

CO<sub>2</sub>-recovery:

# Thinking outside of the box reduces operational costs by up to 60%

Breweries are seeing an increasing amount of pressure placed on prices and have to take a critical look at their costs. This is difficult because marketing costs are increasing, it appears to be almost impossible to reduce the process costs and environmental regulations are becoming increasingly stricter. However, the end user wishes to enjoy an excellent beer for a reasonable price and, for this reason, breweries must find clever cost savings.

Haffmans has developed three concepts for reducing costs through the use of CO<sub>2</sub> recovery technology. This not only concerns reducing costs by producing CO<sub>2</sub> at a cheap price. Haffmans looked further than just the CO<sub>2</sub> recovery process and by thinking outside of the box, a number of interesting possibilities were exposed.

CO<sub>2</sub> recovery

Before discussing these possibilities, let's have a look at how CO<sub>2</sub> is recovered. CO<sub>2</sub> is produced during fermentation. Any foam residue is removed in a foam separator and the CO<sub>2</sub> gas is then collected and stockpiled in a gas balloon. The gas is passed through a gas washer in which water soluble components, such as ethanol, are removed by passing it in counter-current through water. The gas is then compressed to 17 bar and passed through a bed of active carbon and a drying agent. The active carbon removes unwanted smells, such as H<sub>2</sub>S and DMS from the CO<sub>2</sub> and the drying agent removes moisture from the gas. Once the CO<sub>2</sub> has been dried, the gas can be cooled in a condenser without the risk of freezing. CO<sub>2</sub> liquefies at low temperatures, whilst other gases (O<sub>2</sub> and N<sub>2</sub>) will not liquefy during condensation. As a result of the extraction of the non-condensable O<sub>2</sub> and N<sub>2</sub> gases, this step has a substantial effect on the purity of the CO<sub>2</sub>. The liquefied CO<sub>2</sub> is stored in a storage tank, vaporized again and finally supplied, at the desired pressure, to the breweries for processes that require CO<sub>2</sub>, such as water degassing and carbonization.

Process links

CO<sub>2</sub> washing requires a great deal of energy. The most energy is consumed when the gas is compressed, when removing the smells and drying the gas, and during liquefaction and vaporization of the CO<sub>2</sub>.



There are a number of reversible processes in the recovery process. CO<sub>2</sub> is first liquefied, and in the next step vaporized. This means that a great deal of energy must first be extracted, whilst later almost the same amount of energy is added again. Another example is the compression of the gas. Before the gas is sent to the brewery, the pressure must be slightly reduced.

By linking such processes to other processes, both inside and outside of the recovery process, the costs can be considerably reduced. Consecutively, three systems for recovering energy during the vaporization of CO<sub>2</sub> are presented, all of which have been developed by Haffmans.

- Haffmans Heat Recovery System - Direct
- Haffmans Heat Recovery System - Indirect
- Haffmans Heat Recovery System - LiquiVap

Haffmans Heat Recovery System - Direct

There are a number of processes within the brewery where energy is released. These processes (such as the fermentation or the cooling of compressors) must have a cooling unit. Most breweries install a cooling unit and sometimes an intermediate medium (glycol) is used for cooling. Cooling towers with open or closed water circulation systems are also used for cooling compressors.

On the other hand, there are also processes which require energy, such as the vaporization of CO<sub>2</sub>.

Operational costs can be reduced by linking

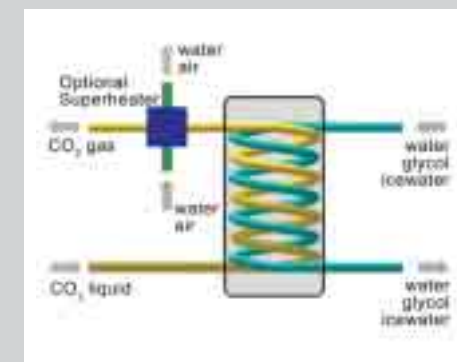
the processes which release energy to the processes which require energy. For a very small cooling unit or cooling tower, such a link will take the pressure off the cooling process, so that no further expansion of the cooling unit or cooling tower is necessary.

The solution which Haffmans offers is a direct Heat Recovery System. Glycol, which has been heated in a fermentation tank, is passed to a heat exchanger. Cold CO<sub>2</sub> is passed to the other side of the heat exchanger and, as a result, CO<sub>2</sub> will be vaporized and (hot) return glycol will be cooled. Possible agents to be used are glycol, iced water or cooling water. However, if glycol or iced water is used, the vaporized CO<sub>2</sub> must receive additional heating.

Such a system quickly pays for itself. An example of a brewery using this system is given below. In this brewery, CO<sub>2</sub> is vaporized with steam. The costs have been reduced considerably by installing a direct Heat Recovery System. Furthermore, the glycol is cooled in advance, so that less pressure is placed on the glycol cooling system.

Annual production: 800,000 Hl/year  
 Costs for glycol: 0.027 Euro/kW  
 Costs for steam: 0.017 Euro/kg of steam

The amount of investment of the Heat Recovery System for this particular brewery paid for itself within 19 months. In general, such systems pay for themselves within 12 to 24 months, although this depends various factors, such as the capacity of the HRS system, the costs for glycol and steam, and the number of operating hours.



Recovery System-Direkt

Haffmans Heat Recovery System -Indirect

If breweries use NH<sub>3</sub> to cool processes, either directly or indirectly, this NH<sub>3</sub> can also be used as an energy source in a Heat Recovery System.

