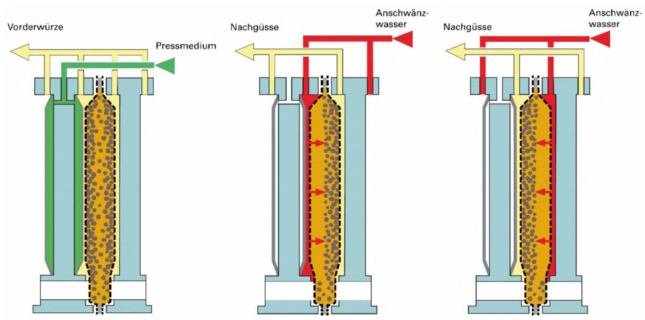

Figure 9: The membranes are moved with a pressing medium and the wort is washed out and pressed from the spent grains cake from both sides.

The plate construction and the associated procedure of a membrane mash filter are more complex compared to the chamber mash filter. Due to the active pressing process, membrane mash filters require, however, very low amounts of sparging water so that, compared to the chamber mash filter, even when using a significantly lower amount of water, high extract yields are achieved. Due to the high mechanical stress, the choice of the membrane material is a decisive factor for the membrane mash filter. A thermoplastic elastomer (TPE) based on polypropylene has proven itself in practice (figure 10). The service life of this membrane is many times higher than in previous solutions [7].

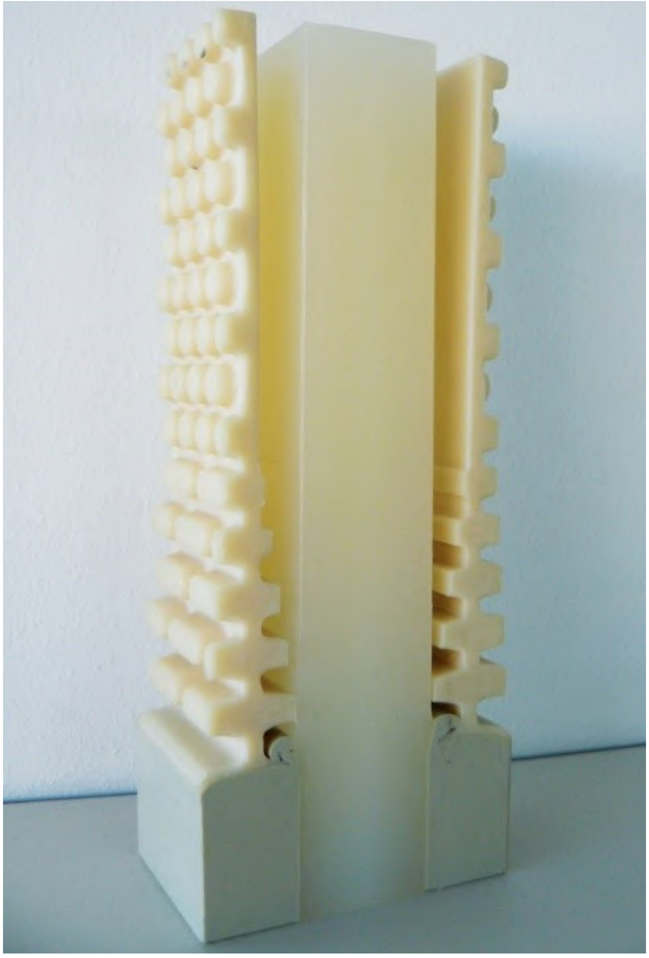

Figure 10: For the membrane mash filter, a thermoplastic elastomer (TPE) based on polypropylene has proven itself in practice.

Parameter	Chamber Mash Filter	Membrane Mash Filter
Sparging water volume	> 3.2 l / kg	< 2.8 l / kg
Design	simple	Different plate types and membrane presses
Grist quality	very fine	extremely fine
Spent grains humidity	< 76 %	< 70 %
Plate package	Chamber plates	Chamber and membrane plates

Table 1: Chamber and membrane mash filter: The most important facts and reference values [7, 6]

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With regard to the batch size variability, mash filters have weaknesses compared to the lauter tun or the continuous mash filtration system. With a separation set (figure 11), the charge can only be varied in a very limited range, approximately +4 % and -4 %, as all the chambers of the filter must be filled as homogeneously as possible. A separation set (Figure 11) allows a higher flexibility, as it can be positioned according to other grist loads. Additionally, a separation set saves the employment of personnel, since no filter elements have to be manually added or removed.

