Versuchs- und Lehranstalt für Brauerei in Berlin (VLB) e.V.

Scale up/down
New possibilities to close the gap between lab, pilot brewery and industrial scale
Overview

+ Challenges of scale up/down
+ How is the normal process
+ Our Approach - construction Nanobrewery
+ Trials/optimization Nanobrewery
+ Downstream process
+ Scale up/down trials
+ Outlook
Challenges of scale up/down
Challenges of scale up/down

+ Scaling down leads higher surface to volume ratio
  + changed mass transfer (O₂↑↓ CO₂↑↓ volatiles ↑)
  + changed heat transfer (cooling, heating)

+ Transfer problems by thinner pipelines
+ Unequal distribution
+ Different flow dynamics
+ Hygienic design, cleaning challenges
Challenges of scale up/down

\[ V = 0.02 \text{ l} \]

\[ A = \pi \cdot r^2 \]
\[ A = \pi \cdot (2 \text{ cm})^2 \]
\[ A = 12.56 \text{ cm}^2 \]

\[ \frac{A}{V} = 628 \text{ cm}^2/\text{l} \]

\[ V = 1 \text{ l} \]

\[ A = \pi \cdot (5 \text{ cm})^2 \]
\[ A = 78.5 \text{ cm}^2 \]

\[ \frac{A}{V} = 78.5 \text{ cm}^2/\text{l} \]
Scale up/down in brewing

+ Scale up/down step lead to:
  + Unknown oxygen uptake (mash/ wort/ beer transfer)
  + Unknown effectivity of DMS evaporation
  + Unknown hop yields
  + Risk of blockage during mash transfer, lautering, wort cooling
  + Undesired dilutions by residual water in pipes/hoses
  + Control of wort flow during lautering

+ Typical steps in a ratio 1:100
Typical work flow

+ Lab scale (??? ml - 5l)
  + Open vessel- Erlenmeyer flask
  + Microtiter plats
  + Untypically brewing and fermentation conditions

+ Pilot scale (1hl – 10 hl)

+ Industrial scale (100 hl – 1000 hl)
Our approach
Our approach

- Full automatization (minimize brewer’s impact)
- Nitrogen gas and degassed water application (reduces oxidation)
- Heat supply and adjusted thermal load by oil bath (circulates in heating jackets)
- Regulation of the lauter flow by pressure difference
- Adjust evaporation rate by reflux condenser
- Usage of available miniplant vessels
Construction Nano-brewhouse

- Grist load: up to 1.2 kg
- Cast wort: up to 5l
- Oxygen free wort production
- Mainly made of glass
- Automated

http://www.brauer-bund.de
Mashtun

+ Capacity: 6l
+ Oxygen free mashing
+ Temperature control by oil bath and heating jacket
+ Measuring instruments: level, temperature
Lautertun

- Capacity: 6l
- Oxygen free lautering
- Temperature control: oil bath and heating jackets
- Measuring instruments: level, temperature, lauter turbidity
- Control of wort flow: adjusting the height of wort kettle
- Specific false bottom load: 100-150 kg/m²
- No raking machine (avoid influence on filter layer)
- Lautering without pump or control valve (avoid blocking, oxygen entry)
- Regulation by setting difference pressure
Lauter process

- Wort circulation
- End of first wort
- Wort kettle position
- Wort very clear
Wort kettle

+ Capacity: 6l
+ Oxygen free wort boiling
+ Temperature control by oil bath and heating jackets
+ Measuring instruments: level, temperature
+ Possibility to reduce evaporation by reflux condenser
Whirlpool and Cooling

+ Capacity: 6l
+ Oxygen free
+ Insulated
+ Measuring instruments: temperature of cooled wort, wort turbidity
+ Counterflow wort cooler
Automatization

- Braumat (Siemens)
- Visualisation of process
- Steps programmed with Step7
- Order and recipe control
- Improved Reproducibility by automatization
- Save measured data
### Influence of oxygen on wort colour

<table>
<thead>
<tr>
<th>Wort colour [EBC] at 12% original extract</th>
<th>Without N₂ atmosphere</th>
<th>With N₂ atmosphere</th>
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</thead>
<tbody>
<tr>
<td>Without oxygen free brewing water</td>
<td>18-20</td>
<td>14-16</td>
</tr>
<tr>
<td>With oxygen free brewing water</td>
<td>8-12</td>
<td>7,5-8,1</td>
</tr>
</tbody>
</table>
Lautering performance - pressure difference

\[ y = 4.5906x + 36.889 \]
\[ y = 4.2823x + 34.308 \]
\[ y = 3.7753x + 35.905 \]

40% Steeping Degree - 1.6 ED
42% Steeping Degree - 1.1 ED
45% Steeping Degree - 1.0 ED
Downstream process
Downstream process
Fermentation tubes - details

CIP

Sampling

Pressure Fermentation

Yeast harvest
Scale up/down trials
Recipe adaptation

- **Ratio Malt: Water**: Changed
- **Mash program**: Slower heating up
- **Mash acidification**: More acid used
- **Wort acidification**: More acid used
- **Fermentation**: Different vessel
## Analytical Results

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</thead>
<tbody>
<tr>
<td>VLB Std</td>
<td>11,51</td>
<td>4,15</td>
<td>2,30</td>
<td>6,19</td>
<td>28</td>
<td>4,88</td>
<td>0,100</td>
<td>0,100</td>
</tr>
<tr>
<td>Minibrau</td>
<td>11,91</td>
<td>4,22</td>
<td>2,04</td>
<td>6,88</td>
<td>25</td>
<td>5,24</td>
<td>0,067</td>
<td>0,085</td>
</tr>
<tr>
<td>Difference [%]</td>
<td>3,48</td>
<td>1,69</td>
<td>12,75</td>
<td>11,15</td>
<td>12,00</td>
<td>7,38</td>
<td>49,25</td>
<td>17,65</td>
</tr>
</tbody>
</table>
Tasting Results

- PanelCheck: Mini vs. VLB Std. little differences
Significant differences

- 3 way Anova
- Significant differences:
  - Palatefullness
Conclusion

+ Reproducing 2hl scale in 5l brewery succeeded
+ Adjusted recipe necessary
+ Sensory analyses can’t detect differences below 10%?
Outlook- Nano Brewing System

- Micro- Malting - 1 kg
- Filling device
- Nano- brewhouse - 5 l
- Fermentation tubes - 4 l
- Filtration- Unit
Thank you for your attention!

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