Gentle cold sterilisation of beer

GENTLE FILTRATION | To satisfy the increasing worldwide demand for premium beers with an unaltered flavour profile, Bucher Unipektin AG Competence Center Filtration has developed Stefinox, a plant for cold sterile filtration of beer and all other kinds of filtered beverages (e.g. wine, spirits, soft drinks or water).

THE MODULARLY DESIGNED PLANT consists of a pre-filter, a sterile filter, and a CIP filter connected upstream of these first two filters during the cleaning process. If required, Stefinox can be equipped with its own CIP station. Designs for a continuous filtration process are also possible. In addition, it offers breweries economic benefits through potential energy and water savings as well as the free choice of suppliers for the filter cartridges.

Due to modern membrane technology, the gentle cold sterile filtration process makes thermal processes for microbiological stabilisation, like flash pasteurisation or tunnel pasteurisation, redundant.

For a long time, the tunnel pasteuriser and later the flash pasteuriser used to be considered the first and only choice for the inactivation of yeast and beer-spoiling microorganisms in the bottling area.

Author: Thorsten Nowak, Bucher Unipektin AG, Niederweningen, Switzerland

However, as Narziß et al. state, membrane filters for sterilising post-filtration were already used in breweries from the mid-1960s onwards. Cellulose ester membranes with a pore size of 0.4 µm (± 0.05 µm) on carrier plates were used for sterile filtration, whilst membranes with a pore size of 1.2 µm were used for the separation of yeast cells. Regeneration of the membranes was however not yet possible back then [1].

Nowadays, cartridge filters are considered the state-of-the-art technology for sterile filtration. Either a pleated membrane or a pleated depth filter is inserted into the candle-shaped support structure during construction. By pleating the filter medium, the available filter surface is maximised while making optimum use of the space inside the cartridge [2].

The membranes used in the filter cartridges should have a pore size of ≤ 0.45 µm for cold sterile filtration to ensure reliable separation of beer-spoiling microorganisms ([3], [4]). Since membranes are absolute filters (retaining all particles above a defined size), safe separation of contaminants is guaranteed.

One or more depth filters should be installed upstream as pre-filters to avoid premature blocking of the membrane filter [5].

Established plant design and free choice of suppliers

As shown in fig. 1, Stefinox basically consists of a pre-filter and a sterile filter. In addition, a CIP filter is connected upstream of the pre-filter during the cleaning cycles to protect the filter media of pre-filter and ster-

Fig. 1 Newly developed sterile filtration plant Stefinox from Bucher Unipektin AG, Switzerland

Fig. 2 Filter cartridge with Code 7 connection (bottom), pleated membrane and fin (top) [6]

ile filter from particles in the CIP liquid.

The pre-filter connected upstream of the sterile filter is typically equipped with 0.6 µm polypropylene depth filters. This pre-filter removes larger particles and microorganisms. This protects the more expensive sterile filter membranes from potential mechanical damage caused by foreign particles in the feed and prevents premature blocking of the membranes, which significantly extends the effective filter life.

By default, Stefinox is designed to use cartridges with a standardised connection (e.g. Code 7 connection, see fig. 2). This offers the beverage producer maximum flexibility in choosing the supplier and makes them independent of expensive non-standard solutions, thus providing potential for considerable cost savings. Usually, 40" filter cartridges are used, as they offer the best ratio between the purchase price and effective filter area from an economic point of view under normal conditions. In addition, the longer 40” filter cartridges can effectively generate more filter area per slot in the filter housings than the shorter 30” filter cartridges.

Modular design on skids for fast commissioning

The filter housings and the other components of the plant, such as the control cabinet, valves, pressure and flow transmitters, are already installed and wired as far as possible on modular skids ex works. At the installation site, the skids can be easily inserted and quickly and simply assembled into a unit. Required time and costs for transport, installation, assembly and commissioning are thereby minimised.

For the process integration in cold sterilisation applications within breweries it is advised to install the plant either directly downstream of the kieselguhr filter or directly upstream of the bottle, can or keg filler. In many cases, an upstream buffer tank is not even necessary.

Individual solutions

The degree of automation of the plant is based primarily on the customer’s requirements. It is possible to install Stefinox as either a partial or fully automated system. The plant can also be designed for manual operation only, significantly reducing initial investment costs. However, partial or full automation provides benefits by increasing reliability and ease of use while reducing labour costs.

Depending on the customer’s requirements, Stefinox can be operated as a stand-alone unit or integrated into an existing control system. The choice of the underlying hardware platform (such as Siemens or Allen-Bradley) and the process control system is also up to the customer. Compatible process control systems include Braumat, brewmaxx, iFix or Simatic PCS7.

