FIRST INDUSTRIAL RESULTS OF CONTINUOUS WORT PRODUCTION

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ABSTRACT

In the last two decades, major advances in performance have been achieved in batch brewhouses mainly by introducing fine milling technology. For example, the productivity of brewhouses increased from 8-0 brews per day to 14 brews per day and even more when equipped with a Meura 2001 mash filter. Despite these important improvements to the batch brewhouses, breweries keep asking for further productivity increases together with a reduction of utilities consumption and waste disposal. The likelihood of further improvements using the current method of batch brewing is limited. Only a conceptual change can respond to the current and future demands of the brewing industry. These inquiries made Meura rethink the brewhouse technology and ended in a continuous brewhouse concept.

The first industrial plant was successfully started up in May 2007. A second plant was commissioned in Suzhou (China) in April 2008 and several other projects are under discussion.

Keywords: waste disposal, utilities consumption, productivity

INTRODUCTION

Reasons to develop a continuous brewhouse

The idea of a continuous brewhouse is not a recent topic. In the sixties, some continuous brewing systems were installed at pilot and even industrial scale, but these were progressively aborted for different reasons.

The current changes in the brewing industry lead to several reasons to develop continuous brewhouses:

- ***Pressure on the commodity costs***
  The increase in oil and other commodity prices is putting pressure on the industry to reduce the consumption of utilities. Furthermore, the costs of raw materials have also increased.

- ***Sustainability***
  The extended consumption of utilities during the wort production leads to a large CO_2 footprint. A sustainable industry needs to aspire to implement the most efficient technologies. Beer processing also consumes a significant amount of drinking water, which is becoming scarce in more and more areas. The pressure from society to reduce wastewater is increasing.

- ***Downstream product differentiation***
  In the last decade, high gravity (and even very high gravity) brewing has become an industry standard within the large lager breweries. One of the consequences is that product differentiation is done downstream in the production process at the beer filtration step and finally, the variation of wort types in the brewhouse are decreasing. The major criticism to the continuous process, a lack in flexibility, is therefore no longer an issue.

- ***Increased plant capacities***
  With the consolidation and concentration of the brewing industry, the breweries' average production capacities are increasing. Brewhouses with batch sizes larger than 1200hl are becoming more common and this is close to the maximum workable size. For higher capacities the brewhouse has to be doubled, which is costly from the investment and operational points of view.

History of the Meurabrew development

In 1998, Meura started the development of the continuous brewing concept. A complete pilot plant was installed in 1999.

Fig. 1 Meurabrew

The first results focusing on a continuous boiling step were published at the EBC congress in 2001[1]. Pilot trials of the full continuous brewhouse process were presented at the following EBC congress in 2003[2].

Based on these successful pilot trials, Meura's engineering department began designing an industrial plant in 2004. With information gained, it was possible to start looking for a 'first mover'.

In 2005, the discussions started with Jan Martens in Belgium, leading to an order in June 2006. The first operation of the Meurabrew on an industrial scale of 200hl/h wort (up to 20°P) took place on 12 May 2007. In January 2007 a similar order was obtained for a plant in Suzhou (China).

The industrial results described in this article are based on the figures from the plant installed in Belgium.

Continuous *vs* batch

Continuous processes are used in several food industries, for example in the continuous extraction and processing of vegetable oils or the continuous processing of Ricotta cheese[3].

In general, continuous processes are more energy efficient, easier to control and consequently lead to a lower production cost. As far as the brewhouse process is concerned, here are the main specific reasons to develop a continuous brewhouse:

- ***Reduced peak consumption of utilities***
  The most important utilities consumed in the brewhouse are steam and cooling liquid. In a batch brewhouse, different batches are processed at the same time and consequently lead to a large steam peak. The wort cooling takes place normally within 50-60 minutes, which means peak consumption during that period.

