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Environmental technology: Liefmans Brewery

Introduction to the company

The Liefmans Brewery was founded in 1679 by the Liefmans family in the same buildings as today, in Oudenaarde. They started to brew an “oud bruin” beer before enhancing their offer with fruit beers and beers of high fermentation. Despite their savoir-faire and their passion, it went bankrupt in 2008 but the group Duvel-Moortgat took them over later the same year. Currently they are producing 13 different beers with only 9 employees.

During the golden ages they had two water treatment tanks but given the cost endured by these installations, they decided only to manage the water’s pH before getting the water cleaned by Aquafin. The reason for still doing a pH correction before sending their water is that, if the pH is not inside the range [6;10,5], Aquafin will simply refuse the water. For the other criteria (like the concentration of some metals), Aquafin is only charging a certain fee if the concentration is above a certain limit.

We went on the Oudenaarde site which is situated on the “Schelde”. We would like to thank M. Cedric Heymans who shows us the brewery around and gives us precious information to write this report. The later will describe the two water treatment installation and compare them in term of costs.

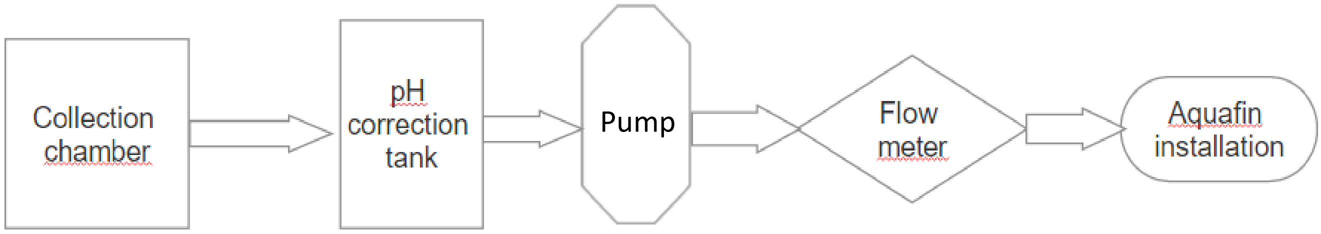
Waste stream process

We focus here on the wastewater treatment. In fact, it is the only waste stream treated on-site. The other waste stream – the yeast – is processed by an external company. For this process, Liefmans simply collects the yeast on-site, separately from the wastewater, in a tank and the external company comes to collect it on demand. This company transforms then the yeast into biogas thanks to an anaerobic treatment but Liefmans does not benefit from this biogas.

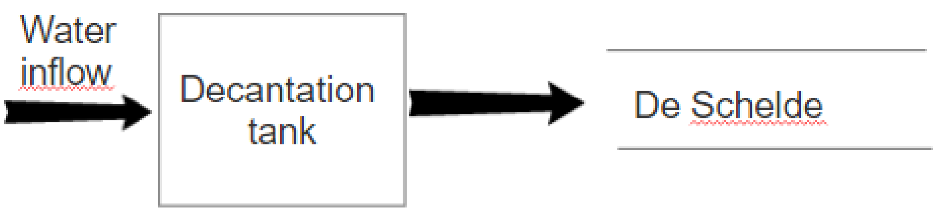
The water that needs to be treated comes from different sources: the cleaning in place process, beer leakage, external cleaning, the toilets, evacuation from steam generator… It is important to note that water is the main ingredient of beer so the wastewater treatment should be particularly important for a brewery.

As explained hereabove, the Liefmans brewery is only using a pH correction system and then, send its wastewater to Aquafin for further treatment. For this service, they are paying a fee called "vervuilingseenheid" which depends on the composition of their water. However, before using this process, they treated their water thanks to a pure anaerobic treatment. The reason for the change was the low production quantity which makes it not profitable any more to keep wastewater treatment installations on site. In fact, these financial problems were witnessed by the bankruptcy in 2008. When Duvel Moortgat took them over, they choose for this simpler solution (pH correction) that was financially more interesting. The new system is in place since less than one year now. So, in this report, we will try to compare these 2 systems and comment on the decision of the company.

In the recent system, the water is first gathered in a tank, called a collection chamber. All the water need to first go through this tank before being further processed. The water is next pumped into the pH correction tank. The water is not continuously pumped; it is pumped in a rate to keep the pH correction tank always full. In order to bring the pH into the range [6-10,5], they add to the water a solution of sulfuric acid (37,5%) and a solution of caustic soda (27%). The water is then pumped out and monitored thanks to a flow meter, which is accredited. After this control, the wastewater is flowed to the Aquafin plant in Oudenaarde. This process can be summarized with this graph:



As already mentioned, Liefmans previously managed a pure anaerobic water treatment installation. The water was collected in a decantation tank where it was treated by bacteria in an anaerobic way. This process can be summarized thanks to the graph hereunder. The technical aspects will be explained in the next section.



Technical aspects

Our calculations are based on these data that were given to us by the company:

- Yearly flow = 5000 m^3
- Operating time = 225 days per year

- COD = 3000 mg/L
- BOD = 2000 mg/L

Concerning the decantation tank (the old installation), it has a capacity of 15 m^3 and they had 2 tanks that were used alternatively.

$$bCOD = \frac{2000mg/l}{0.65} = 3076.9mg/l \;\; => 3000\ mg/l$$

$$3000\,\frac{mg\ bCOD}{L} \times 5000\,\frac{m^3}{y} \times 1000\,\frac{l}{m^3} \times 10^{-9}\,\frac{ton}{mg} = 15\,\frac{ton\ bCOD}{y}$$

<u>Reactor volume and cost</u>

Reactor volume = $15\,\frac{ton\ bCOD}{y} \times 0.15\,\frac{m^3}{ton\ bCOD} = 2.25\,\frac{m^3}{y}$

These calculations are based on the assumption from the syllabus that for an anaerobic process, 0.15m^3 reactor are needed per ton bCOD. Based on this assumption, they should only dispose of 2.25m^3 reactor and they in fact dispose of 15m^3. They disposed of a too important design which lead to higher investment and operating costs. This will be further discussed in the economical section.

