Experience with wort precooling at the Kulmbacher Brewery

WORT PRECOOLING | In the summer of 2005, the Kulmbacher Brewery made the decision to retrofit their new brewhouse, manufactured by Huppmann, with a wort precooling system. Tests were conducted on-site during normal operation and were designed to evaluate the efficiency of the wort precooling system with regard to a reduction in DMS-P degradation and lower thermal stress to the wort, while sustaining coagulable nitrogen levels.

A REDUCTION IN THERMAL STRESS has been attributed to precooling measures during wort production and has become an established practice in numerous breweries. *Coors* and *Krottenthaler* [1] first described the positive effects of wort precooling on DMS formation and thermal stress in 2003. In 2005, the research of *Ogane*, et al. [2] confirmed the advantages of a reduction in wort temperature after casting out. The lower concentrations of Strecker aldehydes and wort aroma compounds positively impact the flavor stability of the beer. Additionally, incorporating a wort precooling system into an existing brewhouse is both simple and economical.

Quality parameters during wort handling

Throughout the entire wort boiling process, DMS-P is converted to free DMS and is liberated through evaporation. The elimination of free DMS from the wort occurs much more rapidly than its formation in the wort. For this reason, the formation of free DMS is not a concern during boiling due to continuous evaporation. By contrast, only a very small amount of evaporation takes place in the whirlpool. The concentration of free DMS increases in the whirlpool, the vast majority of which remains in the wort. The thermal stress to the wort, reflected in the thiobarbituric acid number, increases while the wort is in the whirlpool. Thermal stress to the wort is directly proportional to time and temperature. The loss of coagulable nitrogen, positive for foam characteristics, parallels thermal stress to the wort. In order to suppress the formation of free DMS and to reduce the thermal stress to the wort, Huppmann developed the process of wort precooling.

Function

Using the wort precooling system installed by Huppmann, a portion of the hot cast-out wort is sent directly from the whirlpool to the wort chiller, where it is immediately cooled. This cooled portion is then redirected into the primary stream of hot wort entering the whirlpool from the wort kettle. After mixing, the temperature of the total volume of wort in the whirlpool is 89 °C. This process is depicted in Fig. 1. A standard plate and frame wort chiller, already present in most breweries for chilling wort, is utilized for this purpose. In daily brewhouse operations, it has

