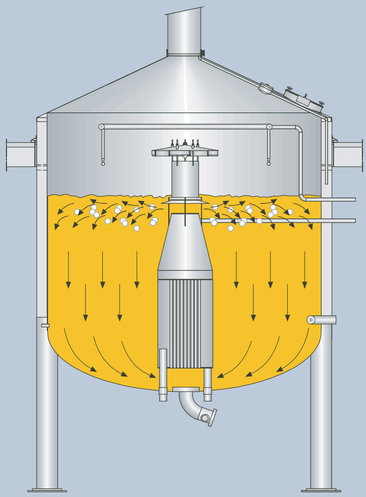
Jetstar: The new generation of internal boilers

Huppmann has developed a new internal boiler that has caught the attention of brewing experts: the Jetstar. With 2-phase boiling in combination with the innovative subjet system, the Jetstar is setting new standards in terms of wort quality and efficiency, also in atmospheric systems. The Jetstar can easily be retrofitted to any wort kettle with internal boiler. Thus, the innovative technology of 2-phase boiling is also available for conventional atmospheric systems.
In the following we have summarized the most important details about this superior technology.

Subjet orifice and two-level wort spreader of the Jetstar

Homogeneity of wort treatment

According to Schwill-Miedaner and Miedaner [1], "a basic requirement for constant wort quality is wort in which the contents are homogenously distributed during the boiling process". To meet this requirement, the equipment manufacturers have continually optimised their internal boiler systems. Particularly the heating phase from lautering temperature to boiling temperature is critical. Long dwell times connected with increased thermal load in the boiler tubes can occur when the wort is distributed unevenly in the kettle and is thus heated unevenly. This can largely be prevented by discharging the wort below the wort level with the so-called “subjet“.The new boiling system from Huppmann operates with this principle. The results of the new internal boiler system “Jetstar“ are presented below.



Jetstar during heating-up and in the first phase, the thermal conversion

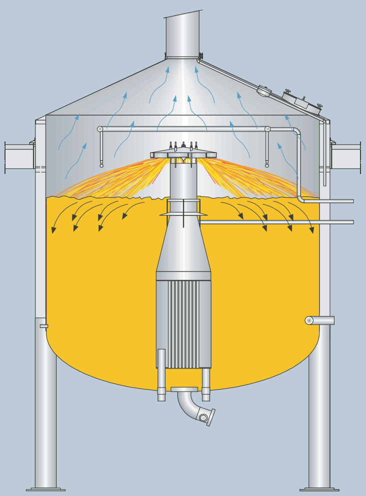
Heating-up

In the presented case, transfer from the pre-run tank to the wort kettle is carried out within 20 minutes for all brews using a wort heater with an energy storage system up to 92 °C. At a kettle volume of 500 hl, heating-up commences with the wort being discharged through the subjet orifice (see Figure 1).

Two-phase boiling

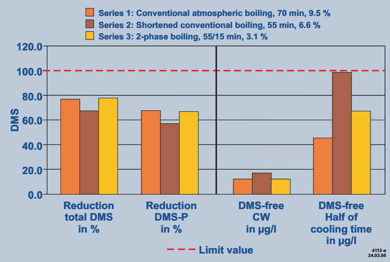
Thanks to the subjet orifice, it is possible for the first time to divide the wort boiling process into two phases with an internal boiler with natural circulation.

Phase 1. Thermal conversion: During this phase, wort flows out of the boiler through the subjet orifice below the wort level. The known processes such as hop isomerization, protein coagulation, degradation of flavour precursors (e.g. DMS precursor), sterilization, flavour and aroma formation take place with the temperature in the work kettle required for these processes. Homogeneous temperature distribution is achieved throughout the entire content of the kettle by gentle circulation. The boiler is pressurized only very slightly during this phase because it is not required to overcome a pumping height for circulation.
High circulation rates combined with the low interfacial temperature conserve the foam-positive substances. The steam bubbles produced in the boiler tube provide for a high momentum exchange below the wort surface thanks to the two-phase flow at the boiler outlet. At the same time, the steam bubbles condense again in the wort, and only very little evaporation occurs. Due to the homogeneous distribution in the kettle, the duration of this thermal conversion can be selected irrespective of the required evaporation. Depending on the content of flavour precursors, thermal conversion generally lasts 50 to 60 minutes. The goal is to reduce the precursors of undesired flavours as far as possible. The evaporation of flavours takes place in the following evaporation phase.

