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ANALYTICAL STUDY OF THE METHODS AND MEANS OF BEER WORT HEAT TREATMENT

Abstract

Beer is a sparkling, refreshing drink with distinctive aroma and pleasant bitter taste. Beer is the most popular alcoholic beverage in the world. In this regard, the brewing industry of food industry needs to control the quality and price performance of the finished product. The process of boiling the wort with hops or hop extract is the main factor, but at the same time it is the most energy intensive process in brewing. The analysis shows that discussed ways of wort boiling enable to save energy costs in the range of 70 to 90%. It in turn can greatly affect the price performance of the finished product and increase competitiveness.

Keywords: beer, wort, extract, boiling, energy, boiler.

1. Introduction

Beer is a sparkling, refreshing drink with a distinctive aroma and pleasant bitter taste. Being a good food emulsifier, it contributes to a proper metabolism and increasing the digestibility of food. In addition, extract beer is very easily and completely digested. Beer is the most popular alcoholic beverage in the world. Estimates of the worldwide annual consumption range from 114 to 132 billion litres. In this regard, the brewing sector of food industry has to control the quality and price indices of the finished product, which in turn depend on the raw material base, perfection of the appropriate technological process and equipment, raw material costs and equipment operation. To create high quality technological equipment and implement optimal process parameters it is necessary to start with the study of the factors that affect beer quality, to identify certain shortcomings in technology and/or equipment, outstanding issues or field problems on the basis of practical and theoretical experience.

In order to systematize and generalize, beer production can be conveniently divided into “hot section” and “cold section”. The first occurs in the brewing

department of the plant, the latest – in the fermentation cellar and in all other points of the technological line. Speaking conventionally, brewing is what happens in the brewing department of the plant, that is the transformation of malt and other additional materials into wort which forms raw material for “cold section” and is turned into alcohol by yeast. As the processes that take place in the brewing department of the brewery are fundamental and they determine further quality of the product, it is necessary to focus attention on this stage of the production.

The constituents used in brewing have a significant impact at the stage of wort preparation. The main component of nearly 90% of beer produced in the world is barley malt. Wheat is the second mostly used cereal in brewing, especially for Weissbiers and Weizenbiers production in Germany, as well as the so-called Kafir beer in South Africa based on sorghum. Different malt and malt-free impurities affect the flavour characteristics of beer and enable to save the costs for raw materials. A lot of brewers use different supplements for reasons of quality (different colours, better beer foam, and interesting flavours) or stability. In fact, the costs cannot be completely reduced that are expected using supposedly cheaper sources of starch because the brewer may have to use more expensive processing procedure. Corn, millet, sorghum, rice and other starch-containing cereals can be additional or alternative components of wort.

Water quality has a significant impact too. Monitoring of the relative characteristics of water, means of its purification and enrichment are priority issues at the stage of raw material preparation.

Hop, its extract or pellets are among the components that affect the qualitative parameters of beer, give it an appropriate bitterness, flavour and aroma. Bitter components and hop resin also contribute to better beer foam and inhibit the development of microorganisms in beer.

Design features of machines and apparatuses performance, methods of raw materials processing, factors that are provided directly by the equipment, where a particular process is, affect qualitative indicators of beer in addition to traditional ingredients and different additives. At the same time, to a greater or lesser extent,

all equipment involves energy consumption, material and involvement of maintenance engineers to ensure performance and expected result. Although the costs of different types of energy and materials used in brewing only partially affect the qualitative characteristics of the finished product, they are, on the other hand, affect price indices. Thus energy consumption in brewing is more than 8% of the total cost. Competitive recovery is possible due to the reduction of energy consumption.

New trends today due to scientific and technological progress of mankind create new topical issues mostly related to ecology, environmentally friendly products, influence of various components of the product on the body and health as well as problems related to energy conservation and rationalization of energy use. These issues are studied by domestic and foreign scholars. But still, not all issues are resolved and the problems are discussed.

