A Novel Mash Filtration Process (Part 1)

CONTINUOUS | With Nessie by Ziemann®, a new lautering unit, intended to change in a sustainable way traditional brewhouse tasks, was presented at the BrauBeviale 2016 in Nuremberg, Germany. BRAUWELT International will be introducing this technology in a series of articles treating all relevant aspects. Part 1 describes the objectives of this development, the actual procedure and the equipment setup. The following articles will be introducing the technological implications on lautering, as well as additional developments for the upstream and downstream process steps.

THE MASH FILTRATION process in a brewery's brewhouse is a central process step, whereby wort and spent grains are separated in two phases: the first one involves the run-off of the wort in a separation or filtration process. During the second phase, the remaining wort in the spent grains and the embedded sugar molecules are then washed out using hot brewing water: a process known as sparging. The objective of lautering is to achieve a high yield with low sparging water in the shortest possible time.

Modern LauterTuns and Mash Filters

For this task, breweries have been predominantly using lauter tuns or mash filters during the past few years. From a technical point of view, both systems work in a static way with a combination of screen and deep-bed filtration, followed by the extraction of the formed filter bed [1]. In this case, many of the malt ingredients, which are valuable for the downstream beer production process, remain in the spent grains.

With regard to the lauter tuns, the entire spent grains form a horizontal depth filter bed with a thickness of 20 to 60 cm. With this deep-bed filtration, modern lauter tuns achieve peak values of up to 14 brews per day, whereby the type of the upstream milling and the selected diameter are decisive criteria when determining the capacity. A special feature of the lauter tun is its flexibility regarding frequently varying charges. With regard to the usable sparging water volume, one fact to be considered with the lauter tun is that water has to be available both in the piping system and under the false bottom before the mash transfer. This water volume can no longer be used as sparging water. Consequently, the yield achieved may be lower, particularly when brewing wort types with a high extract content, for example, for the so-called high gravity brewing or in strong craft beers. This applies, in particular, with a view to the very low evaporation values in current wort boiling processes.

In a mash filter, the entire spent grains 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.

The design of the current mash filters is divided into chamber and membrane filters. Both types allow lautering cycles of between 12 and 16 brews per day [2]. The yields of modern mash filters are therefore around 1 percent higher than those of the lauter tun. The decisive reason is the type of grinding, as mash filters offer the option to filter mashes from the finest ground raw materials. This is not possible with the

Fig. 1
The new lautering unit was first introduced to the public at the BrauBeviale 2016 in Nuremberg

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Fig. 2 Standard version of a rotating sieve filter module with its wheel pair and filtering surfaces

Fig. 3 The wort and spent grains separation process takes place in the modules at the lower segment of the circular filter sieve

lauter tun, because in this case, the husks have to form the necessary depth filter layer. Furthermore, the mash filter also requires a lower volume of water for washing out the spent grains. In this case, mash filters make it easier to master the challenges of high gravity brewing.

Intended Objectives of the Development

Both, the lauter tun and the mash filter, are generally speaking technically mature devices. If at all possible, any improvements to their performance can only be expected on a small scale. In addition, lauter tuns and mash filters are extremely specialized equipment. This specialization starts with the selection of raw materials, continues with the grist mill to be used, and goes through the entire brewhouse process. Relevant selection criteria include the extract content of the wort, the number of brews per day, the desired yield, the available volume of sparging water, the brewing volume and the diversity of beer varieties to be produced. Both the lauter tun and the mash filter are designed for batch operation and do not allow continuous wort production.

The objectives of the new development were therefore to break up this extensive degree of specialization in lautering, to preserve the valuable ingredients for the wort and, apart from optimizing the batch process management in the brewhouse, also to be able to realize continuous wort preparation in the future. Table 1 provides an overview of the development objectives for a new lautering unit, whereby the developers started with the question of how the separation and extraction steps could be designed for the future and be unified into a new overall process.

During a first step, numerous separation and extraction processes were analyzed in completely different applications with regard to the possibilities of adapting them to brewhouse work.

During this phase, the approach described below proved to be particularly promising. The separation stage is adopted by a rotating sieve filter, which had already been successful in other industry segments. The extract is washed out via a turbulent counter flow washing process downstream from the separation stage. The combination of these two process steps created a new lautering technology, which was first introduced at the BrauBeviale 2016 (Fig. 1).