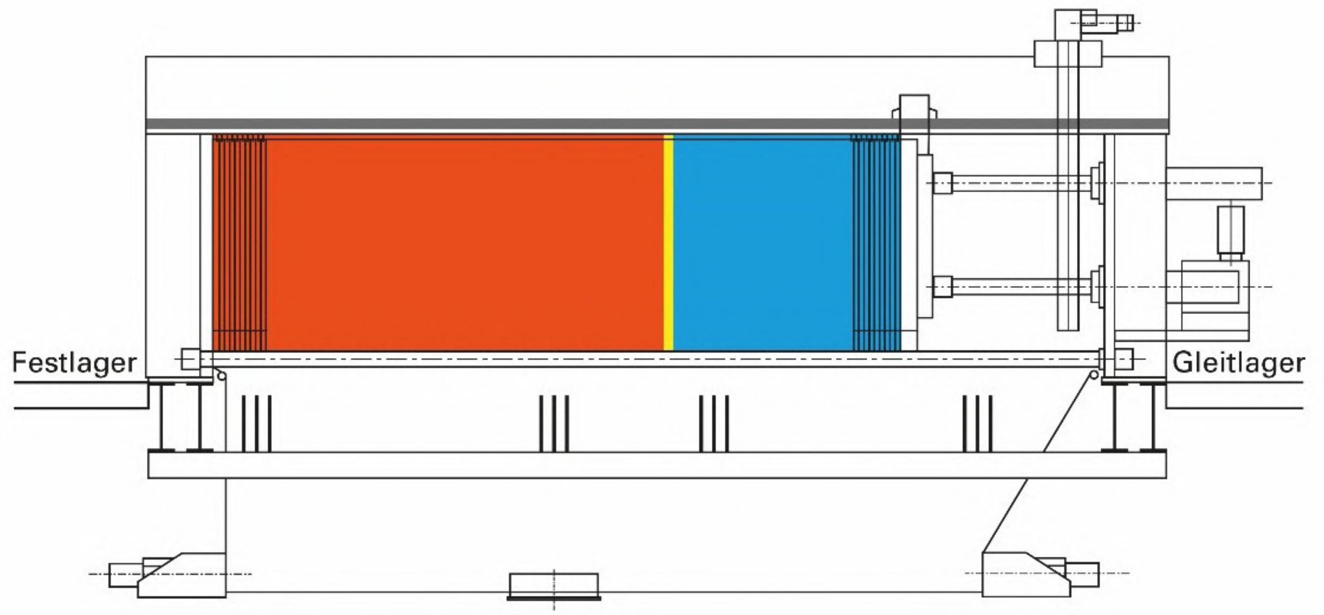

Figure 11: With a separation set, the mash filter may process different batch sizes without having to manually add or remove any filter elements.

The continuous mash filtration system

In the continuous mash filtration system, the mash is fed continuously and passed through a total of four separation and three extraction stages. Thus, the mash transfer time corresponds to the actual lautering time. The system consists of four modules in cascade arrangement (figure 12), connected by transitions.

The membranes are moved with a pressing medium and the wort is pressed out of the spent grains cake from both sides (figure 9). A multiple, repeated and intermediate pressing is possible during sparging. The final pressing dehumidifies the spent grains cake to a water content of less than 70 %. This provides a complete and easy discharge of the spent grains during the spent grains' removal. For operational and plant-safety reasons, water is used as pressing medium. In addition, water allows a hydrostatic uniform distribution of the mash during the filling of the chambers.

Figure 12: The system consists of four modules in cascade arrangement, connected by transitions.

Each module is equipped with two screen filters, rotating in the direction of flow, to ensure the separation of liquid (wort) and solids (spent grains) (figure 12 and figure 13a). The filter surfaces, with a diameter of one meter, consist of sintered stainless steel and have a pore size of 70 µm (figure 14) [8].