Thus the analysis and study of energy consumption efficiency for raw material processing and operation of the apparatus-technological lines are the most critical issues described above.

2. Problems and Methods

The main goal of the article is to analyze the technology of beer wort preparation, related existing factors, problems and unresolved issues; to study possible means how to solve the problems by changing the design features of the machines and apparatuses of the technological line for beer wort preparation; as well as to provide recommendations what further research to choose on the subject under consideration.

Analysis of the factors affecting beer qualitative indices is conducted reviewing foreign literature, mainly monographs on brewing technology and scientific articles of relevant areas.

Critical analysis of the existing technical and technological advances on the possible solutions of the issues and questions is based on the use of national, Ukrainian and international patent databases, scientific publications, technical achievements, and company implementations in brewing equipment manufacture.

3. Results

The processes of beer wort preparation that are in the brewing section of the brewery were chosen for the analysis. These processes affect primarily the product and, in fact, are fundamental in brewing technology. This section has also the most energy consuming equipment where the processes of mashing and wort boiling are held.

Whereas issues related to power consumption were selected among the key issues of brewing, the processes of mashing and wort boiling will be studied further respectively. Beer wort boiling is the most energy consuming stage of the process of beer making. It accounts about 30% of the total energy consumption used by the brewery.

The technology of wort stripping is one of the results to solve these issues. This technology provides better quality, higher productivity, and flexibility of the brewing production at lower costs. Stripping is held immediately before wort cooling. Lighted wort is served to the column at a rate depending on the cooling parameters and required productivity. Wort is evenly distributed across the surface of the column and then passed through stainless steel filler due to a special distribution system inside the column. Steam is served into the bottom of the column at low pressure for stripping of the volatile compounds. Steam flow rate should be less than 1.5% of the wort flow rate. If wort goes into the column at the boiling point, the amount of released steam is equal to the number of the resulting condensate. One of the main advantages of the wort stripping system is an opportunity to save up to 92% of energy.

The development of thin film wort boiling “Merlin” system by “Steineker” company is the next worth attention constructive decision. The “Merlin” system consists of a brewing unit and a standard whirlpool. The heating role is performed by the heat exchange device in the form of a cone divided in height into two independent sectors in the brewing unit. Each of the two steam-jackets can be activated and operate independently. While heating and boiling the wort is pumped six times through a heated cone. The heat load on wort and the degree of volatility

can be deliberately changed by adjusting the temperature of the steam in the steam-jackets and supply of the circulating pump. The total amount of moisture that evaporates with a traditional method of wort boiling with hops is 8%–12%. In the "Merlin" system 4% of moisture evaporate only at boiling (DMS of thin film evaporates much better and there is no need to evaporate 12% of wort). The process of wort evaporation is the most energy consuming. Therefore, by reducing evaporation from 12% to 4%, we proportionally reduce energy consumption. The system provides a significant reduction in energy consumption (in some cases up to 73%).

Wort brewing boilers with boiling at low gage pressure are produced as airtight boilers designed for maximum gage pressure of 0.5 bars and equipped with necessary pressure-relief valves in case of overpressure and vacuum formation. Wort heating is conducted using a remote or internal boiler. The condenser of the secondary steam is calculated according to the pressure in the boiler, so that higher temperature of the secondary steam can be used. Currently the condenser of the secondary steam is frequently produced in the form of a single-stage plate-type heat exchanger. In this case the secondary steam is served from the top in every second plate and it condenses when moving down, while cooling water runs bottom-up in the intermediate plates in the counter flow and at the same time it is heated.

As a result of the use of the heat exchange units a large abundance of warm water is usually produced at different production sections of the brewhouse, which is difficult to be applied. However, hot water of high temperature is needed in the brewhouse as it can be used for heating purposes with small supply of additional heat. It is also necessary to use even a small difference in temperature and to accumulate hot water for using it when needed. It can be reached with the use of thermally insulated system with heat accumulation.