Dynamic Sieve Filtration

The unit consists of four rotating sieve filters arranged cascade-wise in one row on a common frame. The standard version of each of these modules contains a pair of wheels with a diameter of one meter. Each wheel has a filtering area consisting of sintered stainless steel and a sieve mesh with a width of 70 µm (Fig. 2).

The mash flows through the filtering modules consecutively, whereby the wheel pairs rotate in the direction of the flow. The mash transport is supported by gravity, which affects the cascade-wise arrangement.

The retention time of the spent grains in the module can be influenced by the speed of the wheel pairs; it is process-dependent and can be individually adjusted for each module. In the basic setting of 4 rpm, an ideal mash particle requires approximately three minutes to pass through the four modules, which denotes a short process time.

The actual separation process takes place in the modules at the lower segment of the

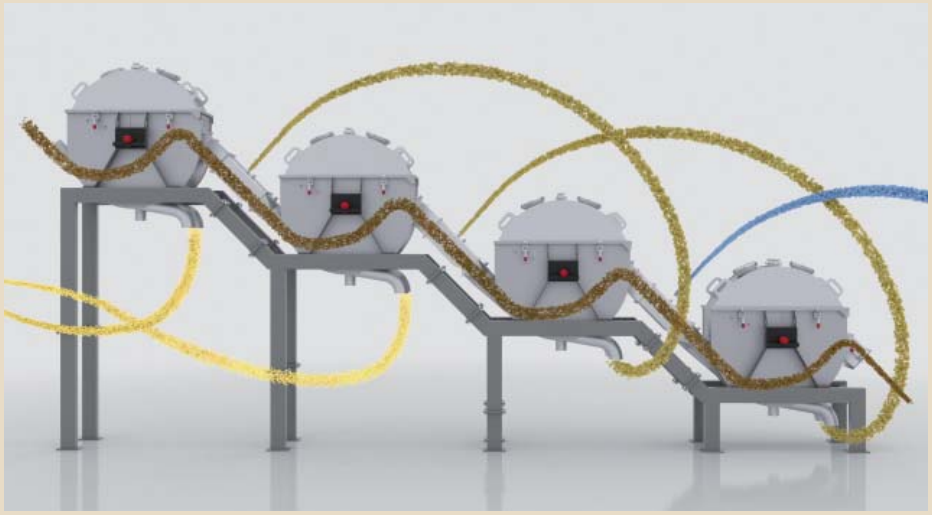

Fig. 4 The quality and quantity of volume flows for mash, sparging water, lauter wort and spent grains (as diagram) can be consistently adjusted

circular filter sieve. This is immediately followed by the solid/liquid separation without the wort accumulating in the module (Fig. 3).

The separated wort is directly and continuously conveyed in a closed system. The solids remain between the sieve surfaces of the wheel pairs, with rotation and gravity transporting it to the next module. Even with fine grist, there is no risk of husks entering the wort. The rotational motion of the sieve discs and the sluggishness of the suspension result in a relative motion on the surface of the sieve. This creates a self-cleaning effect, which prevents particles from adhering to the filter surfaces. As a result, no filter layer is formed, which could block the wort flow. With this self-cleaning effect, the filtering unit is suitable for the lautering of highly concentrated mashes and the processing of alternative raw materials with high charge volumes, as the filtration performance is not further influenced by the viscosity of the mash nor the formation of a filter layer.

Under these conditions, long service life of the sieve elements made of sintered stainless steel is to be expected, as the rotational motion along the mash or the spent grains creates neither press forces nor high speeds.

To extract the spent grains, the sparging water between the last two modules is abandoned. The resulting extract solution is then incrementally returned into the connection shafts between the preceding modules in counter flow to the flow of the spent grains. During these transitions, the spent grains are mixed with the appropriate sparging fluids, transferred into a turbulent current via an integrated baffle plate and then effectively homogenized. Sugar and substances contained in the spent grains are dissolved. Further solid/liquid separation follows in the next module. This creates a four-stage separation process with interconnected simultaneous extraction, whereby the quality and quantity of volume flows for the supplied mash, the sparging water and discharged wort and the spent grains can be set consistently (Fig. 4).

