CO2 recovery in beer production

In a nutshell

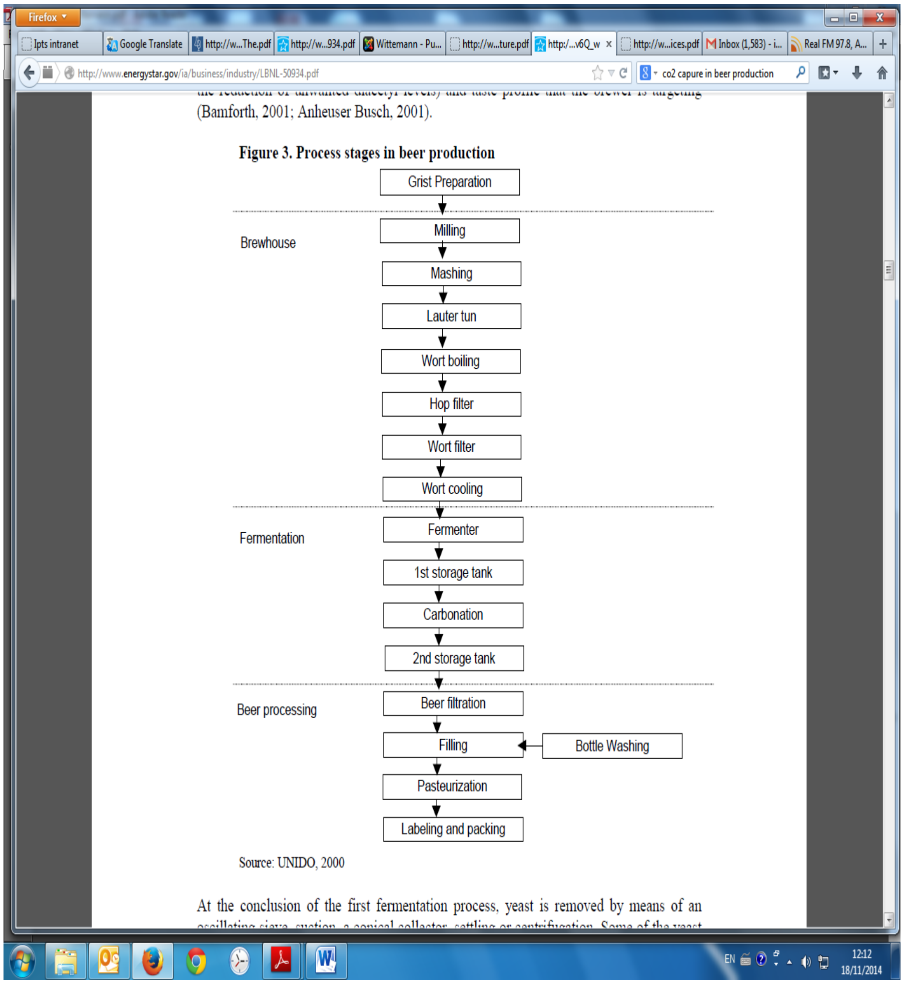
Summary				
Best practice is to recover the CO_2 generated during beer production from the tops of the fermentation tanks/vessels, the maturation vessels and the bright beer tanks. CO_2 can then be scrubbed, purified and compressed for storage. It can later be used in-house in a number of brewery operations, e.g. carbonation and bottling, as well as sold or provided for other applications, in the framework of industrial symbiosis.				
Target activities				
All food and beverage manufacturing	Processing of coffee	Manufacturing of olive oil	Manufacture of soft drinks	Manufacture of beer
Production of meat products	Manufacture of fruit juice	Cheese making	Manufacture of bread, biscuits and cakes	Manufacture of wine
Applicability				
This best practice can be adapted to all scales of beer production. However, microbreweries and small breweries[1] might find it unattractive because of investments costs and the complexity of the system to recover the CO_2 generated.				
Environmental performance indicators				
• Percentage of CO_2 recovered from fermentation (%) • Amount of CO_2 recovered per hectolitre of beer produced (g CO_2/hl) • Hourly capacity of the brewery's CO_2 recovery system (g CO_2/h)				
Benchmarks of excellence				
• A system recovering at least 50 % of the CO_2 generated during fermentation is implemented.				

