SIMULATION OF AUTOMATED WATER TREATMENT CONTROL

PhD Stud. Eng. COSTACHE (BIRA) Lenuta, Politechnica University of Bucharest,
ROMANIA, nuti_bira@yahoo.com

Abstract: *A to optimize the work in wastewater treatment plants can use the automation system consisting the using SIMULINK- MATLAB. The results are very good using FUZZY CONTROLLER if they are programed properly and efficiently. The chosen technology combines natural treatment with biological treatment with activated sludge. This solution the monitoring of the parameters in the purification processes is an essential activity in the wastewater treatment plants significantly reduces electricity consumption and ensures the valorisation of nutrients in wastewater.*

Keywords: simulink, matlab, fuzzy controller

1. Simulink. Basic elements

MATLAB is a programming language developed by MathWorks. It started out as a matrix programming language where linear algebra programming was simple. It can be run both under interactive sessions and as a batch job. This tutorial gives you aggressively a gentle introduction of MATLAB programming language. It is designed to give students fluency in MATLAB programming language. Problem-based MATLAB examples have been given in simple and easy way to make your learning fast and effective.

A dynamical system is an abstract, mathematical notion in which one or more rules describe the time dependence of a point in an abstract space, usually the real three-dimensional geometric space. Simulink is a component of the MATLAB package for modeling, analyzing and simulating dynamic systems. Using the Simulink program is done in several steps:

1. Launch the Simulink program from MATLAB. This is done by writing the command ,,Simulink,, or from the toolbar press the Simulink button. A window called Simulink Library Browser appears (see figure) announcing that Simulink is active.

2. Modeling. In this stage, a pre-existing model of a dynamic system is created or modified. A Simulink type model is a block diagram (see fig. 1). A block is a representation of some fundamental entities of the dynamic system and consists of 3 components: 0, one or more inputs, 0, one, or more outputs and a function that describes how the outputs are obtained from the inputs. Blocks are of several types but automatically receive a unique name in the model. If one of the blocks is repeated, then MATLAB adds numbers to the end of the name to distinguish the blocks. The links between blocks are called connections.

Connection is a line that joins an output of one connection with an input of another connection. A special category of blocks is that with 0 entries. These blocks are called sources. Another category of blocks have only inputs and are called collectors (from the English word sinks). Blocks are found by category in the Simulink Library Browser (see fig.1). Creating a new model is done by typing the button. A new window appears where we have to insert the blocks

To insert a block into the model, use the mouse with drag-and-move. That is, we go to the block in the desired category, select it by pressing the left mouse button, keep the button pressed, place the mouse pointer where we want in the model window and then release the left button. For example, let's introduce a source into the model. For this we go to the Simulink Library Browser and select Sources, then from the right we drag the Sine Wave block into the model window wow. We will connect these blocks with a connection. For this we will go with the mouse to the right exit of the Sin Wave block until a cross appears. We press the left button and keep it pressed and move the arrowhead to the left entrance of the Scope block until a cross appears again. Then we release the mouse button and the connection is created.

Launching the simulation. It is done by pressing the button in the model window. Once the simulation has started, this button turns into a stop button that can be used to stop the installation.

View results. This is done by double-click on each defined collector.

Results analysis. In this phase, the results are interpreted and it is concluded whether the simulation is correct or not. If it is not correct, you can go back to phase 2 to modify the mouse. Other times we simply want to change the input data to see how the model behaves with the new data set. Other times we want to introduce new blocks etc.

2. Simulation of automated water treatment control

In order to verify the control of the purification process (see fig. 1) based on the proposed Fuzzy regulators, models were made in the environment MATLAB/Simulink, one of them is shown in fig. 1.