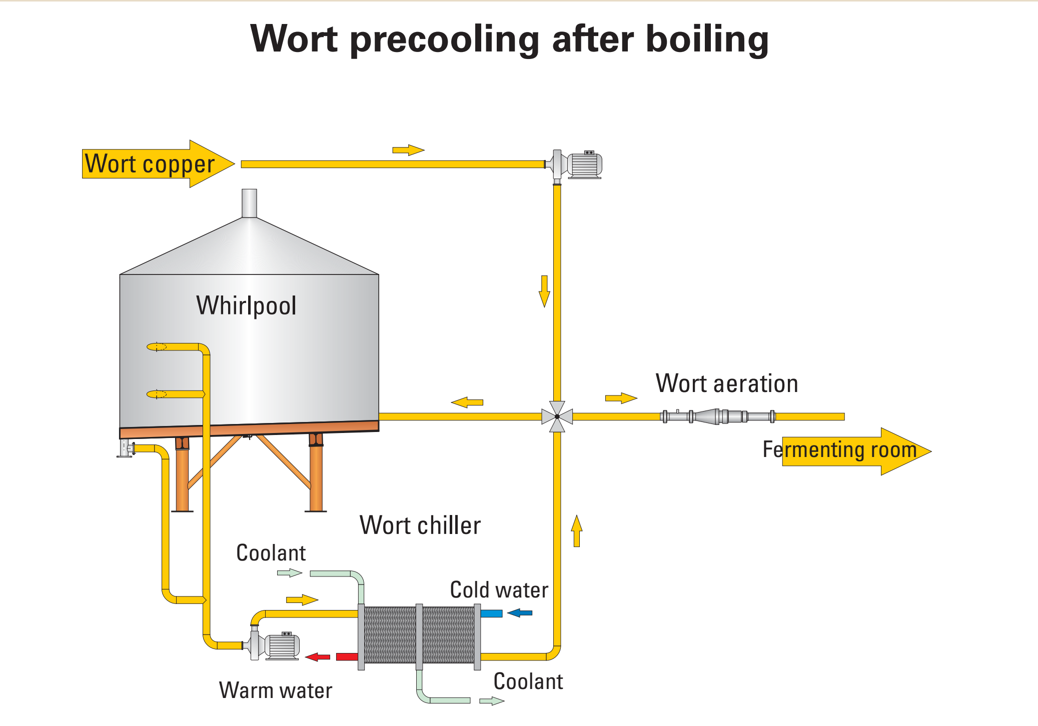

Fig. 1 Flow diagram of the wort precooling process

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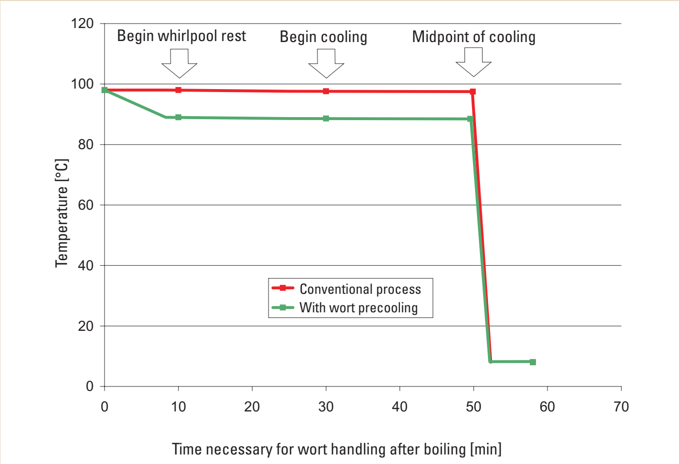

Fig. 2 Time vs. temperature for wort handling after boiling

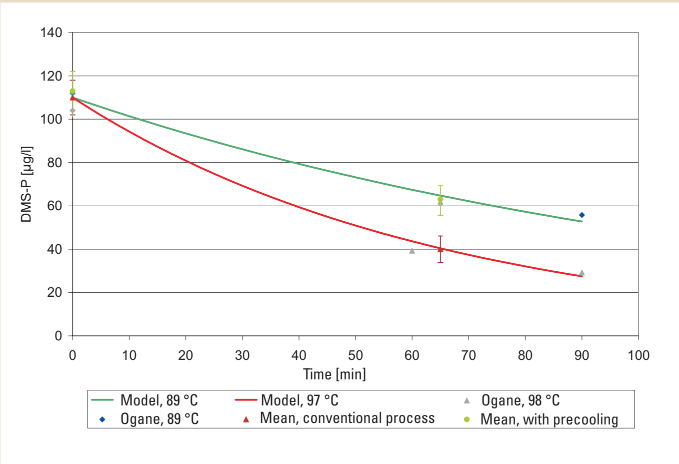

Fig. 3 DMS-P degradation during wort handling after boiling

been shown that this process has no negative effects on either normal whirlpool function or on hot trub removal.

The standard procedure at the Kulmbacher Brewery resulted in a wort temperature in the whirlpool of 98 °C prior to the use of wort precooling. The temperature of the wort remains relatively constant during the whirlpool rest. With the wort precooling process, the final temperature of the wort in the whirlpool is 89 °C. Wort transfer from the "low-pressure" (or "overpressure") wort kettle into the whirlpool lasts approximately 10 min and the whirlpool rest 20 min. Afterwards, the total volume of the wort is cooled in 55 min. The amount of time that the wort remains hot until the midpoint of cooling is, in both cases, 52 min. A graph depicting time and temperature during wort handling can be seen in Fig. 2.