Fig. 3 shows the basic version with manually operated valves. This version is particularly attractive for smaller craft breweries that might not use the system daily or continuously. Before each filtration, a so-called “integrity test” is carried out by the operator using a hand-held device. The test result provides a clear indication about the integrity of the sterile filter membranes.

The version shown in fig. 4 is well suited for larger beverage producers with permanent filling operations or operations with a high degree of automation. This fully automated solution features pneumatically actuated valves as well as measuring devices and transmitters for pressure, flow, temperature, turbidity and conductivity. In addition, the filling status of the module housings is monitored by the process control system depending on the respective process step by employing upper and lower filling level probes.

A separate CIP station is recommended if the sterile filtration plant cannot easily be connected to the site’s CIP station, or if the brewery’s re-used detergents have too high particle loads. Furthermore, steaming the unit is possible as part of the cleaning routine.

Before each production run, the membranes of the sterile filter are subjected to a fully automatic integrity test. In this procedure, the membranes are pressurised on the unfiltered side with a pressure specified by the membrane supplier. The pressure curve is recorded over a defined period. The membranes pass the test if the pressure drops by less than a predefined value during this

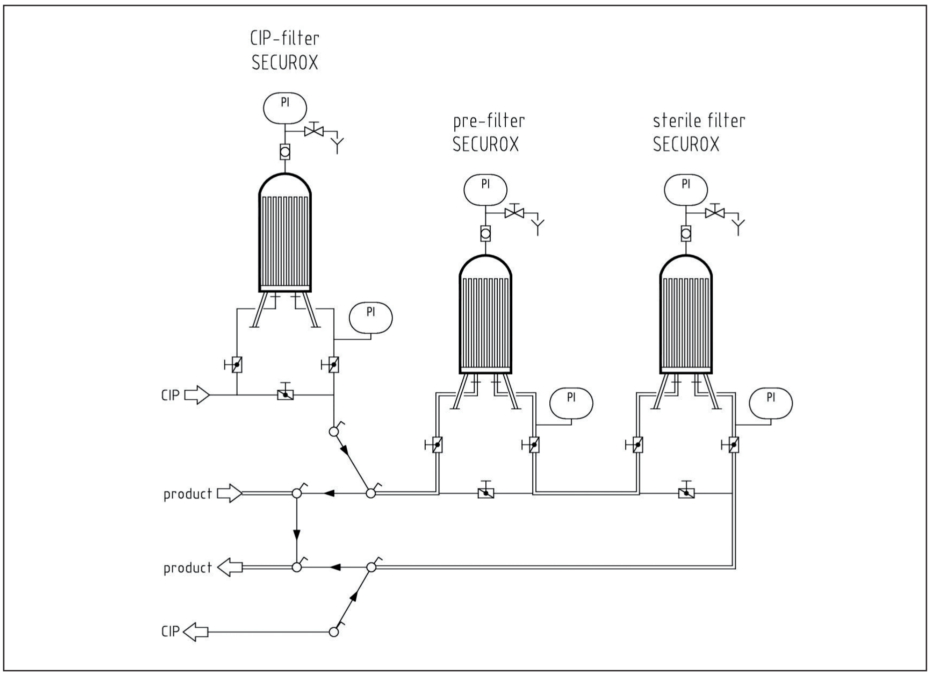

Fig. 3 Basic version of Stefinox, designed for manual operation

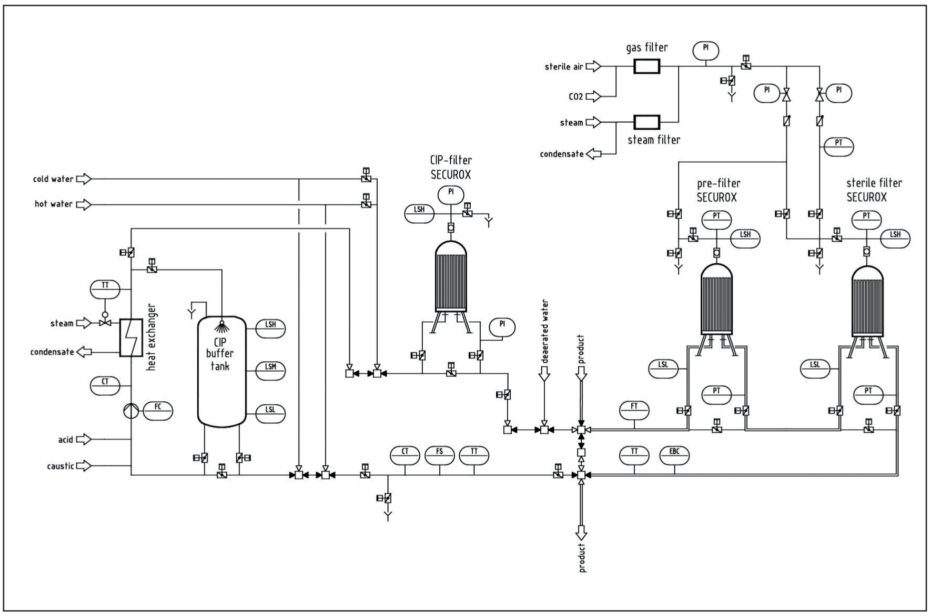

Fig. 4 Fully automated version of Stefinox with dedicated CIP station (optional)

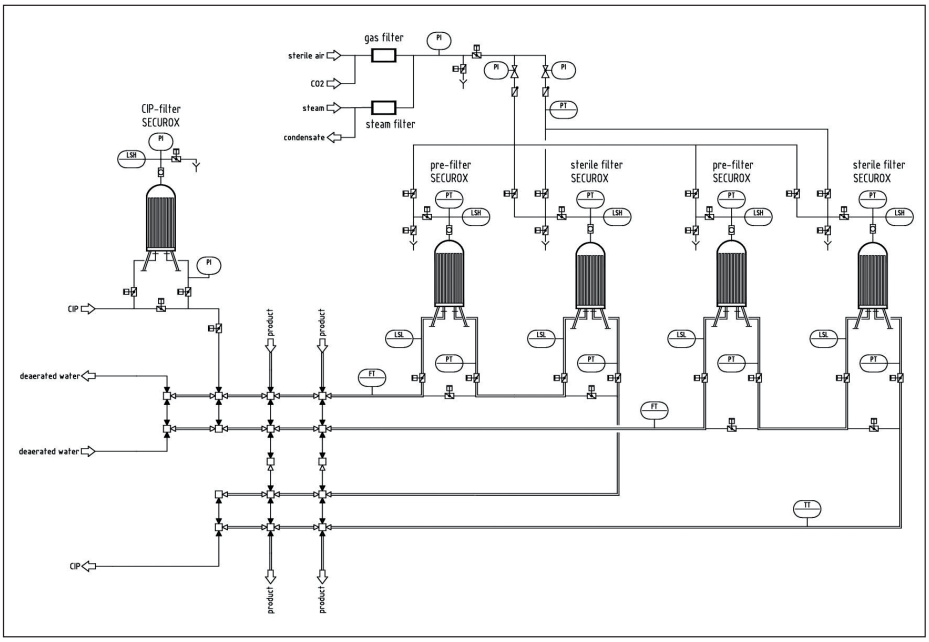

Fig. 5 Version of Stefinox for continuous operation

time, guaranteeing sufficient retention of microorganisms and particles in the next production run. The production sequence starts automatically, and the system transitions to an oxygen-free state by flushing it with CO_2 and deaerated water before filtration begins.