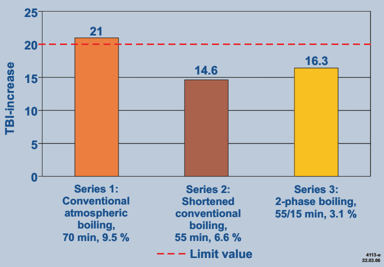


In phase 2, discharging via the two-level wort spreader ensures intensive evaporation

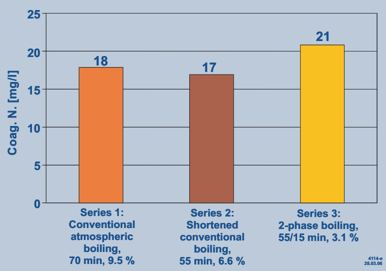
Phase 2. For evaporation, the lower outlet is closed and the upper one is opened. Using simple steam regulation, circulation via the two-level wort spreader commences. The large surface created thereby enables intensive evaporation of the flavours. Depending on the desired final values and the target original gravity, this evaporation phase continues for 10 to 20 minutes.
Due to the intensive degradation of the DMS precursor during the thermal conversion phase, a relatively low evaporation rate suffices to achieve the desired values of free DMS and other flavours in the finished wort. Thanks to the consistent division of boiling into two phases, it is possible to reduce total evaporation to values under 4% without difficulty. An input of additional evaporation energy during phase 1 would not accelerate the degradation of flavour precursors at all. Evaporation of the substances is not necessary at this time, because the degradation reaction is not inhibited by the content of free DMS. Only a temperature increase of the wort by increasing the pressure in the kettle space can accelerate the decomposition processes further and thus shorten the cycle time. The combination of dynamic low-pressure boiling with the Jetstar will open up new possibilities.



DMS precursor and free DMS during 2-phase boiling with the Jetstar



Significant: the smaller thermal load during 2-phase boiling



The coagulable nitrogen ratios also indicate a smaller thermal load.

Trial results

In the Löwenbräu Brewery in Munich, part of the InBev Germany group, trials were conducted with light lager in a conventional wort kettle, with a volume of 710 hl cast wort. The ideal technology was determined in a series of preliminary trials. The two boiling phases were optimally adjusted to each other. The values determined in this manner were compared with those of conventional boiling over 70 minutes, with evaporation rates of 8-9 %. The same raw materials were used to ensure comparability of the analyses. As a further trial, the existing boiling process was simply shortened in order to operate with 6 % evaporation with a boiling cycle of 55 minutes. This procedure is widely used in practice. The goal was to show that it is possible to save energy by simply reducing the boiling time, however not without reducing wort quality. To ensure the comparability of the brews, heating-up was carried out with the same procedure for all brews. Different procedures were used only after the boiling temperature was reached. It was possible to double the ramp rate from 0.6 K/min to 1.2 K/min without impairing the protein ratios. Despite the high heating-up power, the content of the kettle did not foam at all.

DMS ratios

As representative of the wort flavours, the behaviour of the DMS precursor was examined. The diagram clearly shows the efficiency of precursor decomposition in the different procedures. Irrespective of evaporation, it was possible to reduce the total DMS by approximately 77 % and the DMS precursor by approximately 67 % with the same dwell time of 70 minutes. On the other hand, the shortened boiling time of 55 min led to a reduction of only 67 % or 57 %. Therefore the same results were achieved with the reduced energy input of 3.1 % total evaporation as with 9.5 %. It is astonishing that this also applies to the free DMS during casting. An absolute value of 12 g/l on average was achieved in both cases. With a value of 17 g/l during casting, reduced boiling did not perform poorly either. However, the known phenomenon of reproduction of free DMS in the whirlpool occurs here. Midway through wort cooling, the value of 98 g/l was just under the threshold value of minor 100 g/l. In contrast, the other two procedures were both under 70 g/l.

