2020: The future brewery – Part 2

THE NEXT BREWERY GENERATION | In this two-part article the authors, two teachers at The Scandinavian School of Brewing in Copenhagen and their Diploma Master Brewer Class 2010/2011 present their idea of how the next generation of breweries larger than 200 000 hl/month could look like. In the first part of the series (published in BRAUWELT International No. 2 2011, p. 88 ff.) they introduced the subject, reviewed the developments in brewing over the last 70 years and began to describe the core issues for the future brewing industry, focusing on raw materials, brewhouse, yeast and fermentation. The second part covers the issues stabilisation, filtration, energy and environmental aspects, waste water, storage and packaging.

THIS ARTICLE SERIES FOCUSES ON brewers producing international lagers at 200 000 - 500 000 hl/month. It describes how the next generation of large scale breweries could look like in a logical order, following the process flow through the brewery. The first part ended with a description of fermentation issues that will be interesting for the future brewery, this second part will deal with the remaining process steps, beginning with stabilisation.

Stabilisation

Today, breweries largely rely on PVPP, Silicagel or a combination of these two chemical stabilizers. Both work well in preventing the formation of permanent hazes. They are costly, however, and require that the beer be chilled to temperatures below 0 °C to become effective.

Authors: Axel G. Kristiansen, Director of Scandinavian School of Brewing (SSB), Kim L. Johansen, Training Manager of SSB and the Diploma Master Brewer Class at SSB 2010/2011, Copenhagen, Denmark

The development of a proline-specific endo-protease type "Brewers' Clarex" from DSM, which hydrolyses the haze-active proteins, is therefore likely to replace PVPP and silica gel in the future, partly for monetary reasons, but mainly to save cooling energy, as beer treated in that way can be sent to the filter at 4 - 7 °C.

This is also advantageous in the later beer bottling operation, as typical problems with condensation of water on bottle labels can be avoided. For cheaper beers and beers with a short shelf-life, e.g. 3 months, some breweries may even consider not chemically stabilizing their beers at all. This may save chemicals and a process step, but will require to at least chill the beers before filtration.

Filtration

Kieselguhr filters (KGFs) will most likely still be around in 2020, as this technology has already been installed in most breweries, and some of them still prefer well-established technology. But newly built large-scale breweries will probably increasingly prefer cross-flow filtration (CFF), because now that the initial development challenges have been overcome, this method will clearly help reducing energy and water consumption.

Stan Bergenhenegouwen has documented the Norit solution [11]. Several CCF solutions are now commercially available. In addition, a CFF plant can be positioned right in the packaging hall, supervised by the filler operator, as CFFs are not as labour-demanding as KGFs.

Quality-wise there seems to be little difference between CFFs and KGFs, so – again – economy becomes the driving force.

Both KGFs and CFFs rely on an efficient removal of tank bottoms by a high speed centrifuge just prior to the beer filter. Recent improvements in centrifuge technology suggest that we may approach a time when some beers will already be sufficiently bright after passing the centrifuge, not requiring filtration at all.

As there will be traces of microorganisms, a pasteurisation of the centrifuged beer will no doubt become useful.

Whether the brewery uses KGF or CFF, by 2020 many breweries will finish their beers during filtration: Add spices, hops, syrups, flavours or other beers.

As mentioned in part 1 when dealing with potentially relevant brewhouse issues, breweries in 2020 will probably rather finish their beers during filtration than by genuine brewing. As the company Symrise suggests: "One single wort type" will suffice "for a variety of beer types: pilsner, stout, wheat beer, non-alcoholic beer", when adding components for flavouring (**www.symrise.com**).

The 2020 brewery might therefore need comprehensive blending facilities in the filtration department.

Beer recovery

The extract value of lost wort and beer is still too high to accept in large breweries, and the collection systems for tank bottoms and first and last runnings that are in use at present will improve. Cross flow filtration of yeast and other tank bottoms appears to

Students at SSB examining a hollow Cross Flow Filter module

become most promising, since the resulting beer may be blended in small amounts into regular beers, with the better quality flowing back into beer filtration through a flash pasteuriser.

