Possibility and determination of the use of CO2 produced by the production of beers

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Abstract
Carbon dioxide, CO2, causes the greenhouse effect in the earth's atmosphere, and is a product of combustion of organic compounds, for example the methane gas. Carbon dioxide itself does not support burning, and being denser than air it is widely used in fire extinguishers. CO2 reacts with water producing a weak acid according to the equation: CO2 + H2O = H2CO3. Alcoholic fermentation is the process of sugar converting into alcohol and carbon dioxide. The actual process, as any beer brewers can attest, occurs over time and involves many chemical reactions. However, the ultimate result is the breakdown of sugar (C6H12O6) into alcohol (2C2H5OH) and carbon dioxide (CO2). If you know the initial quantity of sugar, you can calculate the volume of carbon dioxide that its complete breakdown will produce.

Carbonic gas formed during fermentation of beer. Carbon dioxide can be compressed and as such be used in production again, which at the same time we also protect the environment and cost savings in the process of beer production.

Given that carbon dioxide gas is heavier than air, he sits at the bottom of workspaces, which presents a danger to life.

Keywords: Carbon dioxide, fermentation, beer, recovery.

INTRODUCTION
During fermentation in fermentors develops CO2 to about 3.8 to 4.2 kg per hl of beer. Part of the CO2 stays tied and the beer (0.3 to 0.35 kg / hl), one part of losing washing, and part of mixed with air (0.4 to 0.6 kg / hl) at the beginning of fermentation the discharge the atmosphere or can be used to neutralize waste alkali.[3],[5]

C6H12O6 -------> 2C2H5OH + 2CO2

Stoichiometric shows that from 180 g C6H12O6 simple sugar produced 92 grams of alcohol and 88 grams of carbon dioxide.[9] CO2 goes into the processing when the fermentation reached concentrations of 99.5% by volume, and this theory is about 2.8 kg of hl beer. Practice, however, proves to be truly catch and processing of 1.8 to 2.5 kg CO2/hl beer.[1],[9]

MATERIAL AND METHODS
Carbon dioxide (CO2) formed as a sub product of the main and additional fermentation of beer; CO2 can compress and as such should be selling or reused in production.[7],[8]

C6H12O6 -------> 2C2H5OH + 2CO2 + Energies
Sugar yeast ethyl alcohol

180gr 92gr 88gr 146.6 kcal

1 hl of produced beer develops cca.3.2 0.8 to 4 kg of CO2.

From-Balling during the fermentation of malt extract 1kg produced 0.464kg of CO2. Depending on the conditions of fermentation and collection system it is possible to use 1.8 to 2.5 kg CO2/Hl.[2],[6]

Degradation of the extract Basic malt extract with 12%
1 day 0.5 % of measured value 11.5 %
2 days 1.0 % 10.5 %
3 days 2.0 % 8.5 %
4 days 2.0 % 6.5 %
5 days 1.5 % 5.8 %
6 days 1.0 % 4.0 %
7 days 0.5 % 3.5 %

Amount of CO2: 100 liters wort gives 1.8 to 2.5 kg of CO2.[3],[4]

Table 1: The characteristic reactions in relation to the concentration of CO2

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 %</td>
<td>difficulty breathing</td>
</tr>
<tr>
<td>7 %</td>
<td>difficulty breathing and fainting</td>
</tr>
<tr>
<td>10 %</td>
<td>suffocation and disorder in the lungs and bloodstream.</td>
</tr>
<tr>
<td>20 %</td>
<td>immediate death</td>
</tr>
</tbody>
</table>

Table 2: Proportion of dissolved CO2 in beer depending on temperature and pressure

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Proportion of dissolved CO2 g/100 g (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.335</td>
</tr>
<tr>
<td>1</td>
<td>0.321</td>
</tr>
<tr>
<td>2</td>
<td>0.309</td>
</tr>
<tr>
<td>3</td>
<td>0.298</td>
</tr>
<tr>
<td>4</td>
<td>0.287</td>
</tr>
<tr>
<td>5</td>
<td>0.277</td>
</tr>
<tr>
<td>6</td>
<td>0.268</td>
</tr>
<tr>
<td>8</td>
<td>0.249</td>
</tr>
<tr>
<td>10</td>
<td>0.232</td>
</tr>
<tr>
<td>15</td>
<td>0.197</td>
</tr>
<tr>
<td>20</td>
<td>0.169</td>
</tr>
</tbody>
</table>

Solubility of CO2 increases:
• with the lower temperature
• with increasing pressure (Henry's law)

For example:
Solubility of CO2 in +1 C and:
1.0 bar = 0.321 * 1.0 = 0.321 %
1.1 bar = 0.321 * 1.1 = 0.3531 %
1.5 bar = 0.321 * 1.5 = 0.4851 %

Sales (beer on tap in the packaging) must contain >0.5% (5 g/l) CO2.
Table 3: Needed CO₂ kg/hl.

<table>
<thead>
<tr>
<th>Brewery/Bar</th>
<th>Kg CO₂/hl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage tank</td>
<td>0.8-1.0</td>
</tr>
<tr>
<td>Pressure Filter</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>Pressure tank</td>
<td>1.0-1.5</td>
</tr>
<tr>
<td>machine for filling bottles with</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>over pressure</td>
<td></td>
</tr>
<tr>
<td>Filling barrels, over pressure</td>
<td>2.0-2.5</td>
</tr>
<tr>
<td>Filling Cans</td>
<td>2.0-2.5</td>
</tr>
<tr>
<td>additionally carbonizes</td>
<td>1.5-2.0</td>
</tr>
</tbody>
</table>

![Picture 1: CO₂ recovery plant.](image)

RESULTS AND DISCUSSION

Budget for the calculation of generated CO₂.

Determining the resulting CO₂ cylinder conical fermentor that ferments wort of 2450 hl.

Amount of CO₂ generated during fermentation worts: 100 L 12% worts give us 1.8-2.5 kg CO₂ \[3,8\]

\[
Q(CO_2) = \frac{V_s \times S_t \times p \times Q_{t}e_{r}(CO_2) \times S_p}{(t - 2) \times 24 \times 10^3 \times CO_2}
\]

Vs-Wort volume in m³ 245
St-Wort weight % 12

\[Q(CO_2) = 245 \times 12 \times 1.140 \times 0.514 \times 0.65 \times (6-2) \times 24 \times 1.977 \]

\[Q(CO_2) = 58.999 \text{ m}^3/\text{h}\]

Neutralization, cleaning agents (NaOH) with CO₂.

The first phase \[CO_2 + 2NaOH = Na_2CO_3 + H_2O\]

\[
pH = 11
\]

Second phase \[Na_2CO_3 + H_2O + CO_2 = NaHCO_3\]

\[
pH = 7 - 8
\]

1 kg NaOH neutralized 1.1 kg CO₂.

CONCLUSION

Carbon dioxide is produced during fermentation. Because it is heavier than air it collects in the bottom regions of the vessels and spaces.

Because a carbon dioxide content of only 45% can have a fatal effect, carbon dioxide must be removed as it is formed.

A small part of the carbon dioxide formed remains dissolved in the green beer, the remainder escapes.

REFERENCES