Partners in Hygienic Design
Potential savings in CIP of food production plants Through Hygienic Design

Abstract of thesis
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Analysis of potential savings for the food industry by comparing the latest state of art of hygienic design versus legacy designs, that use hygienically risky components.

To reduce the risk of undesired microbial growth, effective CIP is vital. This can be achieved only by hygienically designed components. Non-hygienic legacy designs are responsible for up to 20% of GMP claims. The cleaning process is essential for the food safety and is often a CCP of the production process. It can consume up to 70% of the total water consumption and water treatment. This represents a massive opportunity for savings.
Possible Savings in operating Costs through Hygienic Design

• shorter cleaning time, increasing productive time.

• reduced chemicals and additives

• reduced power, steam and fuel consumption

• reduced water and water treatment costs

Correct hygienic design improves cleaning and sterilization via improvements in the mass-and heat- transfer from the CIP-liquids:
A temperature-sensor installed in a T-piece that was 2.6 diameters long and with a CIP-fluid temperature of 85°C, reached only 65°C, even after a full 16 minutes.
All pipe-connections compromise the inner surface of the pipe

• more difficult to clean

• corrosion-resistance is degraded

• minimize use, preferably by using pipe-bending rather than pipe-bends

Design recommendations: Pipe-Couplings

• pipe-alignment, centering

• defined sealing-pressure via metal-to-metal contact

• room for thermal expansion of seals

• no crevice/gap, sealed by elastic material (not plastic)
Pipe-Couplings DIN 11864-2 Form A, DIN 11853-2
Design recommendations

Pipe-alignment, centering
defined sealing-pressure via metal-to-metal contact
room for thermal expansion of seals
no crevice/gap, sealed by elastic material

Centered sealing with defined compression
Comparison of flow between Main flow and flow in dead space

Dead space depth:
- 1d: 13%
- 2d: 8%
- 4d: 2%

At flow velocity of 1m/s, exchange of detergent in a dead space depth of 8d takes 30 minutes. Different cleaning phases may not flush dead space because of less time.
For an optimal CIP process it is important that the installation is clean and in good hygienic condition, as quickly as possible.

• To minimize CIP-time, it is vital to detect the instant when the installation is clean.

• A cleaning method is necessary to identify the real time of CIP success.

• For this study alkaline cleaning agent with a redox-indicator was used, which changes from violet through green to yellow, depending on the concentration of organic material remaining.

• This color-change was measured with an optical sensor.

Colour gradient from alkaline cleaning agent
Analyses of 6 Dairies with an annual turnover of 140 Mio to 270 Mio €
Costs of CIP includes primary costs like cleaning materials, chemicals and secondary costs like power, water, waste water, steam.

Composition of CIP costs
CIP Total Costs
Costs for CIP by HD-related and non-HD-related

Ratio of HD-related and non-HD-related CIP-Costs

Dairy plants
Costs

Total cost of CIP-cleaning per kg raw milk [ct/kg]
Costs

Price for power, water, steam

Price (ct) per kWh power
Price (ct) per cbm water
Price (ct) per kg steam

Dairy plants
CIP Duration per Sensor-Connection

490,-US $

290,-US $

CIP total costs

Sensor with T-piece = 290,- US $

Sensor with Varinline = 200,- US $
CIP Operating-Time for T-Piece Combinations

Time (s)

<table>
<thead>
<tr>
<th>Combination</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4d</td>
<td></td>
</tr>
<tr>
<td>4d2d</td>
<td></td>
</tr>
<tr>
<td>4d2d1d</td>
<td></td>
</tr>
<tr>
<td>4d2d 2XVA</td>
<td></td>
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</tbody>
</table>

I: , II: , III: 
CIP Operating-Time for Valve-Sections

Dead End = 2,6d
**CIP Operating-Time**

<table>
<thead>
<tr>
<th>Hygiene Installation (State of the Art)</th>
<th>versus</th>
<th>Legacy Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1: Dairy Installation with 4,500 Tuchenhagen Valves and 5,000 m pipe line DN 80</td>
<td></td>
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<tr>
<td>CIP time per circuit (assumption)</td>
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<tr>
<td>5 Min. Pre rinse, 20 Min. caustic, 10 Min. Acid, 5 Min. Final rinse, 20 Min. Disinfection = 60 Min total CIP time</td>
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<tr>
<td>Total CIP time = 60 Min.</td>
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Example 2: Dairy Installation with 4,500 Γ

- 5,360 m = 60 Min. = 100 % (5,000 m = 93 %, 360 m = 7 %)
- 5,000 m straight pipe will be cleaned in 55.8 Min., 360 m Γ

Because of the Γ, there is a surplus length of the pipe of 7 %, and a surplus cleaning time of 23.8 Min., which results in 33 % more CIP time and thus production time.
Hygienic Design module results in 76% less CIP time
Pay-off for one HD sensor (Varinline) compared with 4d-T-piece sensor per metric ton of raw milk and per dairy plant

<table>
<thead>
<tr>
<th>Dairy plant</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>t raw milk</td>
<td>65.6</td>
<td>68.3</td>
<td>134.6</td>
<td>216.8</td>
<td>70.9</td>
<td>46.9</td>
</tr>
</tbody>
</table>

\[
\frac{\text{Difference of investment costs}}{\text{HD relevant CIP portion of CIP total costs}} = \frac{200\text{€}}{0.426\text{kg/cents}} = 46.9 \text{ t}
\]

A dairy with a raw milk intake of 380,000 l/day achieves it pay-off:
- Dairy 4 in 0.6 days
- Dairy 6 in 0.1 days
Pay-off for one HD Divert-Valve compared with block & bleed butterfly valve according to the raw milk [t] per dairy plant

<table>
<thead>
<tr>
<th>Dairy plant</th>
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<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>t raw milk</td>
<td>475.8</td>
<td>493.3</td>
<td>975.9</td>
<td>1571.8</td>
<td>513.7</td>
<td>339.6</td>
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</tbody>
</table>

\[
\frac{\text{Difference of investment costs}}{\text{HD relevant CIP portion of CIP total costs}} = \frac{1450 \text{ €}}{0.427 \text{ kg /cent}} = 339.6 \text{ t}
\]

A dairy with a raw milk intake of 380,000 l/day achieves its pay-off:
- Dairy 4 in 4.1 days
- Dairy 6 in 0.9 day
Pay-off for a HD module compared with the common way
according to the raw milk [t] per dairy plant

<table>
<thead>
<tr>
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<th>1</th>
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<th>4</th>
<th>5</th>
<th>6</th>
<th>t raw milk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>800.7</td>
<td>830.1</td>
<td>1642.2</td>
<td>2644.9</td>
<td>864.4</td>
<td>571.4</td>
<td></td>
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\[
\text{Difference of investment costs} = \frac{2440 \text{ €}}{0.427 \text{ kg /cent}} = 571.4 \text{ t}
\]

A dairy with a raw milk intake of 380,000 l/day achieves it pay-off:
- Dairy 4 in 6.9 days
- Dairy 6 in 1.5 days
The figures from the previous tables show that the complete change of a production-plant to hygienic design needs high investments, which often deters budget-holders from opting for HD.

Please note that the validation of the CIP program is essential.

The work reported demonstrates that pay-back will be achieved in a vanishingly short time, with the added bonuses of faster processing, increased plant capacity and an extended plant lifetime.

Thank you for your attention.