OPTIMIZATION OF CLEANING PROCESS IN BREWERIES AN IMPORTANT TOOL IN EFFICIENT USE OF WATER AND MINIMIZATION OF DISCHARGES

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ABSTRACT

In breweries to produce 1 hl of beer it needed a lot of water ranged from 5 to 10 Hl. The major part of this water is used for cleaning purposes. The longer these waters can be retained in a sanitary condition, the more money is saved in water costs, water discharge and energy to heat replacement water. Optimizations of water consume through conservation and recycling is the best technique to fulfill this goal. The inefficient use of water as a raw material in a brewery can have environmental impacts. Therefore, minimization of waste water should not only include the improved management and control of water discharges, but also an optimization of process water input. The need to recycle water is becoming increasingly important. One of the main factors limiting the potential for water recycling is the high level of Total Dissolved Solids (TDS) and particularly sodium, which is the main compound of cleaning chemicals used to maintain high hygienic and quality levels in the brewery. TDS reduction and substitution at the source appear to be the best approaches as they avoid costly desalination technologies and the difficult handling of the segregated by-products. Therefore, to reduce TDS loads discharged to the sewer it is necessary to review current industrial cleaning practices. The aim of this paper is to identify technologies that can be used to minimize CIP (cleaning in place) running costs in terms of water, energy and detergent savings. Reuse systems that collect and reuse used CIP solutions for subsequent CIP cycles, impact directly on running costs due to lower chemical requirements. Otherwise, several optimization methods can be implemented to control CIP efficiency including the review of cleaning frequency, the use of mechanical action (pigging systems, high pressure sprayers and floor scrubbers) and CIP monitoring.

Keywords: Efficient use of water, reuse, water discharges, cleaning-in-place.

INTRODUCTION

CIP cleaning process requires a significant amount of water and produces wastewaters with high biochemical oxygen demand and suspended solid content. Water reduction procedures in cleaning consist on: fitting of hoses with shutoff nozzles in order to prevent wastage when not in use; using of a closed system for cleaning operations; using of manual procedure of cleaning for attached solids prior to wash down, so as to reduce effluent pollutant loadings; using of compressed air instead of water whenever is possible, etc. (The brewers of Europe, (2002); UNEP (United Nations Environment Programme), (1995). One of the main advantages of CIP systems is that they can recirculate and allow the reuse of chemicals and rinse water, thereby reducing consumption by as much as 50% compared to manual cleaning (Dufour, M., R.S. Simmonds and P.J. Bremer, (2004)). CIP systems largely remove human contact with cleaning and sanitizing agents, thus reducing the

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risk of harmful exposure (Hamblin, R.., (1990)). They also assure a more consistent cleaning by removing some of the common sources of human error in cleaning.

There are two types of cleaning detergents used in the brewery: alkaline-based or acid-based detergents that are often formulated with surfactants, chelating agents, and emulsifiers to enhance the effectiveness of the detergents (Sakiyama, T., et.al., (1998)). Sodium hydroxide, commonly used in the CIP system, is quite effective for removing organic deposits from stainless surfaces. Phosphoric acid is used as acid detergent because it is effective in the removal of beerstone and similar deposits on surfaces such as protein material resins and yeasts (Dufour, M., R.S. Simmonds and P.J. Bremer, (2004)). Nearly all brewery equipment including tanks, fermenters, brew kettles, and lauter tuns are made of stainless steel. Most brewery equipment is constructed from Type 304 stainless steel, which has good corrosion resistance properties. (Hamblin, R.., (1990).

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METHODOLOGY

Monitoring of water consumes and final effluent for the parameters listed in this document was carried out at least twice per month or more frequently if the flows vary significantly. Monitoring data were analyzed and reviewed at regular intervals and compared with the operating standards. The required legislative standards are applied managed and controlled based on HACCP, Occupational Health and Safety, ISO 14001-2000 and ISO 9001.

The reported average results are the “Stefani & Co” data, taken during 2013-20016 period and publicities to the responsible authorities and relevant parties, as required.