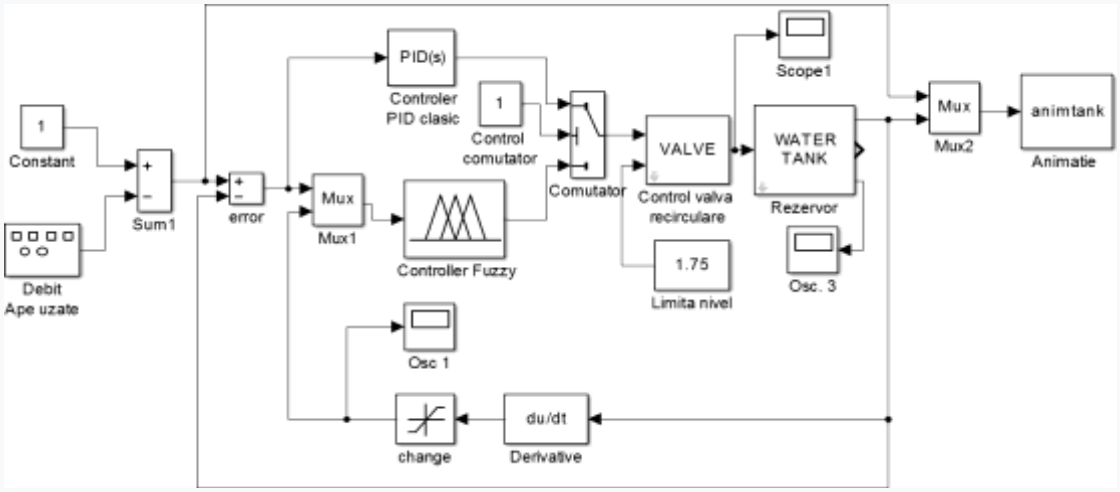
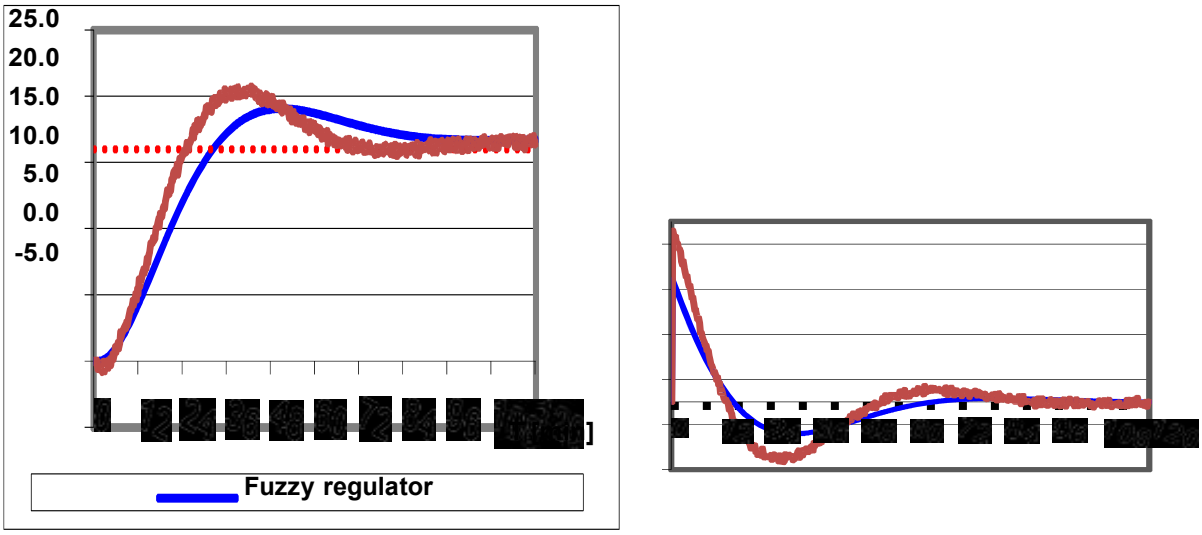


Fig.1 Fuzzy controller simulation in MATLAB/Simulink environment.

