Controlling Cod In An UASB Reactor

I. INTRODUCTION

Studies carried out by the worldwide system of environment monitoring have shown a significant growth in pollution of natural resources, a cause of the accelerated activity from the development centres. This fact has promoted the creation of environmental rules in order to guarantee a limit to the quantity of toxic matter released in industrial and urban effluents [1]. Wastewater treatment plants (WWTP) have been developed as a solution to mitigate the contamination problem.

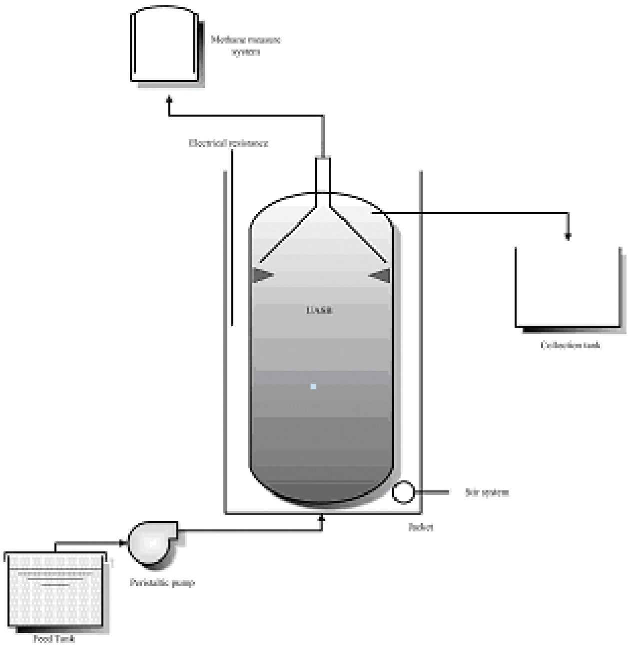
The purpose of this work is to evaluate the feasibility of a feedback linearization control strategy, considering temperature as control action. It is implemented in an up-flow anaerobic sludge blanket (UASB) reactor for the treatment of a dilute leachate stream produced in the Municipal Landfill La Esmeralda from Manizales-Colombia.

II. DESCRIPTION OF THE SYSTEM

The UASB reactor was developed by Dr. Lettinga and his colleagues from Wageningen University, in the late 1970’s [2]. This reactor allows high retention of biomass without any support material, through the formation of sludge granules of 0.5-2 mm diameter with exceptional properties of settling. This study was performed at the Laboratory of Productive Process from the National University of Colombia at Manizales, using a 8.17 l lab scale equipment with a 10.5 ml/min average flow rate. The reactor was made of a 147.5 cm high circular Plexiglas column with 8.4 cm inside diameter. This system relies on a jacket to regulate the temperature reactor by means of a 70W electrical resistance. The sketch of the reactor is shown in Fig. 1.

1. Acquisition system: The components of the acquisition system are: 1. Temperature sensor (LM35). 2. Methane sensor: this device was made under the Mariotte bottle principle. 3. Acquisition card: National Instruments PCI 6034E series. 4. Power and signal adjustment circuit. 5. PC: DELL X86 family model 6 with 129 Mb-RAM.

2. Process phenomenological model. The phenomenological model of this process is based on the physiologic state of the bacteria, interaction between phases, ionic equilibrium and the hydraulic behaviour of the reactor. The complexity for modelling this kind of process is even higher compared to other biotechnological ones, because of the variety of microorganisms involved (which are not perfectly known). Also, the substrate to be treated is often a blend of several very different and complicated substrates whose composition is evolving and is not perfectly known [3]. The set of equations presented below constitutes the developed model, which was validated in [4] by means of reactor operation data for a ten-month time period.



$$\dot{S} = D(S_0 - S) - Y\Theta^{T-30}\mu X$$
$$\dot{X} = D(X_0 - (1-\eta)X) + \Theta^{T-30}\mu X$$
$$Q_{met} = k_{met}\Theta^{T-30}\mu X$$

where D is the dilution rate, S and X are, respectively, the concentrations of COD and VSS, μ is the specific growth rate, Y and k_{met}, are, respectively, the yield coefficients for COD degradation and methane production. The parameter η (0 d» η d»1) is associated with the settling efficiency, which allows a high biomass retention, a typical property of high rate systems. The

$$\mu = \mu_{max}\frac{S}{K+S}X$$

term Θ^{T-20} includes the temperature influence [5] and the subscript «$_0$» indicates influent concentration. The specific growth rate is given by Monod expression:

The model above is analogous to other models reported before for an anaerobic upflow fixed bed reactor. Model parameters are:

Y= 3.35 (mg COD)/(mg VSS), k_{met} = 0.0146 (ml CH4)/(mg/l VSS) ; μ_{max} = 1.32 day^{-1}; K= 5522.3 (mg COD)/l; η = 0.93 ; Θ= 1.04.