At “Stefani & Co” brewery there is a Clean-in-Place system for cleaning. One of the main advantages of CIP systems is that they can recirculate and allow the reuse of chemicals and rinse water, thereby reducing consumption by as much as 50% compared to manual cleaning.

RESULTS

For 2014 the total well water consume was 6.5 hl/hl beer from which 4 hl/hl beer produced is water as raw material treated by reverse osmoses, 0.7 hl/hl is the volume of soft water used for boiler and cooling process and the rest, 1.8 hl/hl was the volume of water used for housekeeping and manual washing procedure (just chlorinated water).

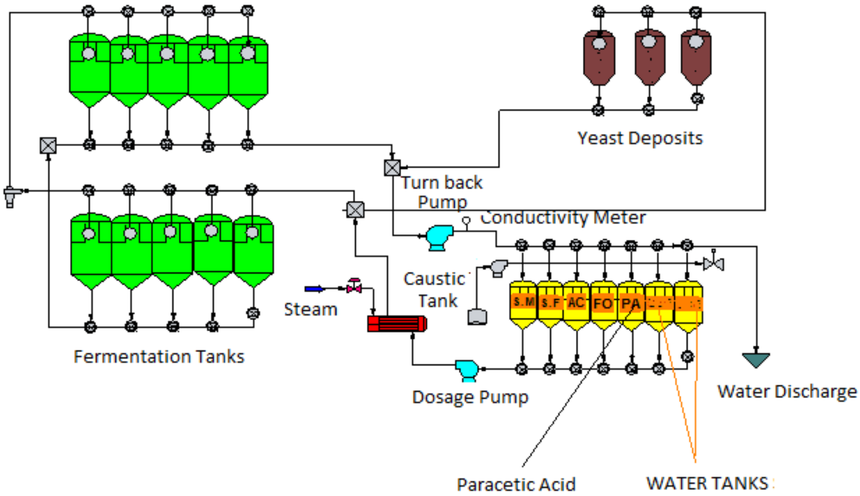


Figure 1. Cleaning in Place System at "Stefani & Co" Brewery

BREWHOUSE
High water consuption
High amounts on discharged of waters with high organic matter
Caustic and acidic wastes from CIP cleaning

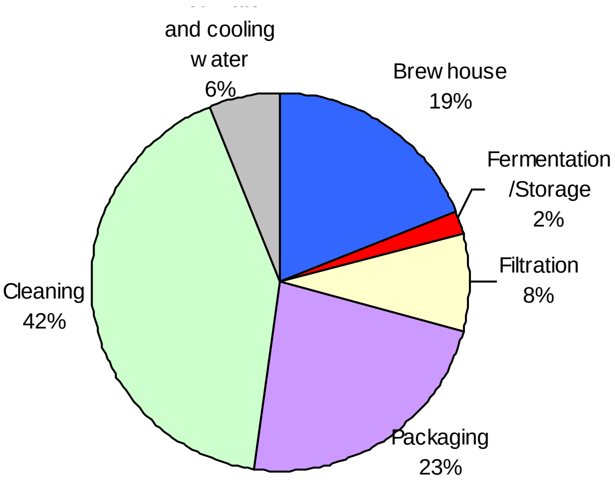
FERMENTATION/STORAGE
High water consuption for cleaning
Caustic and acidic wastes from CIP cleaning
High amounts on discharged of organic matter
Yeast Sunspension discharges

FILTRATION
High water consuption for cleaning
Caustic and acidic wastes from CIP cleaning
High amounts on discharged of organic matter
Yeast and Kieselguhr Sunspension discharges