- ***Reduced energy and extract losses***
  All pipes and vessels stay continuously filled with mash or wort, which makes it possible to avoid the heat and extract losses experienced in batch processes.

- ***Reduced waste disposal***
  During the production no drainage occurs, which considerably reduces the wastewater volume.

- ***Limited space requirements***
  The most state-of-the-art batch brewhouses only brew about 14 batches a day. About every 100 minutes one batch is produced, which consequently requires vessels that can handle the necessary volumes. Brewhouse vessels of a large size also mean large piping diameters, large-sized valves and pumps at the high flows. A continuous flow significantly reduces the plant dimensions.

- ***Easy process control***
  In practice, it is difficult to have the same process conditions between similar batches. The fouling of the mash tun/s and wort kettle during production alters the heating performance of these vessels and thus changes the process conditions. Consequently a significant variation in, for example colour or bitterness, is noted between batches of the same brands. These fluctuations are avoided with a continuous process.

Table I shows a comparison between a batch brewhouse at 12 brews a day and a continuous brewhouse for a brewery with 3 million hl final capacity.

TABLE I Comparison of a 3 million hl final capacity at 12°P		
	Batch brewhouse	**Continuous brewhouse**
Capacity	12 brews/day of 400 hl cold wort at 20°P	200 hl/h of cold wort at 20°P
Pumps		
Mash	1500 hl/h – 15 KW	180 hl/h – 5,5 KW
Wort	3600 hl/h – 30 KW	225 hl/h – 4 KW
Utilities		
Steam peak flow	14 T/h	3T/h
water peak flow	650 hl/h	220 hl/h
Electricity installed	375 kW	250 kW
Electricity peak	300 KW	200 KW
Peak cooling power	4.650 kW	2.200 kW

THE MEURABREW

Part of the 'Brewery of the Future' concept

The first industrial Meurabrew installed in Bocholt (Belgium) is part of the 'brewery of the future' concept, which is a combination of the process technologies of Meura (brewhouse) and Norit (cold block including membrane filtration and utilities) and continued with a Sidel PET bottling plant. The brewery of the future at Martens is a 3 million hectolitres brewery, combining the most innovative technologies on the market. Measuring only 200 metres by 350 metres, the plant houses raw material storage and treatment, milling room, brewhouse, fermentation, beer filtration, yeast management, wastewater treatment and all utilities. The entire operation is managed by 45 people, with just two staff members per shift to run the brewing operation from raw material intake to filtered beer during the daytime. This first industrial Meurabrew is designed to produce 200hl/h cold wort at a density up to 20°P. The plant is able to handle different recipes from 100% malt brews up to brews with 40% of adjuncts. On a weekly basis a maximum of 31200hl at 20°P cold wort can be produced. After 6.5 days of production the brewhouse is cleaned during less than 12 hours and restarted again.

The continuous brewhouse is connected to a batch fermentation process. Every 24 hours one fermenting vessel of 4800hl net is filled.