However, if the pressure drops below a certain level during the integrity test, the process control system informs the operator that the integrity test has failed and that the membranes may be defective. As a result, the production sequence will not start, and the operator must check the membranes. Filtration can only start after a successful integrity test.

Another possible plant concept is shown in fig. 5. This concept is particularly relevant for companies where very long and uninterrupted filling processes are the norm. One unit consists of a pre-filter and a sterile filter. As both filter housings are duplicated, one unit can be in production whilst the other one is in CIP or standby. The CIP-filter is always used by the unit currently being in CIP. Food product safety is ensured, among other things, by mixproof valves and valve combinations.

Conclusion

Using sterile filter membranes with a pore size of $\leq 0.45\ \mu m$ in combination with the obligatory integrity test before each filtration, Stefinox provides a reliable separation of undesired microorganisms and particles from the final product. These include microorganisms such as yeasts, gram negative bacteria and lactic acid bacteria, as well as kieselguhr, PVPP, metal, glass, and plastic particles.

In contrast to flash pasteurisation or tunnel pasteurisation, microbiological stabilisation with cold sterile filtration is exceptionally gentle on the product with minimal thermal stress. Beer sterile filtered using this method accordingly experiences no negative impact on quality parameters such as aroma, taste, bitterness, mouthfeel, colour or foam.

This fact pays off for the brewery in several ways: Firstly, most consumers prefer the sensory properties of cold sterile filtered beer over a thermally treated beer. Furthermore, cold sterile filtration provides a competitive advantage in targeted advertising strategies or by notes directly printed on the packaging ("cold sterile filtered beer", "unpasteurised", "original taste", ...).