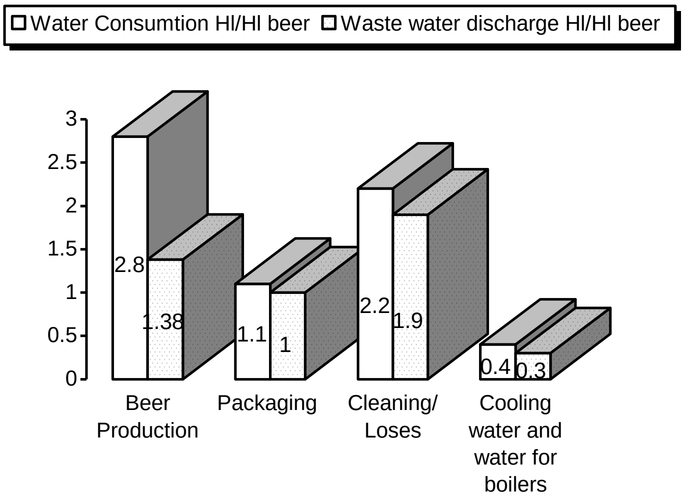
PACKAKING LINES
High water consuption for cleaning
Caustic wastes from cleaning
High amounts on discharged of organic matter (beer)

OTHER OPERATIONS
High water consuption for cleaning
Chemical and special waste water handling

Figure 2. Specific consumption and specific waste water discharge in different sections of beer production

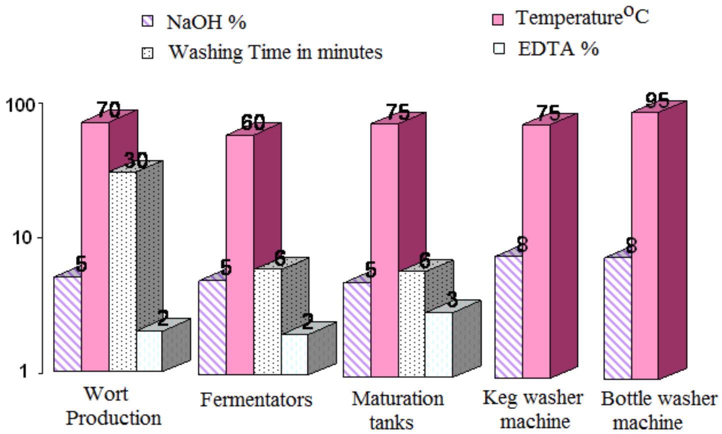


Graph 1. Waste water discharges distribution in the brewery



Graph 2. Specific water consumes and water effluents for different processes in the brewery

CIP cleaning procedure and the time it takes for different processes is presented at Graph 3. EDTA is used to keep in control beerstone.



Graph 3. Washing agent concentration, temperature and washing time for the most important equipments in the brewery

Table 1. Characterisation of water cleaning discharges for a typical cleaning fermentation tank procedure Cleaning waters characterization

	pH	TSS (mg/l)	COD (mg/l)	BOD_5 (mg/l)	Turbidity (EBC)
First Rinsing	6 - 7.5	225 - 380	1000 - 1620	500 - 1395	> 100
Second Rinsing	8.5 – 10.8	10 – 85	65 – 254	5 -15	10- 25
Acid Rinsing	5.8 – 7.5	-	-	-	< 2
Last Rinsing	6.8 -7.2	-	-	-	<1