In the given model, the input variables - wastewater flow and the output variables - the amount of excess sludge were applied to the purification process. Computer simulations were run to verify the availability of the proposed controller in practice. The regulation of the recirculating sludge was carried out for comparison both by the classic PID method and by the fuzzy method under the same process conditions.

Preliminarily, the adjustment of the classic PID controller was performed according to the Ziegler-Nicols method [6],[7] to obtain a quasi-optimal adjustment, then it was implemented the Fuzzy regulator, in which they were included in the rule base with compound premises, which reflect a situation composed of two variables that simultaneously act on the flow of waste water *Yes.u.* and the variation of *dDa.u/dt* (the variation of the wastewater flow rate) determine the amount of recycled sludge.



a) b)

Fig.2. Results of the simulation of regulating the excess sludge, applying Fuzzy and classic PID regulators: a) Process reaction (excess amount of sludge);
b) The control signal of the regulators.

For simplicity, the triangular and seven-curve/segment membership function shape was applied to adequately cover the required range of input values:

N – "normal";
NP – "slightly negative";
NM– "average negative";
NF – "strongly negative";
PP – "slightly positive";
PM – "medium positive";
PF – "very positive".

The simulation results shown in show that the Fuzzy controller achieves practically the same performance as the classic PID controller, being a little more inert. This PID tuning procedure is sophisticated and requires a proper approach [5,6,7].

Fuzzy set theory emergence and development electronic systems have opened the way

to application in automatic regulation systems. In this case, the classic PID control algorithms are replaced by a series of IF (premise) THEN (conclusion/action) type rules.

The application of fuzzy theory in automatic control systems can be in several ways.

SIMULINK-MATLAB is successfully used in the simulation of water treatment and purification processes.

3. Conclusions

The basic principles of industrial process control can also be applied in wastewater treatment plants, but the characteristics of treatment plants require specific considerations in the design of control systems. Due to the complexity of the physical-chemical-biological processes, in which a multitude of parameters of a different nature interact and the limited number of parameters that can be manipulated, it is difficult to conduct these processes optimally. He proposed the application of advantage of which is the realization of a heuristic algorithm for managing the process, which can take into account the experience of the human operator in managing these processes, having the performance of classical PID regulators.

The monitoring of the parameters in the purification processes is an essential activity in the wastewater treatment plants, being closely related to the monitoring of the environment in general. Its purpose is to follow the degree of compliance with the legislation, by monitoring the water quality parameters at the exit from the wastewater treatment plant and to follow the operation of the treatment processes and their efficiency, by monitoring the parameters of the treatment processes.

References

[1]. **Ianculescu O., Ionescu Gh., Racoviţeanu R.** *Wastewater treatment*, Matrix ROM, Bucharest 2005.

[2]. **Roberts E., Alley PE.** *Water Quality Control Handbook*, McGraw-Hill, Inc, 2000

[3]. **Robescu D., Robescu D. et al.** *Automatic control of wastewater treatment processes*, Technical Publishing House, Bucharest 2008.

[4]. **O'Dwyer A.** *PI and PID controller tuning rules for time delay processes: a summary. Part1: PI controller tuning rules*. Proceedings of the Irish Signals and Systems Conference, National University of Ireland, Galway, Ireland, June 1999.

[5]. **Åström K. J., Hägglund T.** *PID Controllers – Theory, Design and Tuning, second* ed, Instrument Society of America, 67 Alexander Drive, POBox 12277, Research Triangle Park, North Carolina 27709, USA. 1995.

[6]. **Guillermo J., Silva A.D., Bhattacharyya**. *New results on the synthesis of PID controllers*. IEEE Trans. on Aut. Cont., 47(2):241–252, Feb. 2002.

[7]. **Panagopoulos H., Astrom K.J., Hagglund T.** *Design of PI controllers based on Constrained optimization.* IEE Proc. Account. Theory and Applications, 149(1):32–40, 2002.

[8]. **Nicolae Mitu,, Viorel Paleu** *Introduction to MATLAB – SIMULINK*, . Indrumator de laborator , p 288, Mar.2020.