Precooling reduces the degradation of DMS-P

Fig. 3 shows the DMS-P content of the wort. Both the values from the Kulmbacher Brewery and those published by Ogane (90 min of total wort handling after boiling) were plotted in the graph as well as the theoretical progression of the degradation of DMS-P, a first order reaction. This demonstrates that this model accurately describes the degradation of DMS-P. The mean value for the DMS-P in the cast-out wort was 112 µg/l for the eight batches analyzed (one beer style). The batches, for which precooling was employed, possessed a mean initial value

Fig. 4 A double-seated valve is used to direct flow during wort precooling

for DMS-P of 108 µg/l. The mean value for DMS-P measured at the midpoint of cooling was 42 µg/l without wort precooling; with wort precooling, it was 61 µg/l. On average, at a wort temperature of 10 °C lower than the conventional method, DMS-P degradation was reduced by 30 percent.

Precooling reduces the concentration of free DMS

After boiling, the concentration of free DMS rose as the amount of degradation of the precursor increased. The initial mean values of free DMS in the cast-out wort were 27µg/l (conventional) and 35 µg/l (with wort precooling).

At the mid-point of cooling, concentrations of free DMS were measured without precooling at 97 µg/l and with precooling at 83 µg/l. The increase in concentration during wort handling was 70 µg/l without precooling and 48 µg/l with precooling. Approximately 31 percent less DMS was formed with precooling than in the conventional process. Quantitatively speaking, almost all the DMS created through DMS-P degradation after boiling remained in the wort. In both cases, the values measured are below the recommended concentration of 100 µg/l.

Lower whirlpool temperatures

Reducing the temperature by 10 °C during hot trub separation resulted in a significant decrease in thermal stress to the wort.

The increase in TBA measured between the end of boiling (36.8) and the midpoint of cooling (43.4) was 6.6 units without precooling. With precooling, the increase in TBA between the end of boiling (35.2) and the midpoint of cooling (38.6) was 3.4 units. Lowering the temperature by 10 °C reduces the thermal stress to approximately half that of the conventional method.

Positive effects on the level of coagulable nitrogen

On average, without wort precooling, a concentration of 1.4 mg/100 ml of coagulable nitrogen is a typical value for wort at the midpoint of cooling. With wort precooling, the value was 2.1 mg/100ml – a clear indication of the positive influence on wort thermal stress.

Conclusion

The information above corroborates earlier results published in the literature. Wort precooling can lower the amount of DMS formation after boiling by approximately 30 percent. The values for thermal stress are also dramatically lower, which in turn has a positive effect on the coagulable nitrogen content of the wort.

A plot of the wort analysis results from brewery samples was consistent with the theoretical progression of DMS-P degradation, a reaction of the first order. Using these equations, it is possible to predict the time necessary for both boiling the wort and subsequent wort handling with regard to DMS-P degradation. With a two-phase boiling system, as is possible with the Jetstar, the length of the DMS-P conversion phase, during which the wort is boiled using the Subjet, can be calculated in advance.

The result is an optimized boiling process with an emphasis on wort quality without an increase in energy consumption. A Jetstar was commissioned in May of 2007 at the Kulmbacher Brewery. ■

TEST RESULTS

Sample			with wort precooling	without wort precooling
End of boil (BE)				
	Free DMS	µg/l	35	27
	DMS-P	µg/l	108	112
	TBA	[ ]	35.2	36.8
Midpoint of cooling (CM)				
	Free DMS	µg/l	83	97
	DMS-P	µg/l	61	42
	TBA	[ ]	38,6	43.4
	Coag. N	mg/100ml	2.3	1.4
Difference BE – CM				
	Free DMS	µg/l	+48	+70
	DMS-P	µg/l	–47	–71
	TBZ	[ ]	+3.4	+ 6.6a

Literature

1. Coors, G., Krottenthaler, M. und Back, W.: Auswirkungen einer Würzevorkühlung beim Ausschlagen, Brauwelt 140, (2000), 42/43, 1696-1699.
2. Ogane, O., Imai, T. ,Yutaka, O., Ohkochi, M. et. al.: Influence of wort boiling and wort clarification conditions on aging-relevant carbonyl compounds in beer, MBAA Convention, Orlando, 2005.