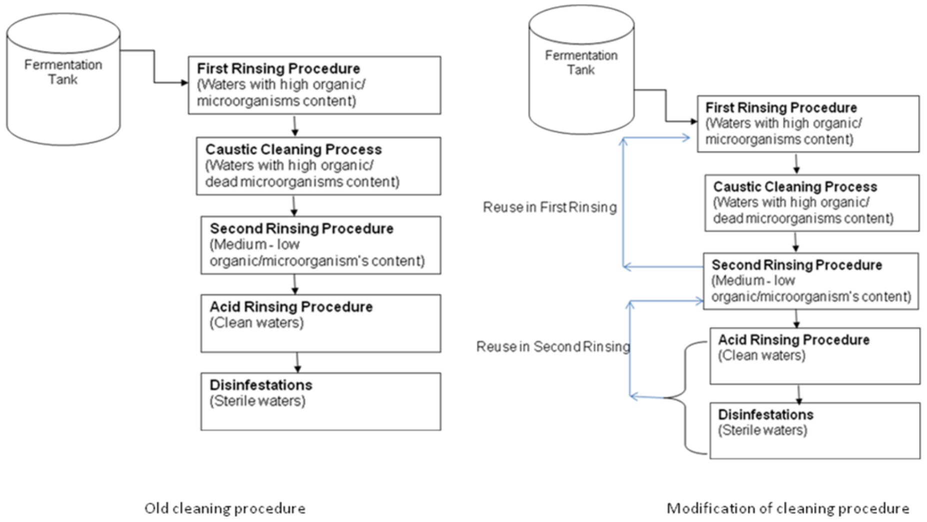
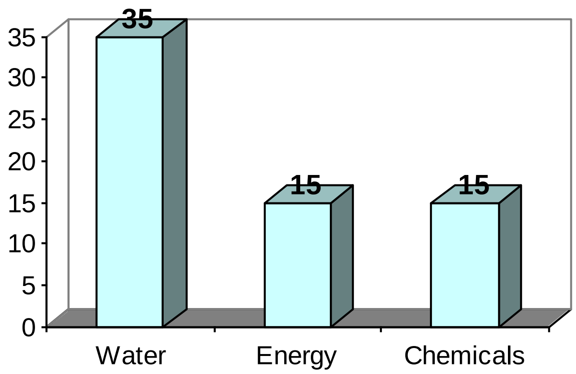


Figure 3. Modification of cleaning procedure



Graph 4. Impact of intervention on water, energy and chemicals consume in %

DISCUSSION

Water Recovery in the brewery

In breweries to produce 1 hl of beer it needed a lot of water ranged from 5 to 10 Hl. The major part of this water is used for cleaning process, where we can recover and reuse considerable quantity.

- Water recovery in CIP system (final rinse waters; reuse of detergents several times etc.) There are a number of ways of sterilising this liquor, both physical (ultraviolet light, heat, filtration) or chemical (silver, ozone, chlorine dioxide, paracetic acid).
- Recirculation systems use less water and cleaning detergents through optimisation of the use of detergent and water.

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- Water recovery in the bottle washers.
- Reuse of "clean" waters from every point for housekeeping.
- Reuse of water from cooling system.
- Recovery through condensing of steam in boilers.

Cleaning programmers for vessels are determined by the soil on the surface, the stage of the process (hot or cold) and the geometry and attachments in the vessel. Cleaning and sanitizing programmes for pipe work and related in-line pumps, valves, instruments, heat exchangers, hoses and other items (e.g. fillers) are determined by the soil on the surface, the stage of the process (hot or cold) and the design of all the items of plant in the cleaning circuit.

Intervention implemented in industrial scale to optimize CIP process:

- Modification of CIP with recovery systems (installation of external tanks) for detergent and rinse recovery in order to reduce chemical, water and energy consumption and effluent production;
- Using of different cleaning program for different equipments. For example, a satisfactory result can be achieved with hot cleaning and sterile rinse liquor alone. Large storage tanks using CO_2 where low soiling (e.g. Bright Beer Tanks), and could be cleaned using acid detergents. Where tanks are routinely acid cleaned, regular caustic cleans should be carried out to ensure protein scale removal. Where caustic cleans is carried out in a CO_2 environment, sacrificial recirculation cycles are preferred to eliminate high carbonate/bicarbonate content in the main caustic detergent tank;
- Applying always turbulent flow rates during cleaning mains;
- The pressure at the spray heads must be appropriate to the spray head design and vessel to be cleaned;
- Using of manual procedure of cleaning for attached solids prior to wash down, so as to reduce effluent pollutant loadings;
- Using of low-volume/high-pressure washers.

CONCLUSIONS

Cleaning and housekeeping are the most water consummators and discharger processes that impact directly on total water balance of the brewery and waste water volume. Optimisation of processes, maintenance and redesign (CIP system) results in potential consume reduction. Modification of CIP with recovery systems for detergent and rinse recovery result reducing chemicals used up to 15%, water consumption in CIP process 35% and energy consumption 15%. In the same time were minimized significantly effluent discharges.

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