Thermal load: TBI

Parallel to this, the TBI increase is interesting. As expected, conventional boiling showed the worst performance. Here the increase from kettle-full to end of boiling was 21 units. The lowest increase of 15 units occurred with the shortest total time of 55 minutes. However, the Jetstar two-phase boiling showed a much smaller increase of 16 units with a total time of 70 minutes, than conventional boiling with 70 minutes. This illustrates the extremely gentle, homogeneous circulation of the wort with the Jetstar.

Coagulable nitrogen

In the preliminary trials it was possible to set the content of coagulable nitrogen at the end of boiling in ranges of 1.8 to 4.3 mg/l. The appropriate optimum value must be determined based on the head retention and cold stability for the respective plant. It is known that the value of the still coagulable nitrogen, the parameter for good or bad beer foam until now, can be used as an indication at best. The possibility to influence this value deliberately is decisive. The degradation rates from kettle-full to the end of boiling were 55 % for conventional boiling, 54 % for shortened boiling and 51 % for two-phase boiling. The absolute content during conventional boiling of 18 mg/l was certainly at the lower limit of the desired range of 15 to 25 mg/l (diagram). However, beers with perfectly satisfactory foam values also resulted from these worts. The shortened boiling time of 55 minutes yielded a value of 17 mg/l on average; two-phase boiling produced 21 mg/l. An improvement is noticeable in combination with the reduced thermal load.

Conclusion

The Jetstar enables two-phase boiling with an internal boiler with natural circulation for the first time. This means the separation of thermal conversion processes and necessary vaporization (evaporation) in an atmospheric wort kettle. Thanks to the thermosiphoning principle, the wort is subjected to a very gentle and homogenous treatment. Technological advantages are achieved through the minimized heat load during pulsation-free heating. Greatly reduced steam temperatures are also used during thermal conversion. The desired analytical parameters can be set deliberately and separately from one another. The homogeneous temperature distribution in the kettle guarantees high conversion rates. Evaporation is carried out effectively via the large surface of the two-level wort spreader.
In view of system design, the Jetstar can be easily retrofitted without much installation effort and without additional consumption of electric energy. The hygienic design ensures excellent cleaning properties. Thanks to the small thermal load, daily intermediate cleaning is not necessary. Thus, the costs for water and cleaning agents can be minimized. The primary energy savings are not reduced by the use of other energy forms. When an energy storage system is used, the hot water balance is closed within the brewhouse. Thus complete condensation of the vapour is possible also during atmospheric boiling.

Installation and retrofitting

The Jetstar can be installed with little downtime. If the design data of the existing tubular boiler are right, a new optimized outlet cone for improved flow with a two-level wort spreader is mounted on the existing boiler. The subjet orifice is located in the upper part of the outlet cone below the wort level during casting. Variations in the cast-out quantity can be compensated for by a simple mechanism. Depending on the kettle design, the mechanical equipment for opening and closing the two outlets is installed on the kettle bottom or at the kettle outlet.

References

Löwenbräu 1, Munich, Germany; Löwenbräu 2, Munich, Germany; Alken-Maes, Alken, Belgium; Martens, Bocholt, Belgium; Stralsunder, Stralsund, Germany; Kompania Pivowarska, Byalistok, Poland; Kompania Pivowarska, Tychy, Poland; Kulmbacher Kulmbach, Germany; Nordbräu, Ingolstadt, Germany; Newlands, Cape Town, South Africa; Oettinger, Oettingen, Germany; Oettinger, Mönchengladbach, Germany;

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[1] Schwill-Miedaner, A. and Miedaner, H., Würzekochung – heutiger Stand der Technologie und Technik, Brauwelt 141 (2001), 18, 670 - 673

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Huppmann AG, 97318 Kitzingen, Germany, Phone: +49 9321 303-0, Fax: +49 9321 303-603, e-mail: sales@huppmann.com, www.huppmann.com