<u>Electricity analysis</u>

Electricity produced: $1000\,\frac{kWh}{ton\ bCOD} \times 15\,\frac{ton\ bCOD}{y} = 15{,}000\,\frac{kWh}{y}$

This is again based on the assumption from the syllabus that 1 ton bCOD produced 1000kWh. This production of 15,000kWh can be reused elsewhere in the production process and lead to savings.

<u>Thermal analysis</u>

Energy produced: $3000\,\frac{kWh}{ton\ bCOD} \times 15\,\frac{ton\ bCOD}{y} = 45{,}000\,\frac{kWh}{y}$

This calculation is again based on the assumption from the syllabus and this thermal energy could have been reused to heat the water needed in the production process to retrieve the starch from the malt.

<u>Sludge production</u>

Sludge produced: $15\,\frac{ton\ bCOD}{y} \times 0.1\,\frac{ton\ sludge}{ton\ bCOD} = 1.5\,\frac{ton\ sludge}{y}$

Economical aspects

We will first develop the costs associated with the new system. Thanks to the composition of the water that was given to us by the company, we can compute the fee that they have to pay to Aquafin:

- COD = 3000 mg/L
- BOD = 2000 mg/L
- N = 20 mg/L
- P = 10 mg/L
- Cr = 0.05 mg/L
- Cu = 0.1 mg/L
- Zn = 0.2 mg/L
- Pb = 0.05 mg/L
- Suspended solid = 1g/L

The other components that are not mentioned are not present in the wastewater. Thanks to the formula's given in our syllabus we can compute the polluting units.

$$N_1 = \frac{22222.22l}{180} * \left(0 + \frac{0.35*1000mg/l}{500} + \frac{0.45*(2*2000mg/l+3000mg/l)}{1350}\right) * \left(0.4+0.6*\frac{225d}{225}\right) = 374.49$$

$$N_2 = \frac{5000m^3}{1000} * (40*0 + 10*0 + 5*(0.2mg/l+0.1mg/l) + 2*0 + (0.05mg/l+0.05mg/l)) = 8$$

$$N_3 = \frac{5000m^3*(20mg/l+10mg/l)}{10000} = 15$$

$N_k = 0$

$$K_v = \frac{22222.22l}{180} * \frac{0.45*2000mg/l}{1350} * \left(0.4+0.6*\frac{225d}{225}\right) = 82.30$$

=> Thus V.E. = 374.49+8+15-82.30 = **315.45**

The price for one V.E. in 2017 is 52.39€. The yearly cost of that strategy is then 16,526€. To this cost however, we have to add the costs of the additive used to control the pH, the amortization of the infrastructure and the salary of the operator of the installation. We can consider that the operator works on it 0.5 hour per day at a salary of 40€/hour (this an estimation since he did not want to disclose his wage). On a yearly basis (225 days of effective work), they need 112.5 workhours for the maintenance of the installations and this will cost 4500€.

There are also investment costs associated with the installation. According to M. Heymans, the installation cost 45,000€, including the cost for the pump. They also had to pay for the pipes to transport the water to the Aquafin installations. This costs them around 5,000€. We can assume that they will amortize these costs over 10 years. The annual amortization is so equal to 5,000€.

They also need to do four five-day measuring campaigns every year and this costs them 1,000€ per campaign. The annual cost is then equal to 4,000€.

The last operational cost is the cost of the chemicals used to control the pH. Since this way of treating water is relatively new for the company, they do not exactly know to how much it amounts but they estimated it to be 1,500€ per year.

The total cost of this system is then equal to 31,526€ including the amortization of the installations.

Now we discussed the costs of the current installation, we will briefly discuss the costs of the previous one. To process the water anaerobically, they need chemicals and they estimate the costs of them to 4,000€ per year. They estimated the operational costs of such a system to be 9,000€. The sludge produced needs to be processed as well and this results in a cost of 750€/year as calculated hereunder.

Sludge processed: $1.5\frac{ton\ sludge}{y} \times 200€ \times 0.4 ton\ sludge^{-1} = 750\frac{€}{y}$

However, Liefmans failed to use the electrical and thermal energy produced by the anaerobic treatment. This could have brought savings as calculated hereunder because this energy could have been used in the production process.

Electricity savings: $15{,}000\frac{kWh}{y} \times 0.01\frac{€}{kWh} = 150\frac{€}{y}$
Thermal energy savings: $45{,}000\frac{kWh}{y} \times 0.04\frac{€}{kWh} = 1800\frac{€}{y}$

The total cost from which we retrieve the savings for the production of energy amounts to 11,768€. This doesn't take the investment costs into account because they already dispose of the tank. We should however add an investment for the CHP unit to produce the electricity and the heat. According to us, this investment can be readily recovered and this is so cheaper than the new installation.

General advice for the company

First, they are not processing the yeast themselves but are outsourcing it. We can advise them to do it on-site because they can transform the yeast to biogas and obtain energy from it. This energy could be used to run other processes in the brewery and help them cut costs in other departments.

Secondly, we compare the two different installations – the old one and the new one – and what concern the cost, the old one seems more cost-friendly. This may require a bigger investment at the beginning but in the long run, it brings savings in other department of the company. Moreover, the cost of the new technique strongly depends on the cost of the V.E. that is set by the government and we can expect that this fee will continue to increase in the following years to encourage companies to treat their waste and avoid pollution.