This helps maintain the loyalty of the brand's customers and, at the same time, promotes the acquisition of new customers. For the producer, this can mean correspondingly higher sales volumes and, assuming sufficient price elasticity of demand, offers a valid argument for increasing the sales price, which can subsequently lead to rising profit margins. In addition to the opportunity to upgrade the quality and marketing of existing products, there are also options for product innovations, such as introducing a sterile filtered dry-hopped craft beer.

From an economic and ecological point of view, a key factor is the low energy consumption of Stefinox compared to thermal systems. Due to the low pressure loss in the plant, the electrical power requirement is in the range of only 2 to 4 Wh/hl. The saturated steam requirement for regular steaming of the plant is approximately 1 t/year. These values can be considered almost negligible compared to tunnel pasteurisation and flash pasteurisation. Consequently, the brewery's ecological footprint is also sustainably improved.

Since brand changes or plant emptying at the end of production can be performed either with CO_2 or deaerated water, the product losses and mixed phases are also at a very low level.

The system has minimal space requirements, especially compared to the tunnel pasteuriser. Therefore, it can be easily integrated into an existing bottling plant or filter cellar, even if space is limited. If Stefinox is used to replace an existing tunnel pasteuriser, the factory effectively gains usable production space.

Apart from valves and feed pump, the sophisticated plant design has no moving parts, promising trouble-free and reliable performance with low maintenance effort and easy access to all components. Moreover, as a result of the intelligent control software, Stefinox requires comparatively little attention from operators so that they can spend their working time on more labour intensive production processes.

The four standard sizes shown in fig. 6 already cover the capacity requirements of most breweries. If a filtrate flow of more than 500 hl/h is required, then several pre-filter and sterile filter units can be connected in parallel. Tailored solutions with larger housings and additional slots for more filter cartridges are also possible. Due to its modular design, the plant can be easily expanded, if required. ■

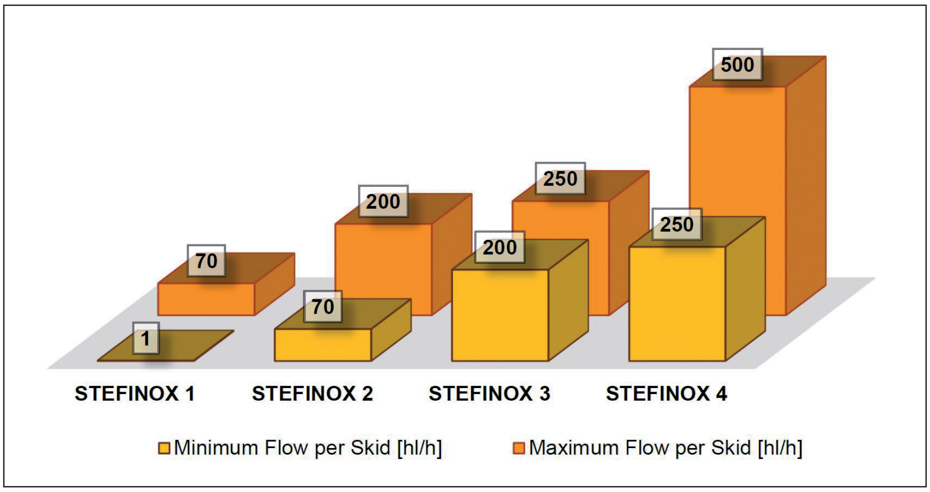

Fig. 6 **Capacity ranges of the four different housing versions of Stefinox in hl/h filtrate flow rate**

References

1. Narziß, L.; Back, W.; Gastl, M.; Zarnkow, M: Abriss der Bierbrauerei, Wiley-VCH Verlag GmbH & Co. KGaA, 2017, p. 311.
2. Freeman, G.: “Reducing Microbial Spoilage of Beer Using Filtration,” in: Brewing Microbiology: Managing Microbes, Ensuring Quality and Valorising Waste, Woodland Publishing Series in Food Science, Technology and Nutrition, 2015, pp. 245–246.
3. Narziß, L.; Back, W.; Gastl, M.; Zarnkow, M.: Abriss der Bierbrauerei, Wiley-VCH Verlag GmbH & Co. KGaA, 2017, p. 347.
4. Manger, H.-J.: “3.5.17.4 Die Membranfiltration”, in: Praxishandbuch der Brauerei, Behr’s Verlag, 2001, p. 71.
5. Freeman, G.: “Filtration and Stabilisation of Beer”, in: Brewing: New Technologies, Woodland Publishing Series in Food Science, Technology and Nutrition, 2006, pp. 282–283.
6. Filtrox AG, St. Gallen, Switzerland.