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MANAGEMENT STRATEGIES APPLIED IN WATER STATIONS USED IN THE FOOD INDUSTRY IN ORDER TO INCREASE THE QUALITY OF THE BIOGAS

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Abstract
Reducing the costs of wastewater treatment plants in the food industry is a necessity. Thus, it is necessary to find solutions to make their operation more efficient. The use of biogas obtained in the production process is a variant that leads to the increase of the profit at the whole plant level. This is how the Balance Scorecard model was used. The use of this model was based on non-financial indicators. These were: biogas quality and wastewater indicators from the UASB reactor that ensures biogas quality.

Keywords*: anaerobic reactor, Balance Scorecard, sludge*

Introduction
Waste water treatment in the food industry is one of the current problems in the field of industrial wastewater treatment. Achieving the purification process in the context of continuously changing raw materials in the food industry is one of the most difficult issues (Deublein et al 2008). The introduction of new compounds that provide additional oxygen supply leads to the destabilization of the purification process and therefore of the anaerobic reactor.

In this paper, the management of the wastewater treatment plant from the beer industry was studied through a direct connection between the parameters followed in the treatment station and the Balance Scorecard concept. This notion aims not only to streamline the process of purification, increase the quality of the biogas and reuse it in the process of beer production. The use of the physical-chemical indicators of industrial wastewater in the management of the treatment plant was achieved by developing the interdependence between them, used for the technical-economic optimization of both the purification process and the beer production process.

This is how the Balance Scorecard model is used, which is very often used in management (Robert et al 2000). The non-financial indicators are thus extrapolated to the station level by choosing the quality of the biogas and the wastewater indicators that ensure the quality of the biogas. This ensures the profitability of the treatment plant which under normal conditions is a large consumer of funds allocated for environmental protection by the factory to which it belongs (Al Seadi et al 2013, Nam et al 2018).

Materials and Methods

The anaerobic purification process takes place in a UASB reactor. The reactor has a biomass load from anaerobic microorganisms. The waste water from the brewing process is introduced into the reactor. Exit from the reactor results in purified waste water and biogas. To separate the biogas at the top of the reactor there is a three phase separator. The biogas is washed at the top in a scrubber for disposal CO_2 and H_2S. The diagram of the installation is shown in Figure 1 and Figure 2.

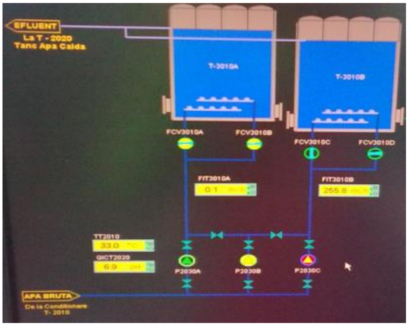

Figure 1. Description of the wastewater treatment process

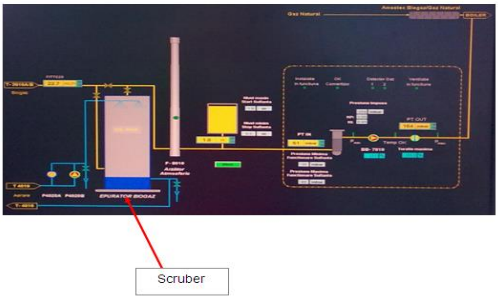

Figure 2. Scruber details

The continuous measurement of the pH value in water contributes to its regulation in order to ensure the conditions necessary for bacterial degradation. In normal cases a pH of 6.8 is expected.The continuous measurement of the temperature value in water contributes to its regulation in order to ensure the conditions necessary for bacterial degradation. Typically, the temperature range of anaerobic reactors is between 25-39^{o}C.
Volatile fatty acids are the substrate for methane bacteria and under normal operating conditions the VFA concentration is less than 2-5 meq / l in anaerobic effluent.
The production and composition of the biogas offers real and immediate information about the operation of the treatment plant, being in direct connection with the CCO transformed into the plant. Dividing this number (expressed as transformed CCO) into the total CCO loading of the system, calculated as flow or CCO concentration,

results in the rate of purification of gas production. Biogas production also provides information on biomass activity.

Knowing the total volume of biogas, one can calculate the energy released by burning it. Then using the price value for one MW of energy sold by national distributors for industrial consumers we can calculate the costs saved by using this biogas plant.

The formula is used (Deublein et al. 2008):

$$E = Vb \times PCS \quad (1)$$

where E is the energy (kWh), Vb is biogas volume (Nm^3), PCS is the superior calorific power (kW/m^3).

Results and Discussion

Anaerobic scrubbing removes approximately 75-80% of COD load and 350-400 litters of gas per kg COD is obtained.

Biogas consists largely of methane (60-90%) and carbon dioxide (10-40%). Most of the organic matter anaerobic degradation is transformed into biogas, a relatively small part is transformed into new cellular material.

The production and composition of biogas provides real and immediate information about the operation of the WWTP, being directly related to the CCO transformed into the installation. By dividing this number (expressed as converted CCO) to the total CCO load of the system, calculated as flow or concentration of CCO, the gas purification rate results. Biogas production also provides information on biomass activity.

Real VFA means the sum of the current concentrations of weak fatty acids such as: acetic, propionic and butyric acid. A higher concentration in the anaerobic effluent indicates that the process is overloaded. All fatty acids are determined by the titration method. At the same time, the analyzes confer the alkalinity (pH capacity) of the effluent. During unstable conditions, the alkalinity will decrease and the VFA concentration will increase. The higher the alkalinity, the higher the resistance to ph fluctuations. Alkalinity is expressed in milliequivalents of bicarbonate per liter (meq / l).