III. FEEDBACK LINEARIZATION CONTROL SYSTEM.

Considering the temperature as input and the concentration (S) as the variable to control and testing the controllability of the system [6], we find that it is possible to control it. The central idea of FLC approach is to algebraically transform a nonlinear system dynamics into a linear one [6]. The control law must be designed to guarantee that error dynamics (deviation of the variable with the set point) is governed by stable differential equation. Considering the following control law:

$$\Theta^{T-20} = -\frac{v - D(S_0 - S)}{Y\mu X}$$

where v is the new input to the closed loop, the deviation between S and the set point S^* is given by the error $e= S^* - S$. The stability condition for error dynamics, is achieved if $\dot{e} + \lambda e = 0$, where λ is a positive constant. To apply the previous control law it is necessary to prove the stability of internal dynamics [4]

IV. RESULTS AND CONCLUSIONS

The control law obtained is influenced by the selection of λ parameter. To study this relationship, some simulations were carried out, considering as operational conditions: D=2.0 day^{-1}, S_0=2700 mg/l COD, X_0 =320 mg/l VSS and changing S_0 to 3500 mg/l COD when t= 2 days. The reference value was set to S^*=428.8 mg/l COD.

The open-loop system response is compared with the closed loop system for different values of λ in Fig. 2. For the first two days, all the loops were in the equilibrium state, corresponding with the parameter S^*. When the disturbance in S_0 was applied, the open loop converged towards another equilibrium, while the closed loops escapes from S^* in a very short time. After this, the system went back to the equilibrium defined by the set point. Thus, the disturbance was efficiently rejected. For increases in λ, the settling time and the overshoot decreases. Thus, from a theoretic point of view, making $\lambda \rightarrow \infty$, the closed loop would have better performance. However, it is known that a physical system has dynamics limitations and it is not possible to force it more than its inherent conditions would allow. Experimental set up including state observer was performed but it is not presented here.

This study presents the feasibility for COD regulation in an UASB, using the temperature as control action, which has been demonstrated by means of the *nonlinear controllability matrix* analysis. The PI, fuzzy and feedback linearization strategies were evaluated by means of simulation. The feedback linearization strategy is better than the others, and its implementation was easy to make from the Municipal Landfill La Esmeralda, establishing the biogas produced in the reactor as the energy source for heating.

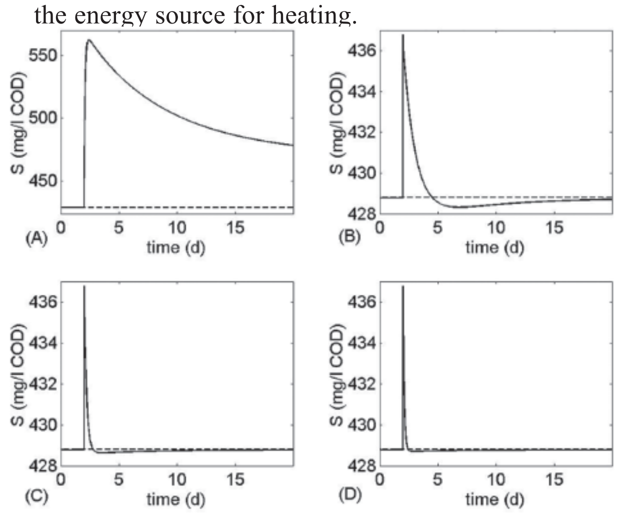


Figure 2. Simulations. (A) Open loop response. B) FLC, λ = 1. (C) FLC, λ = 5. (D) FLC, λ = 10

V. REFERENCES

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License Plate Recognition System

1 Objectives

The objectives of this project are to know the techniques, tools and elements of a vision system to make an application for vehicle license plate recognition through LabVIEW programming.

From different processing image techniques, the image is prepared to be analyzed. Next, using extraction methods, the license plate is located and later, OCR is applied in order to find the license plate alphanumeric code.

The system lacks external illumination, and this is why algorithms have been added to deal with difficult images.

The developed application can acquire images from different sources: webcam cameras, generic frame grabbers, Firewire 1394 cameras or images files.

Figure 2 Valid camera positionation

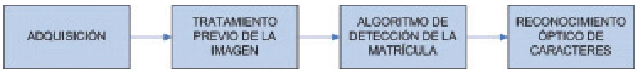

Figure 1 Block diagram of the system

The basic characteristics we sought for the webcam were that it had a wide angle of view and a CCD sensor (this type improve the system indirectly to allow clearer images with little illumination) in comparasion to CMOS sensor. Another important desired characteristic is that it had an automatic control exposition.

2 Image acquisition

The system has initially been developed with a webcam as the device for capture imatges to reduce the cost and to allow the portability, but if other devices are connected, the source can be selected.

The image acquisition in LabVIEW is made with the functions of NI-IMAQ library, but this library does not allow acquisition from webcam cameras or generic frame grabbers. This problem was solved reprogramming a free code distribution of acquisition cameras and compiling it into a DLL to be able to be used in LabVIEW.

3 Treatment of the image

The method known as scale amplitude is applied because the improvement that it introduces and facilitates the detection of the edges of the objects, which is one of the used techniques later used to detect the license plate.