[1] Council Directive 92/83/EEC of 19 October 1992 on the harmonization of the structures of excise duties on alcohol and alcoholic beverages (OJ L 316, 31.10.1992, p. 21) defines ‘independent small brewery’ as a brewery whose annual production does not exceed 200 000 hl.

Description

The main processes of beer production are illustrated in Figure 1.

Figure 1: Overview of the main processes of the beer manufacturing (Galitsky et al., 2003)



During the fermentation process, the yeast feeds on the wort which results in the production of carbon dioxide (CO_2) and alcohol.

It is best practice to recover the CO_2 generated during beer production from the tops of the fermentation tanks/vessels, the maturation vessels and the bright beer tanks. CO_2 can then be scrubbed, purified and compressed for storage. It can later be used in-house in a number of brewery operations, e.g. carbonation and bottling, as well as sold or provided for other applications, in the framework of industrial symbiosis.

More in details, the CO_2 generated during the fermentation process contains impurities, hydrogen sulphide, oxygen and dimethyl sulphide. These compounds must be removed due to their negative effect on the taste, odour and shelf life of the final products/beer.

The next step after the collection of CO_2 is therefore its cleaning. A number of processes can be put in place, e.g. liquefaction and then vaporisation. This means that a high amount of energy is needed for this operation.

A brief outline of a CO_2 recovery system would include the following processes:

- Foam trap (separator): removes the foam carry-over occasional generated from fermentation
- CO_2 booster compressor: maintains the fermenter pressure and provides positive pressure for purification and compression
- CO_2 scrubber: provides bulk removal of water-soluble impurities in an efficient manner using potable water as the scrubbing medium

- CO_2 compressor: elevates the gas pressure to allow for efficient purification, dehydration and liquefaction
- CO_2 aftercooler/precooler: reduces the temperature of the gas, condenses the gaseous CO_2 and remove the humidity in the gas
- CO_2 dryer: removes impurities and water vapour
- CO_2 liquefaction: conversion of CO_2 gas to a liquid form by use of refrigeration
- Liquid CO_2 tank (storage tank): stores the liquid CO_2

A typical CO_2 recovery system from a brewery fermentation process is illustrated in Figure 2.

Figure 2: Overview of the CO_2 recovery system from the fermentation process in a brewery

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During beer fermentation, about 4 kg CO_2 are produced per hecytolitre of beer. Of these 4 kg, about 2 kg can be recovered thanks to currently available CO_2 recovery systems. Usually, a brewery requires about 2 kg/hl of CO_2 which means that almost the whole CO_2 demand can be covered by CO_2 recovery (Kunze, 2007).

Environmental benefits

Implementing this technique reduces the amount of CO_2 purchased, decreasing the environmental footprint of the final product. This is because industrial production of CO_2 to be added into drinks requires a high energy input.

Side effects

Implementing this process requires energy (heat and electricity) and the installation of additional equipment, increasing the environmental footprint of the process.

Applicability

Virtually all breweries use CO_2 in some form in their processes, typically for purging and bottling. If not recovered from the brewing process itself beverage-grade or at least food-grade CO_2 has to be sourced externally at a cost. The technique is therefore of potential interest to all brewers.

In theory, the technique can be sized to adapt to all scales of beer production. In practice however, micro-scale breweries might find it unattractive to recover their own CO_2.

The reusable CO_2 has to meet certain standards to be reused in the final product, most importantly in terms of residual oxygen concentration, as oxygen in the final products reduces the product shelf life and harms its organoleptic qualities. Therefore the CO_2 purity must be checked before its use in final products; to achieve this, the necessary inlet purity for the CO_2 treatment is approximately from 95 % to 99.7%. This reduces the scope of potentially recoverable CO_2 to only about 50 % of the released CO_2 from fermentation. In fact, it is difficult to separate the initial high concentrations of N_2 and O_2 from the CO_2 (CO_2 recovery normally begins 24 hours after the start of fermentation to ensure that the incoming fermentation gas has a minimum CO_2 concentration of 99.5 % vol).

Economics

CO_2 is required at the end of the manufacturing process in order to achieve the fizzy effect in the final product. Therefore on-site generation, by recovering it, reduces the operational costs of the breweries.

Driving forces for implementation

The main driving forces are reduction of operational costs (reduction of CO_2 purchased) and improved market visibility thanks to promoting an innovative product.

Reference organisations

Molson Coors Brewing Company, Göss and Calsberg Denmark are brewing companies that implement the CO_2 recovery system.

Literature

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