Evaporated in the wort brewing boiler water condenses in the condenser of the secondary steam while cooling water is heated to 97° C in the counter flow. Heated to 97° C water is served into the upper part of the energy storage.

Unhopped wort, which is in the collector or wort in the mashing apparatus, can be heated by this hot water from the upper part of the energy storage. There are other facilities for heating, but it is necessary to pay attention to the fact that hot water does not cool.

In such systems of heat energy accumulation it is possible to store heat excess for a long time and use it at any time. The economy of primary energy in contrast to the traditional methods of boiling without heat reuse is:

- About 40–50% for boiling at low overpressure;
- About 60–70% for boiling at low overpressure using energy storage.

Kaspar Schulz company can offer its customers a product of diligent research and years of experience gained by the brewers-engineers in the sphere of energy saving and high-tech wort processing: SchoKolino – gentle boiling system for the brewery with brewing up to 30 HL of wort output; SchoKo – gentle boiling system for the brewery with brewing more than 30 HL of wort output.

The principle of operation is that using a vacuum evaporator it is no longer necessary to boil wort in the brewing boiler. It is enough to maintain wort at a temperature below 100° C (simmer). Simmering occurs at a temperature of 98° C and with additional wort stirring by a pump and its subsequent dispersion in a brewing boiler of a dome shape. The required level of stirring and initial evaporation at 1% is achieved by stirring and dispersion. Wort dispersion occurs due to the secondary node – adjustable wort dispersion plate (AWDP). Due to the fact that the gap clearance can be adjusted to AWDP, the brewer can either reduce or increase the level of initial wort evaporation. All necessary processes occur during wort simmering at a temperature below 100° C: wort sterilization, isomerisation of the hop substances, proteins coagulation, formation of the taste and aroma characteristics, etc. However, wort evaporation does not occur in the brewing boiler when it is simmered. In the traditional process about 70 % of the heat energy for wort production is spent for moisture evaporation from wort in the brewing boiler.

Wort enters the vacuum evaporator after a simmering phase and proteins separation in the whirlpool. At the entrance to the vacuum evaporator the temperature of wort is 95° C. Discharging occurs in the vacuum evaporator by a vacuum pump. Proceeding to the vacuum evaporator tangentially, wort forms a thin, flowing down layer, then wort boils due to the differential pressure and moisture evaporates containing undesirable aromatic substances such as DMS. After evaporation wort enters the cooler that gives the additional benefit as the remaining DMS does not manage to be restored unlike the traditional method of wort boiling. In the vacuum evaporator evaporation rate can be set be the changes in pressure. Temperature reduction of wort is 5° C at 1% of moisture evaporation; it implies that with the evaporation of 3% wort with temperature of 80° C comes into the cooler. Hot water with temperature of about 80° C is generated in the wort cooler, it is sufficient for its further use for brewing purposes without additional heating that maintains positive energy balance of the brewery. Steam coming from the vacuum evaporator has also energy value, the evaporation data pass through the condenser where hot water is produced.

Using SchoKo system there is a reduction in the consumption of a litre of liquid fuel per hectolitre of wort in comparison with the traditional systems. Energy consumption is reduced to 2.2 litres of liquid fuel per hectolitre of wort (Fig. 1). Water consumption is reduced due to less evaporation to 400–500L per cooking.

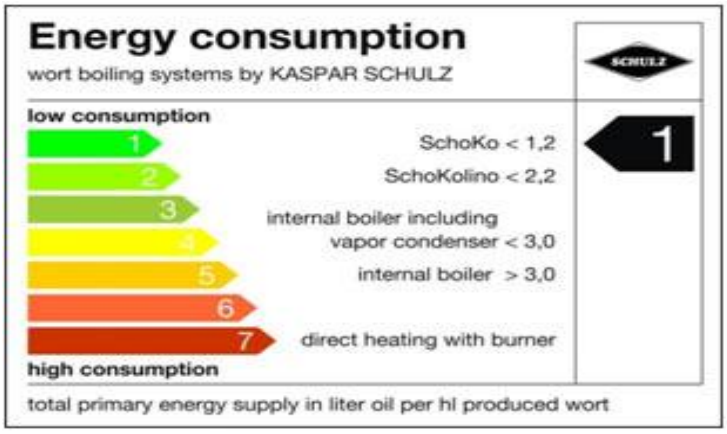

Figure 1. Energy Consumption (Litres of Liquid Fuel per Hectolitre of Wort) by Different Systems of Wort Boiling in Schulz Company