Basically, the extract yield could be steadily increased with a rising number of separation and extraction stages. In numerous test series, both on a pilot and industrial scale, the current four-stage cascade arrangement proved to be the ideal solution under technological and commercial aspects.

Short Contact Periods, High Yields

The new mash filtration process results in continuous fluid flows. All flows are quickly gained from a relatively small proportion of mash or spent grains. The contact periods with the atmosphere and the sparging fluid are appropriately short. The spent grains are therefore not permanently washed out. Instead, this results in quick and effective washing out and dissolving of valuable malt substances. Base ingredients of the husks, such as tanning agents and silicates, which only dissolve during a longer contact period, were only detected at small quantities in these worts.

The conventional sparging water volumes of modern lauter tuns and mash filters range between 2.5 and 3.5 l/kg of malt. Given the dynamic counter flow extraction of this novel process, these volumes can be used with efficiently. Even with low evaporation values of modern wort boiling processes, excellent yields can be obtained for worts with high original extract. The necessary equipment volume is reduced due

THE OBJECTIVES FOR THE NEW DEVELOPMENT OF A LAUTERING UNIT

Criterion	Objective
Wort and beer quality	Maintaining the valuable malt substances
Brewhouse process	Both as continuous and as batch process
Batch size	Maximum flexibility regarding brew volume
Raw materials	Not respective to the type of raw material and the composition of the grist
Grinding	Not respective to specialized mill types
Mash concentration	Processing of highly concentrated mashes
Lauter wort	Consistent quality and quantity
Lautering	Rapid wort yield during separation stages
Sparging	Short contact periods during extraction
Yield	Increased due to the optimized integration of individual process steps
Spent grains	Reduced residual extracts and water contents in spent grains
Process time	Shortened overall process time, heat retention time and set-up times
Construction	Compact and modular in "Hygienic Design"
Personnel assignment	Reduced personnel costs, the system is resistant to wear and maintenance-friendly
Energy consumption	Reduced energy requirements

Table 1

to the short process times. In the standard version, this is approximately 150 L gross per module. All modules and their interconnecting shafts form a closed system with a vapor atmosphere above the flowing mash. Therefore, a direct contact with the atmosphere is impossible.

The low volume of each module has additional advantages: it allows a compact design on a minimum surface at a relatively low weight, even during operation. This results in less demands on and requirements in terms of the structure of the building. Installation is also simplified. A small volume also results in a reduced cleanable surface, which is in contact with the product. The filter discs are rotating during cleaning and in full contact with the cleaning medium via spray heads. Due to the complete stainless steel construction and the use of sealing material common in the sector, any conventional cleaning media can be used.

Lautering Performance

With a sieve diameter of 1 m in the standard version and a rotation speed of 4 rpm, the described filter unit achieves an hourly output of 120 hl of wort, with the mash transfer time corresponding to the actual lautering time.

A higher lautering output is possible with the modular extension of the filter units. In this case, additional wheel pairs are installed in each of the four modules. Two pairs of sieve discs per module therefore mean a duplication of the lautering performance.

By appropriately parametrizing the rotation speed of the filter discs or the output of the mash pump, the process can also be adjusted to smaller mash volumes and their throughput performance. All globally conventional brewery sizes can be optimally operated in this manner.

Conclusion

The new lautering procedure results in great advantages for breweries. The same system can therefore process strongly varying original wort volumes, depending on the variety, just as well as different starch sources or the smallest batch sizes. Due to the efficient counter flow extraction, conventional sparging water volumes achieve ever increasing yields. The system is characterized by its particularly compact design, its simple expandability and good cleaning properties.

One central aspect is the high process speed. In principle, the mash transfer time corresponds to the lautering time, whereby the mash is separated and the spent grains are washed out simultaneously. The previous static and batch process is therefore turned into a continuous transfer, with separation and extraction taking place in a step. By means of a clever optimization of the remaining brewhouse processes, a reduced brewing time of up to 30 percent, from mashing to cooling, can be achieved compared to the conventional brewhouse processes. The technological implications in using the new filtering unit and additional innovations will be introduced in subsequent articles. ■

Sources

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