Returns from packaging from e.g. over- and under fills will also increasingly be worth collecting. They will most likely go back to the whirlpool, as this a) saves an additional pasteurisation, b) does not affect the capacity of the brewhouse much and c) does require only a minimum of supervision and work.

Bright beer tanks

In the future brewery, the bright beer tank (BBT) farm will probably remain as such, featuring a minimum of one BBT per filter line plus one stand-by BBT. The steps final carbonation – and possibly blending – to packaging will by 2020 be stationed post-BBT, en route to the filler.

Filling and packaging

In most parts of the world the returnable glass bottle is becoming a thing of the past, and this trend is not likely to stop, except for countries where legislation favours returnable glass bottles.

PET bottles have recently improved their barrier characteristics to such quality that bottling premium beers in PET is possible, as we already see in Eastern Europe and the Baltics. More PET filling lines operating with preforms and a blowmoulder prior to the filler will be installed in future, as they may serve also for packaging soft drinks and water.

As for the packaging lines, the urge to constantly increase speed will not continue: Most breweries do not prefer glass lines faster than 60 000 bph and can lines faster than 100 000 cph. Anyway, lines already in operation with higher output are equipped with duplicate machines for EBIs, fillers and labellers.

Packaging machines are huge investments, and the practice that demands palletizer and depalletizer to have 40 - 50 percent higher capacity than the filler may well be challenged. It is expected that the palletizer/depalletizer overcapacity will reduce to 15 - 20 percent to save machine costs, space and buffer time. Consequently the demand to avoid short stops at the packaging lines which nowadays cost efficiency will increase.

Volumetric fillers will become increasingly cheap, gradually replacing classic level fillers.

Self adhesive labels and the "no-label look" will continue to be popular, which will increase packaging material costs. To compensate this, brewers will further standardize their container sizes. This way they will achieve longer filling runs and avoid costly changeovers.

Pasteurisation: Yes or no?

The world is not quite united in determining the methods of pasteurisation, let alone the question whether to pasteurise at all.

Several studies, among the one by SSB students in 2008 [10], compare microbiological safety, investments and space cost, manning demands and operational costs between flash pasteurisation and tunnel pasteurisation, but still there are no clear results. Some breweries have introduced sterile filtration instead of pasteurisation, a technology first tested in the 1980s, which has not gained much popularity ever since, because of strict hygiene requirements demanding time for additional cleaning.

Although there is not one single common global approach to pasteurisation, sterile filtration or aseptic filling, a tendency can still be made out: There will be a slow development from tunnel pasteurisation to flash pasteurisation, and some countries like Germany will opt for aseptic filling, i.e. without pasteurisation.

Brewery utilities

Until now, the utilities management of breweries has been treated rather step-

THE PAST, CURRENT AND FUTURE BREWERY

Parameter	Data year 1980	Data year 2010	Data year 2020
Farmers malt barley yield	4 t/ha	7 t/ha	8.5 t/ha
Malt consumption for 1 mio hl lager beer	16 000 t	16 000 t	0 ? (if replaced by unmalted barley)
Alfa acid content in raw hops	10 %	15 %	18 %
Bitterness in lager beer	25 BU	20 BU	16 BU
Heat consumption	40 kWh / hl	20 kWh / hl	15 kWh / hl
Electricity consumption	13 kWh / hl	9 kWh / hl	7 kWh / hl
Factor water / beer	9 hl / hl	4 hl / hl	3 hl / hl
Consumption of yeast	1 kg / hl wort	1 kg / hl wort	1 kg / hl wort
Yeast re-production	2.7	2.0	1.7
Extract loss in entire brewery	15 %	7 %	4 %
Productivity	2000 hl / FTE	20 000 hl / FTE	30 000 hl / FTE
Packaging line utilisation	70 %	70 %	80 %
Biogas amount of total heat supply	0 %	7 %	15 %

Table 1

SSB Students examining a label magazine

SSB students monitoring CO_2 flow

motherly, but future breweries will need to focus on this department, as

- cost of utilities is rising faster than inflation;
- environmental demands increase;
- utilities are increasingly becoming a new target for cost reductions, like brewing and beer processing have already been for a while.

