The use of aqueous Ozone for Cleaning Operations in Breweries

Ozone & Related Oxidants in:
Advanced treatment of water for human health and environment protection
Disinfection, elimination of persistent pollutants and control of by-products
International Conference

May 15th, 2008 - Brussels, Belgium

ttz Bremerhaven
1. Cleaning and disinfection activities in breweries

2. Ozone as sanitising agent

3. The OZONECIP project
Cleaning and disinfection activities in breweries are characterised by:

- consumption of large volumes of fresh water
- production of large volumes of waste water

<table>
<thead>
<tr>
<th>Fresh water consumption</th>
<th>Waste water production</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,7 – 13,4 hl / hl beer sold</td>
<td>2 - 3 hl / hl beer sold</td>
</tr>
<tr>
<td></td>
<td>1 – 8,5 hl / hl beer sold</td>
</tr>
</tbody>
</table>

(1) Heidemann, Rosenwinkel and Seyfried (1990 to 1992)
(2) Institute for Prospective Technological Studies-“Reference Document on Best Available Techniques in the Food, Drink and Milk Industries” (2006)
Cleaning and disinfection activities in breweries

Practices for cleaning and disinfection vary according to the target surface:

- **Closed Equipment:**
  - Tanks, pipes, vessels, etc.
  - “Cleaning In Place” (CIP)

- **Open surfaces:**
  - Fillers, conveyors, floors, etc.
  - Foam cleaning, high pressure jet cleaning, etc.

<table>
<thead>
<tr>
<th>Action</th>
<th>Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerinsing</td>
<td>Water</td>
</tr>
<tr>
<td>Foaming</td>
<td>Foam cleaner</td>
</tr>
<tr>
<td>Soak time</td>
<td>Foam cleaner</td>
</tr>
<tr>
<td>Intermediate rinsing</td>
<td>Water</td>
</tr>
<tr>
<td>Spraying</td>
<td>Disinfectant solution</td>
</tr>
<tr>
<td>Final rinsing</td>
<td>Water</td>
</tr>
</tbody>
</table>

E.g.: Foam cleaning and disinfection programme
Cleaning in Place CIP

CIP systems are characterised by automatic cleaning programmes based on a sequence of water and solutions of cleaning chemicals and disinfection agents.

**CIP typical sequence:**
- Pre-Rinse
- Alkali cleaning
- intermediate rinse
- Acid cleaning
- intermediate rinse
- Disinfection
- Final rinse

**Waste water produced by CIP processes contains:**
- High COD and BOD values
- Chemicals used for the cleaning and disinfection rises

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD&lt;sub&gt;5&lt;/sub&gt;</td>
<td>mg/ l</td>
<td>1000-1500</td>
</tr>
<tr>
<td>COD</td>
<td>mg/ l</td>
<td>1800-3000</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>mg/ l</td>
<td>10-60</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/ l</td>
<td>30-100</td>
</tr>
<tr>
<td>Total Phosphorous</td>
<td>mg/ l</td>
<td>30-100</td>
</tr>
<tr>
<td>pH</td>
<td>-</td>
<td>3-13</td>
</tr>
</tbody>
</table>

Untreated waste water characteristics for breweries
Several microorganisms are likely to grow because due to the beer’s nutrient-rich environment they are exposed to alcohol, carbon dioxide, low pH, etc. reduce the range of organisms most likely to be found to relatively few species.

- *Lactobacillus* (*Lactobacillus brevis, L lindneri, L. brevisimilis, L. frigidus, L. coryniformis, L. Casei, L. pediococcus damnosus and L. pediococcus incotinatus*)
- *Pectinatus cerevisiiphilus*
- Yeasts cultures
- Etc.
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Disinfectants

Adequate disinfectants should:

- Be effective against Gram-positive and Gram-negative bacteria and against yeasts and moulds
- Be effective in the presence of proteins
- Be effective at low temperatures
- Have CIP-suitability
- Be easily rinsable, readily biodegradable, etc. (Environmental aspects)
- Be effective at low concentrations, reusable, (Economical aspects)
- Be safe to use (Health aspects)
- Be compatible with the product (no adverse effects on the product)
Disinfectants