Based on the above described material, a diagram of the percentage of energy savings when using different systems of wort boiling can be built (Fig. 2).

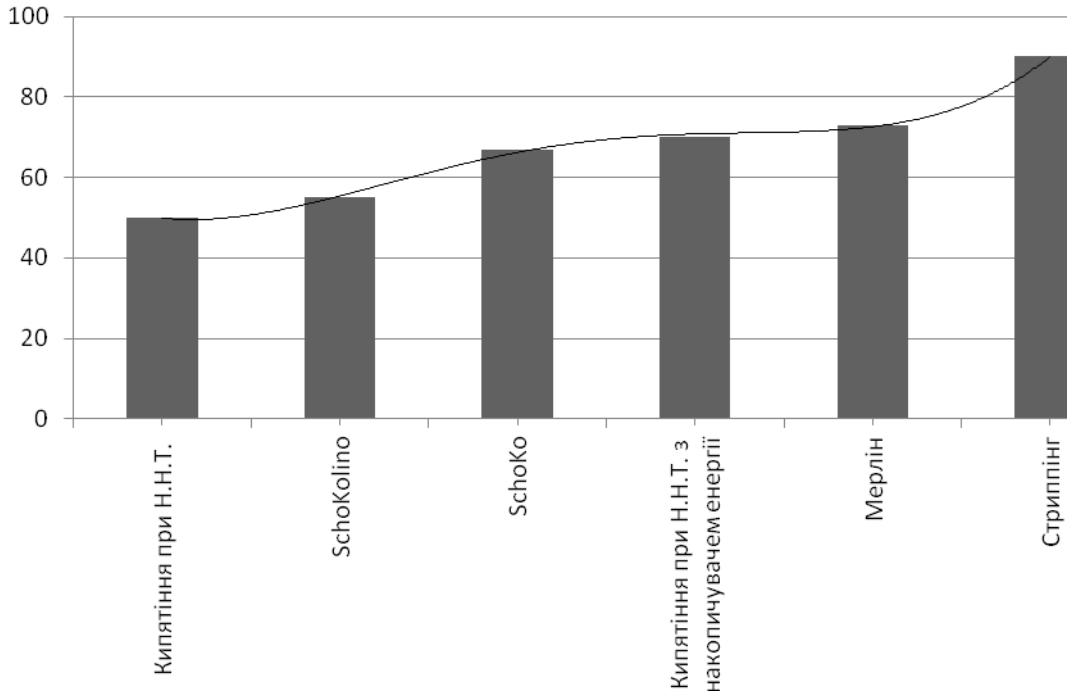

Figure 2. Energy Saving at Different Methods of Wort Boiling

At this stage extensive work has been done to implement energy-saving equipment in the development of the brewing branch of food industry. New systems have been developed by the different manufacturers of the equipment that enable to reduce energy consumption and use waste energy. However, every system has its shortcomings that need further research, examination and elimination.

4. Conclusions

Due to the analysis of key problems and unresolved issues of brewing food industry it was found out that one of its main problems is associated with excessive energy consumption. Their solution is embodied in the technological and industrial innovations. The most perspective system, according to the results of the analysis, is wort stripping that saves about 90% of energy. However, the most popular systems of wort boiling are Merlin, SchoKo and boiling systems (with remote

kettle) at low overpressure using energy storage that enable to save energy within 70–75%.

Received data can be used when choosing current areas of research, doing corresponding studies on the above described issue and in scientific and methodical works.