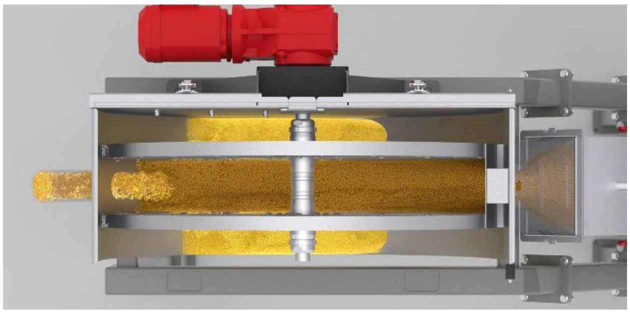

Figure 13a. Sectional view of a module with two rotating screen filters for the separation of liquid (wort) and solids (spent grains).

Figure13b: An integrated baffle plate creates turbulences, resulting in an improved mixing of the spent grains and thus leading to an effective extraction.

The sparging is carried out in the transition between the filter units, which – depending on the brew recipe – can be carried out with brewing water or a low-concentrated wort, e.g. from module 3. The baffle plate, which is additionally installed in the transitions, creates turbulences, leading to an improved mixing of the spent grains and thus to an effective extraction (figure 13b). The spent grains are discharged continuously after passing the fourth module. The residual moisture of < 78 % lies between the values of a mash filter (76 %) and lauter tun (80-82 %).

For the first time, a lautering system simultaneously produces four continuous wort streams with different properties, for example, with regard to the pH value and the original wort content. Depending on the mashing program, sparging liquid type and volume, the initial mash concentration (> 30°P are possible) is lowered to a level below 2°P on the last module. With decreasing concentration, depending on the water quality, the pH value increases. The worts produced by the system are highly turbid (about 8 g/l of dry matter in the cold wort), which has a positive effect on the yeast vitality during fermentation due to the increased zinc and fatty acid contents.

Due to the continuous lautering process, the total brewing time is reduced by 30 % compared to a lauter tun. This results in a lower thermal load and shorter contact time of the spent grains with the atmospheric environment and the sparging liquid. The leaching of the ignoble substances such as tanning agents from the spent grains is prevented is prevented. Different raw materials and cereals as well as different grist composition can be easily processed. Due to the continuous filtration, the batch sizes can vary and different original gravities can easily be adjusted. In addition to a small, rectangular base area, there is a weight saving for the load-bearing ceiling construction, since always only a part of the total mash is in the lautering system. This results in a particularly compact design.

The system can be used both in a continuous brewhouse concept and in a batch process.

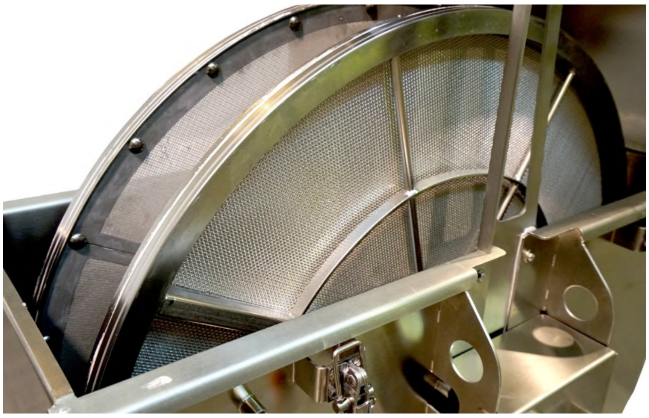

Figure 14: The filter surfaces, with a diameter of one meter, consist of sintered stainless steel and have a pore size of 70 µm.

Technological comparison of the lautering systems

The direct comparison of the lautering systems in table 2 shows the advantages and weaknesses of each system. For example, the mash filter and the continuous system have a significantly higher flexibility with regard to the addition of cereals (rice, maize). These cereals can be easily processed in the lauter tun only up to a certain percentage, since the husks, which are necessary for the filtration, are missing. Furthermore, mash filters, with their thin filter layer, and the continuous system, with its dynamic filtration, are very resistant to highly viscous worts. These arise, among other things, in the processing of cereals such as rye, which have a high content of so-called gums.