Disinfection practices in the brewing industry are based on:

- **Disinfection chemicals**: Chlorine compounds, or other halogen compounds, $\text{H}_2\text{O}_2$, peroxyacetic acid, etc.
- **Hot Water and steam disinfection**

Ozone-enriched water has the potential of replacing the chemicals and hot water rinses currently used in CIP processes in breweries.
Ozone is a very efficient anti-microbial agent and it does not leave any residue since it breaks down into Oxygen after its disinfection action.

\[ \text{O}_3 + 2\text{H}^+ + 2e^- \rightarrow \text{O}_2 + \text{H}_2\text{O} \quad \text{E}^\circ = 2.07 \text{ V} \]
Advantages:

1. Water saving
2. Faster disinfection
3. Water re-use possibilities, the water used for disinfection could be applied for initial cleaning steps
4. No storage of hazardous chemicals
5. Improvement of waste water's quality, by increasing the performance of aeration tanks and biological waste water treatment processes
6. Energy saving, as it is used at low temperatures
Ozone as disinfectant

Ozone is a toxic compound

**Threshold Limit Value (TLV) of Ozone in ambient air at the working place**

0.1-1.0 ppm → Headaches, dry throat, irritation to the respiratory system and sore eyes

0.1 ppm 0.2 mg/m³

Ozone is detectable by human sense of smell at 0.01-0.04 ppm concentration
Ozone has a high corrosion potential

Evaluate all materials that should come in direct or indirect contact with ozone

Stainless steel is the most common surface currently used in CIP systems and in production equipment in the brewing industry.

Most of them are compatible with a continuous use of aqueous ozone at moderate concentrations (1 – 3 ppm)
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The OZONECIP-Project

The Project-consortium
- 3 RTD
- 3 Industries
  Diary, Brewery, Winery

www.ozonecip.net

The OZONECIP project is co-funded by the European Union’s LIFE Environment Programme, (LIFE 05 ENV/E/000251).
The global objective is the reduction of the environmental impact produced by the food processing plants during their cleaning operations.

Demonstrating the environmental advantages of ozone instead of the traditional disinfection chemicals used in CIP processes.

OZONECIP will be tested on a pilot scale in order to assess its performance and economic viability for its large-scale implementation.
The OZONECIP-Prototype

An Ozone-based CIP prototype was designed, built and prepared for testing different CIP processes.

It will allow collection of environmental indicators and values.
Indicators and parameters

Environmental indicators
- Amount of water consumed
- Amount and quality of waste water produced
- Energy consumption

Food Safety
- Disinfection efficiency
- By-products

Other parameters
- Legal aspects
- Economic feasibility
1. Two reference CIP sequences

<table>
<thead>
<tr>
<th>Reference CIP1 and CIP2</th>
<th>Reference CIP3</th>
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<tbody>
<tr>
<td>Prerinsing</td>
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<tr>
<td>Alkaline cleaning</td>
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<tr>
<td>Intermediate rinsing</td>
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</tr>
<tr>
<td>Acidic cleaning</td>
<td>Disinfection</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>Disinfection</td>
<td>Final rinsing</td>
</tr>
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2. Two ozone based CIP sequences

Ozone enriched solutions will progressively replace the different rinses carried out in the reference CIP processes essayed.
The different rinses with aqueous ozone will be tested using different ozone concentrations and cycle durations.

**Evaluation vs. Reference CIPs**

The beer samples will be polluted with different type of microorganisms and will be essayed separately.

lactobacillus; *pectinatus cerevisiiphilus*; different yeast cultures

Based on the results and tendencies of the initial Trial results, subsequent Ozone-based CIP will be designed and essayed.
Expected benefits for the brewing industry

- Reduction of water consumption and waste water production
- Reduction of production downtime due to cleaning and disinfection operations
- Improvement of the waste water quality
- Absence of unhealthy chlorine derivates
- Energy savings
- Reduced risk of environmental accidents
Thank you for your attention