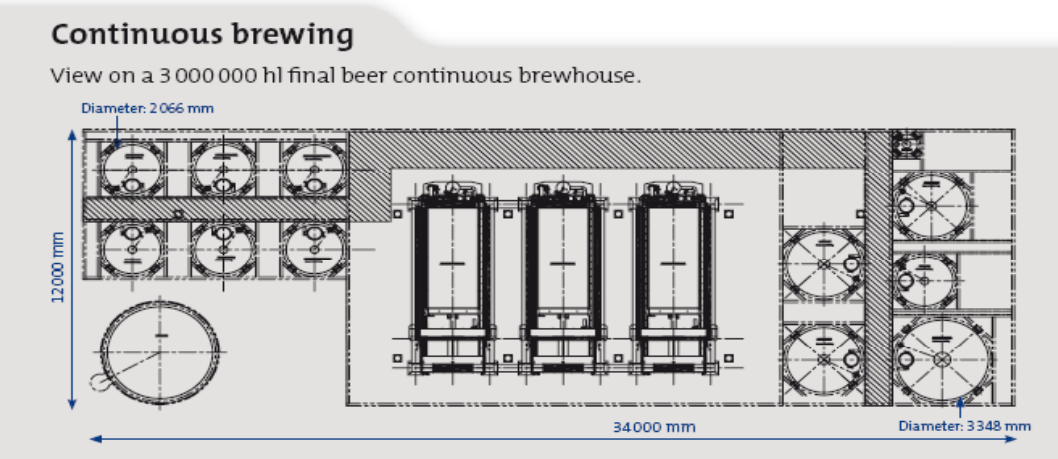

Fig. 2 Continuous brewing

Principle of the Meurabrew

As mentioned in the introduction, it took almost 10 years between the first research and the industrialisation of the Meurabrew. Nevertheless, during that period most of the proposed technologies were first industrialised in batch brewhouses. In fact, the Meurabrew is a combination of Meura's proven technologies that have been adapted to a continuous set-up.

Fig. 3 shows the first part of the Meurabrew from milling to mash filtration using the following technologies:

Milling: Meura's Classicmill or Carbomill is perfectly able to work in a continuous system.

Mashing-in and mashing: The Mechamasher provides a continuous lump free mash that will be pumped to the mash unit. Different mash vessels keep the mash at a constant temperature with a specific holding time. A continuous flow passes through these vessels and ensures the brew diagram. Thanks to the Aflosjet system, Meura's patented direct steam heating system, these vessels do not need to be cleaned during the production process. Foolproof mash heating is required for the continuous process. Classical double jackets are thus not an option.

Mash Filtration: Wort filtration is performed with Meura 2001 mash filters equipped with Meuraclean; three parallel filters ensure a regular continuous filtration process. Consequently all the renowned advantages of the Meura 2001, for example the highest yield, wort quality and density, are retained with the Meurabrew.