If the high concentration of VFA continues or worsens, the first action to be taken is to reduce the wastewater flow until the process parameters are again within normal limits. If the station is well operated, moderately charged, biogas production will increase as soon as the CCO load is increased. If this does not happen it means that the station is already operating at the maximum possible biomass load at that time. It may also indicate that the biomass is not kept under optimal conditions or the amount of biomass present in the system may be too low. In both cases the concentration of volatile fatty acids in the anaerobic effluent will increase and this is a sign that the system is overloaded.

Knowing the variations of gas consumption characteristic of a beer factory, we can conclude that the biogas production and exploitation plant cannot be a guiding element of the process. The main objective during the operation of the boilers is to provide the quantity of steam required for the production of beer at the set pressure values. It is desirable that biogas consumption values be maximized but this can only be done by optimizing biogas availability. The next challenge was to optimize the installation and increase the volume of biogas burned in the boiler. A pressure sensor is mounted on the blower suction pipe, which reads the instantaneous pressure and transmits the information to a controller. Upon reaching the pressure of 400 mbar the controller activates a three-way valve by diverting the biogas route to the facla. This value of 400 mbar was chosen for the safety reasons of the equipment, because at values greater than 400 mbar the buffer vessel constructed of deformable plastic material was in danger of explosion.

From the four perspectives of BSC, the perspective of internal processes was chosen, namely the quantity of biogas that was consumed in May 2019. For the implementation of BSC, a logical scheme was developed.The logical scheme of the Balanced Scorecard is shown in Figure 3.

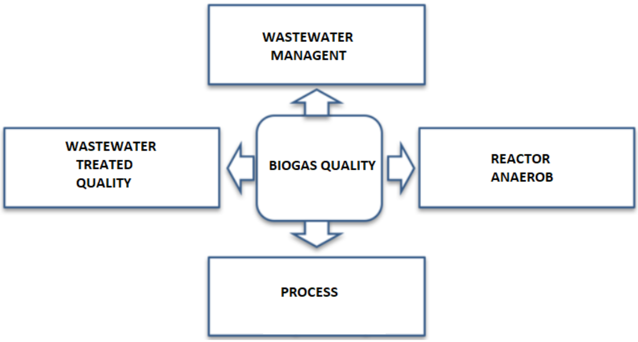

Figure 3. The logical scheme of the Balanced Scorecard

A more accurate picture of gas consumption can be seen in Figure 4 daily total gas consumption and biogas consumption in May 2019. Daily consumption has close values, on average 14500 m^3 per day with a maximum of 17300 m^3 and a minimum of 10100 m^3. Biogas consumption remains constant, on average 1650 m^3 per day (Figure 5).

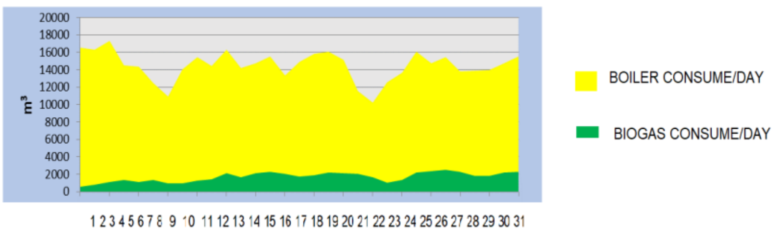

Figure 4. Boiler gas consumption in May 2019

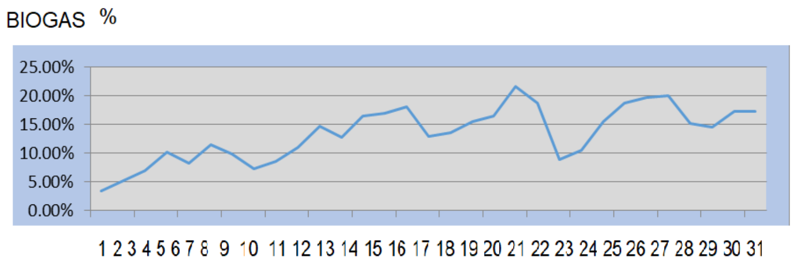

Figure 5. Biogas percent from gas consumption in May 2019

Boiler gas consumption in May 2019 shows the percentage of biogas from the total gas consumed by the boiler in May 2019. The percentage remains on average at a value of 13.5% with peaks over 20% and minimums below 5% at the beginning of the month.

As biogas consumption has been tracked for several years, a price value for MWh of 29 Euro is chosen, an average of the price for industrial consumers in these four years. The final value also adds a 19% VAT. Excise duties on gas are not taken into account. For E=9408000kWh results after applied equation (1) the value for burning natural gas mix with biogas: 324670 Euro/year.

Knowing that the investment in the design, construction and equipment works was about 200,000 Euro we can say that it was amortized and in the end the company made a profit of 124670 Euro. Even if from this the amount is reduced the cost with the replacement of the boiler economizer, which stood between 50,000 Euro and 100,000 Euro the company still remains in the profit area.

Conclusions

The case study from the present paper shows that a treatment plant equipped with a UASB reactor type anaerobic biological treatment stage can produce enough biogas to supply 4.1% of the total gas requirement of a brewery. It has been demonstrated the capacity of a biogas production and exploitation facility to be economically efficient under real operating conditions in which the occurrence of operating defects and errors is inevitable and must be taken into account.

The installation was stopped for long periods of time, totaling about 14 months out of the four years of operation. Also, the discontinuous operating mode of the steam boiler did not favor the consumption of biogas, the optimization attempts by using the Balanced Scorecard increased the availability for the consumption of the biogas. However, the total cost saved by burning the biogas was 324670 Euro/year. The initial investment was amortized in three years.

The processing of the by-products of the food industry for the production of biogas is a real alternative for increasing the profit of an enterprise and offers a friendly solution with the environment and the efficiency of solving the problem of waste.

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