In contrast, lauter tuns and the continuous system have a greater adaptability in terms of varying batch sizes. Further advantages of the lauter tun are its great robustness and, especially at brew sizes < 300 hl, the significantly lower investment and operating costs. However, the mash filter and the continuous system are much more compact than the lauter tun.

Parameter	Mash Filter	Lauter Tun	Continuous Mash Filtration System
Total occupancy time of the lautering system	≥ 90 min	> 102 min	< 45 min
Space requirement (with the same cast-out wort volume)	small, due to rectangular design	large, due to circular design	very small, due to rectangular design and continuous operation
Flexibility regarding different charges	low: ± 10 %, can be increased by the separation set	high: + 15 % / - 50 %	very high: (theoretically: no limit), practically: ± 50 %
Percentage of adjuncts	up to 100 %, e.g. rice	up to 40 %	up to 100 %, e.g. maize
Possibilities to influence the filtration process	low	flow rate, height and speed of the raking unit are variable	flow rate and sparging liquid are variable
Yield – depending on the mill system	very high	high	independent of the milling system
Maximum first wort concentration	~ 25 °P	~ 21 °P	~ 32 °P
Personnel and maintenance costs	high, due to many moving components	low	low
Cleaning agents demand	high, due to complete filling of the filter	low	low
Wearing parts	filter cloths, pressing membrane	no wearing parts	rotary seal

Table 2: Mash filter, lauter tun and the continuous mash filtration system: the most important facts and reference values.

Considering the process times during the brewhouse work, the lauter tun with a lautering time of > 102 minutes is the pacemaker. The mash filter with ≥ 90 minutes and the continuous mash filtration system with < 45 minutes have significantly shorter lautering times. In addition, the extensive specializations in the lautering work on the mash filter and lauter tun processes, are not lifted by the continuous mash filtration system, where specific raw material and grist requirements become less relevant for the efficiency.

For the selection of an appropriate lautering system, it is important to review and evaluate the brewery-specific parameters. Only then, an appropriate lautering system can be selected, which ensures optimal lautering work.

It will be exciting to see how the three lautering systems mash filter, lauter tun and the continuous mash filtration system position themselves side by side in the market.

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Author

Tobias Becher

Graduate Engineer Tobias Becher (Dipl.-Ing.)

Tim Elbert is a certified mechanical engineer and bachelor of technical business management. In 2001, he started a training as a metalworker specializing in design engineering at Ziemann Holvrieka in Bürgstadt. After completing his vocational training, he worked as a metalworker for a few years, before completing his further education as a state-certified mechanical engineer and bachelor of technical business management. Between 2013 and 2017, he worked in the quotation department. Since 2017, he works as a sales engineer for tanks. Today, he advises international customers from the beverage and food industry.

About Ziemann Holvrieka

Ziemann Holvrieka GmbH in Ludwigsburg/Germany was established 165 years ago and is one of the globally leading manufacturers of brewery plants. The best-known beers in the world are brewed in plants from Ludwigsburg. Our customers include breweries of all sizes - from craft breweries to international corporations. Ziemann Holvrieka further offers a large selection of tanks and process technology for the beverage and food industry and chemical applications. Many years of experience, global references and its innovative solutions make Ziemann Holvrieka a reliable partner for modernizations, capacity expansions as well as for completely new turnkey brewery plants.

Ziemann Holvrieka provides innovative and tailor-made solutions for complete turnkey brewery plants or individual components for the entire brewing process. The product range in the area of the wort treatment extends from the malt intake, via grist mills, mash vessels, lauter tuns, mash filters, wort kettles and whirlpools up to wort cooling systems. In the area of the cold block, Ziemann offers fermentation and storage tanks, bright beer tanks, yeast tanks and all required CIP tanks. Ziemann Holvrieka plans, engineers and automates the process and the cleaning technology in all production areas, including the installation of process pipework and the integration of all required utilities.

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