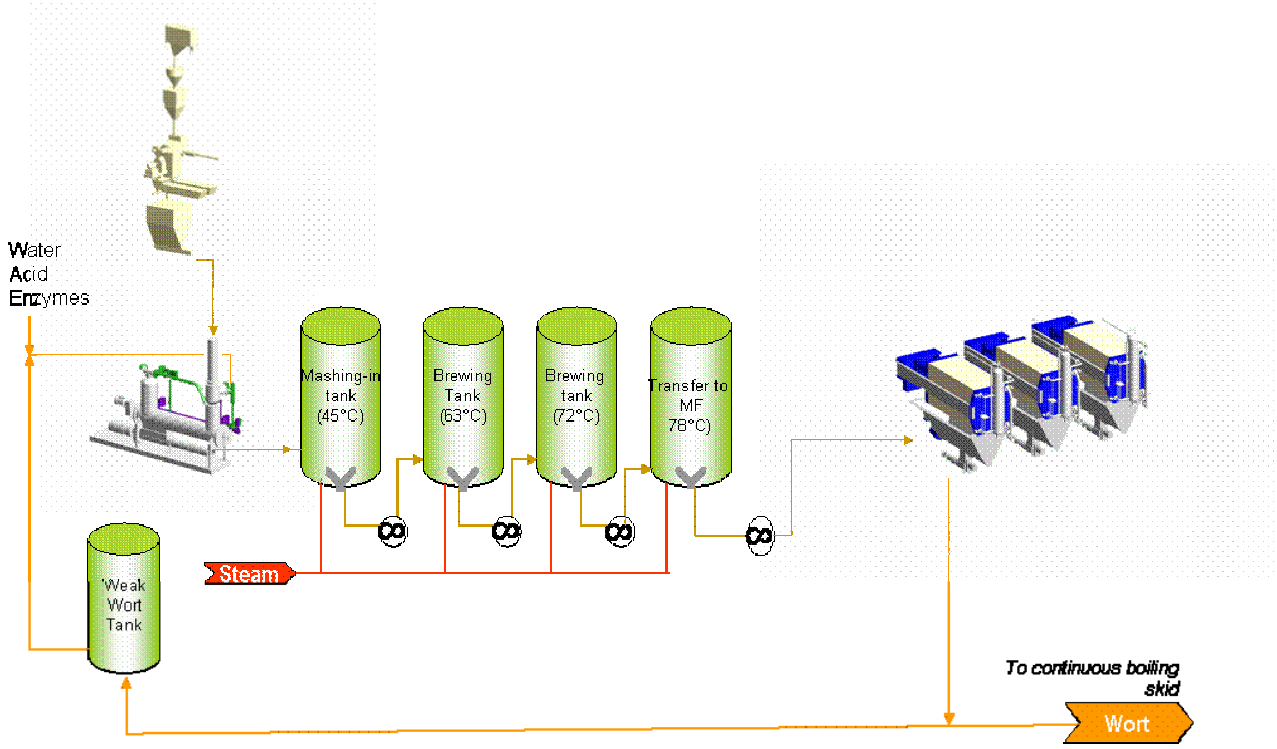

Fig. 3 From milling up to mash filtration

Wort boiling and trub recovery: As the first step, the wort is in-line heated up to its boiling temperature. Added hops are also homogenised. An adapted agitator ensures sufficient mixing for the trub formation. Among other chemical/biochemical reactions, the SMM is turned into DMS. An external agitation must be provided. The wort is clarified by a continuous Clarisaver in the next step. Clarification is necessarily done prior to stripping in order to avoid fouling the column with hot trub. From the clarification unit, the wort is then stripped by the Ecostripper, which is a single pass stripping column. The unwanted volatiles are stripped by a counter flow of live clean steam. From the bottom of the stripping column, the stripped wort is continuously pumped through.

Wort cooling: Two wort coolers in parallel ensure continuous cooling of the wort. Since fouling is unavoidable one wort cooler is cleaned when the other is cooling the wort. ***Fig. 4*** shows the second part of the Meurabrew using the following technologies.