However, in case of a leak, CO<sub>2</sub> and NH<sub>3</sub> would come into contact with each other (cross-contamination). The result would be a chemical reaction between the gases and a salt would be formed. Such a reaction is extremely undesirable and would force the brewery to stop the entire production process.

In order to prevent cross-contamination, Haffmans has developed an indirect Heat Recovery System, which uses an intermediate system. In case of a leak scenario, the second heat exchanger forms a physical barrier between the CO<sub>2</sub> and the NH<sub>3</sub>. However, regarding the low temperature of the NH<sub>3</sub>, additional heating is required.

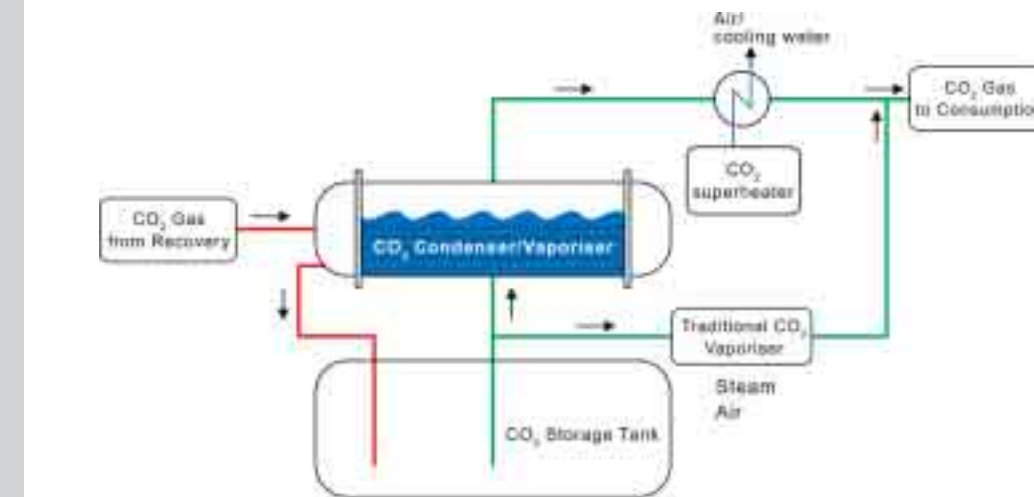
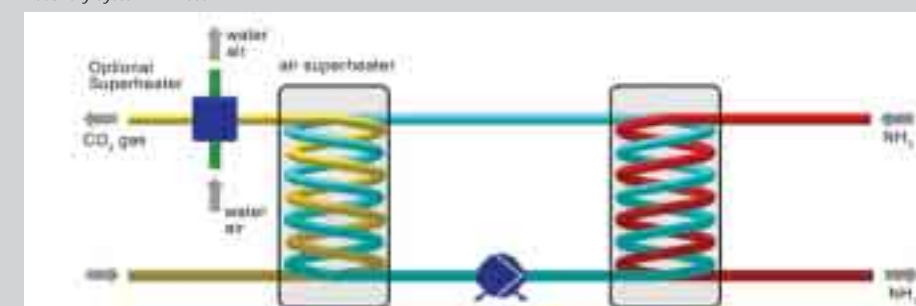
Haffmans has also tested this system in practice. The large advantage that cross-contamination is not possible requires larger investments though.

Consequently, it will generally take longer for such a system to pay for itself. It typically takes an indirect Heat Recovery System between 18 and 30 months to pay for itself, depending on things such as the capacity of the HRS system, the costs for glycol and steam, and the number of operating hours.

Haffmans Heat Recovery System - LiquiVap

For the third and last concept, Haffmans

Recovery System - Direct



HRS-LiquiVap

makes effective use of irreversible processes within the CO<sub>2</sub> recovery process. The large energy consumers within the process are linked to each other, so that, depending on the configuration, the net energy use for CO<sub>2</sub> recovery can be reduced by up to 60%. A large quantity of energy must be extracted from the process during the liquefaction of CO<sub>2</sub>. After it has been stored, a lot of energy is required again for vaporizing the CO<sub>2</sub>. In the new Haffmans concept, both flows are brought together in the Heat Recovery System LiquiVap (Liquefaction-Evaporation). The HRS-LiquiVap system makes it possible to liquefy the CO<sub>2</sub> whilst using hardly any energy for cooling. If CO<sub>2</sub> production and consumption take place simultaneously, there is an immediate energy saving because the extracted CO<sub>2</sub> can then be used to liquefy the CO<sub>2</sub>.

At times when there is no CO<sub>2</sub> production or consumption, it is possible to liquefy or vaporize CO<sub>2</sub> in the traditional way, for example, at the start of the week when the fermentation has not yet started, but the beer is already being kegged, casked, bottled or canned. This system has also been installed and undergone extensive testing at a brewery with an annual capacity of 2 million hectoliters. Besides a number of different beers, this brewery also produces a considerable quantity of soft drinks and other alcohol-free products. The results are very positive. The expectations at the beginning of the project have been exceeded easily. Since using the HRS-LiquiVap system, the brewery has saved energy for a number of processes, namely:



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- CO<sub>2</sub> condensation energy with the consequent release of heat to the centralized brewery cooling system linked to it
- When pre-cooling the cooling water.
- The energy necessary to vaporize CO<sub>2</sub> (steam).

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