"Sustainability" will become an even hotter topic than it already is today, something to consider before major investments and decisions are made. There are some main issues the breweries of the future will have to consider:

- **heat supply:** Gas boilers not delivering 96 percent efficiency will be improved or replaced. Newer boiler type economizers will allow for a smoke temperature < 50 °C. Condensate return systems for steam boilers will become more efficient, and volume targets for returned condensate will increase;
- **power:** Electricity supply will still mostly come from the national grid, but some breweries will find it economically attractive to install a Combined Heat and Power (CHP) plant. A CHP plant designed to supply the needed heat will normally deliver more than the needed electricity, so the brewery will need to sell electricity, if it runs a CHP plant;
- **cooling:** The use of underground brewery plants will become attractive in order to chill the cooling circuit, except for tropical areas. A move from two-stage cooling circuits to one-stage cooling circuits is only expected to a greater extent by direct NH_3 evaporation.
- **CO_2:** CO_2 recovery will still only be installed if economically attractive. The breweries' CO_2 supply plant will be of the "Liquivap"-type which helps re-using cooling energy from evaporating CO_2;
- **water:** Efforts already spent to reduce the water : beer factor from nowadays approx. 4 : 1 will continue, and a target of 3 : 1 will become achievable for many breweries by 2020;
- **materials:** Stainless steel will loose its monopoly as the preferred material for hygienic tanks and pipe construction for beverages, water and even steam supply, as new food-grade polyethylene (PE) materials will be available, which will be able to withstand high and low temperatures and chemicals and which will offer longer life than stainless steel.

Waste water treatment

The technology for anaerobic WWTP producing biogas supplying 15 percent of the brewery needs for boiler gas is in place. Many implementations of this concept are to be expected, as it serves both energy conservation (environment) and cost savings.

Brewery production waste will become increasingly valuable, as it becomes possible to generate biogas from more waste sources like spent grains and surplus yeast as suggested by *Günther Pesta* [13].

Storage and distribution

The just-in-time (JIT) principle is not exactly new, but still some breweries may benefit from shorter storage time for all material supplies and for finished products.

To achieve a good JIT rate, a fast rotation of raw material and packaging material is required, but the benefits are clear: Reduced work-in-progress = reduced cash demand.

Malt storage for only 24 hours is manageable, and empty cans and disposable bottles may arrive continuously as needed, leaving no stock, as long as the suppliers carry a preferred supplier status and can guarantee the quality for each batch.

High-bay warehouses will prevail in some breweries, where price of land or plant transport costs are high. For other breweries the concept of no warehouse at all may become attractive, demanding trucks / trains ready to be filled directly from packaging lines. Large breweries will more and more seek to avoid depots and opt for direct store distribution (DSD) from packaging lines to large supermarkets. Wherever this is possible, much time and value of stock can be saved. In practice, a brewery may operate direct supply delivery to large supermarkets and at the same time continue to distribute from a picking area for smaller customers.

Conclusion and outlook

Going through the entire brewery in the flow of the manufacturing process as documented in this two-part article has shown that substantial improvements concerning consumption are still achievable. Table 1 shows some data and estimates for the past, the present and the future brewery. Operators will increasingly also do maintenance jobs, weekly planning of production, weekly call-off of supplies of raw and packaging materials and quality assurance jobs. Only few untrained operators will remain in the brewery, as the breweries will probably drive automation further. Large breweries face many challenges. Many have in the past been overcome by capital investment projects driven by the desire for new technology, often offering less manual work which

in turn also led to staff reduction. As seen from above, still much improvement work is possible at no or little capital investment costs, for example higher HGB degrees, thicker mashes, reduced yeast reproduction and more blending of final beer at the filtration stage, to mention but a few. Perhaps a brewery of the future should keep in mind that this type of work needs even more attention, and perhaps more educated and experienced brewery staff will be needed to manage these process optimisations. ■

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