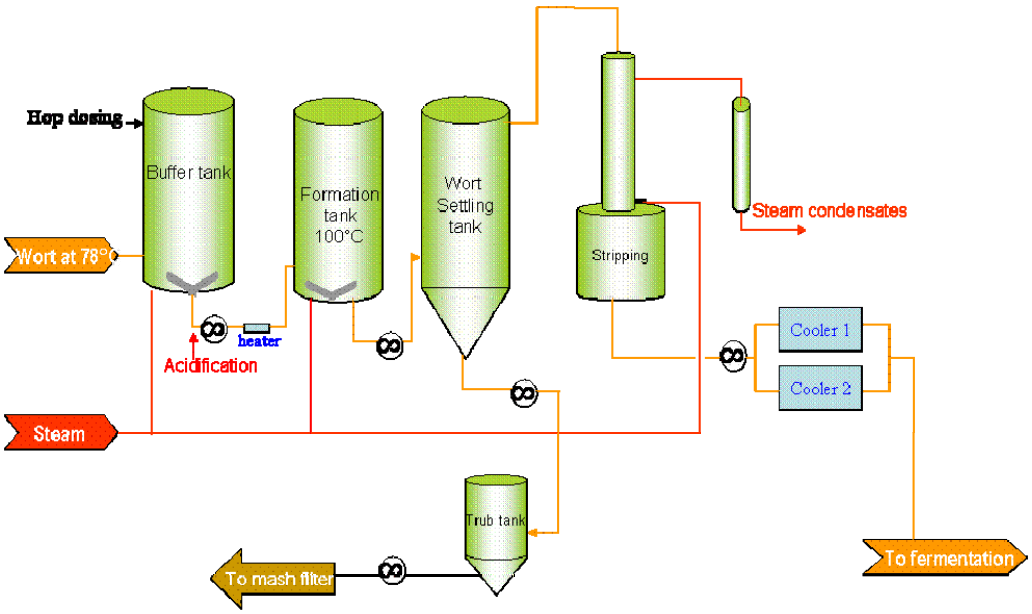

Fig. 4 Continuous wort boiling and hot trub separation

THE FIRST INDUSTRIAL RESULTS

The first industrial results of the new brewery are quite promising and confirm the assumptions that were made. All the figures have been recalculated to hl of final beer. The final beer has an 11.5°P original gravity. The figures given were obtained from a measuring campaign during July 2007. That was only two months after the first production day and these figures may improve even further.

- **Water consumption**
  Depending on the type of process and bottling, a state-of-the-art brewery consumes between 4hl and 6hl of water per hl of beer sold. **Table II** shows the water consumption at the beginning of the year 2008.

TABLE II **Water consumption per hl final beer**		
Brewing and process water	2,56	hl/hl
Process water bottling	0,25	hl/hl
TOTAL	**2,81**	**hl/hl**

  At this moment, no system to re-use wastewater is in operation. However, in the future the brewery intends to partially treat wastewater and re-use it for the production. It is estimated that the final water consumption after that implementation will be below 2.0hl/hl.

- **Electrical Energy**
  A modern batch brewery consumes about 10-12kWh per hl of beer brewed. The electrical consumption costs depend not only on the total consumption of kWh electricity per hl of beer, but also on the peak consumption. Thanks to the Meurabrew, electrical consumption peaks in the brewhouse are negligible.

Table III shows the electrical energy consumption of the complete brewery of the future. Taking out the consumption for the PET bottle blowing it can be considered that the plant has about half the consumption compared to a traditional brewery.

TABLE III **Electrical energy in kwh/hl**		
Brewing process	3,50	kwh/hl
Bottling (excl. PET blowing)	1,17	kwh/hl
TOTAL	**4,67**	**kwh/hl**

- **Thermal Energy**
  The consumption of thermal energy in a state-of-the-art batch brewery is between 25kWh and 30kWh per hl of beer brewed. **Table IV** shows the average thermal energy of the complete brewery of the future during July 2007. Steam is generated with natural gas as the fuel source.

TABLE IV **Thermal energy in kwh/hl**		
Brewing process	11,03	kHz/hl
Bottling (excl. PET blowing)	1,22	kwh/hl
TOTAL	**12,25**	**kwh/hl**

- **Extract losses**
  The Meurabrew itself uses the Meura hammer mill together with the Meura 2001 thin bed mash filter. This combination, thanks to the fine milling, attains at least the laboratory yield. Moreover, in combination with the Clarisaver, which allows trub recycling, the brewhouse losses are negligible. Further, thanks to the membrane filtration in the cold block, there is no pre- or post-run and no losses of beer as with beer filtered the traditional way with kieselguhr. Another cost-saving feature is that the brewery is designed to recover the beer from surplus yeast. In total the final target of the average extract losses from malt intake up to the final bottle of beer is less than 2.5%. A state-of-the-art batch brewery loses more than twice this amount.

SUMMARY

The brewing industry requires increased productivity from the brewhouse manufacturers together with a reduction of the consumption of utilities and waste disposal. The current method of batch brewing has limited room for further improvement and the only answer is a conceptual change to the current and future demands of the brewing industry.

Meurabrew's industrial results show that they combine a number of exceptional performance features responding to the demands of the breweries, such as:

- consumption of water, electricity and steam cut in half at least
- considerable reduction of wastewater
- no peak load in utilities
- better productivity (one CIP per week)
- drastic reduction in oxidation of mash and wort
- improved consistency in the products parameters
- very limited extract losses.

ACKNOWLEDEMENTS

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Furthermore we want to take this opportunity to congratulate the Martens Brewery on their 250 years anniversary!

Thanks also to the colleagues of Meura and Meura Technologies involved in the development of this revolutionary technology.

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