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DESIGN OF FUZZY CONTROLLER OF pH NEUTRALISATOR

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ABSTRACT

In this paper design of a fuzzy controller of pH neutralizer has been performed. Adjustment of control parameters is based on model of the pH neutralisator. Inputs of the process (control variables) are flow of acid and hydroxide. The working temperature of the process is 128°C, with installed pH meter of operating range 2-12 pH with combined glass electrode in the upper part of the neutralizer, 20 cm bellow the level. Fuzzy controller can be formulated on the basis of human understanding of the process or can be identified from measured control actions. This paper demonstrates a simple fuzzy controller with two inputs and two outputs. Design of the fuzzy controller is based on data obtained by measurement.

Keywords: pH value control, fuzzy logic

1. INTRODUCTION

In this paper desing of a fuzzy controller of the PH neutralisator based on a model of the neutralisator is performed. Model of neutralisator is determined using Ziegler Nichols identification method, based on response curves [1]. Using fuzzy controller, better results can be obtained concerning settling time, peak value, steady state error, etc. Fuzzy controller consists of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value. During the design of the fuzzy controller several design choices have to be made, such as:

- *Rule base*: number of inputs and outputs, universes, continuous or discrete, the number of membership functions, type of these function and their overlap and width;
- *Inference engine*: modifiers, activation operation, aggregation operation and accumulation operation.

Defuzzyfication method*: COG, COGS, BOA, MOM, LM and RM.***.**

Inputs of the process are: distilled acid and hydroxide solution. The working temperature in process is 128°C, with installed pH-meter of operating range 2-12 pH with combined glass electrode, in the upper part of neutralisator 20cm bellows the level.

Registrations of acid and hydroxide flow are shown on the Figure 1.

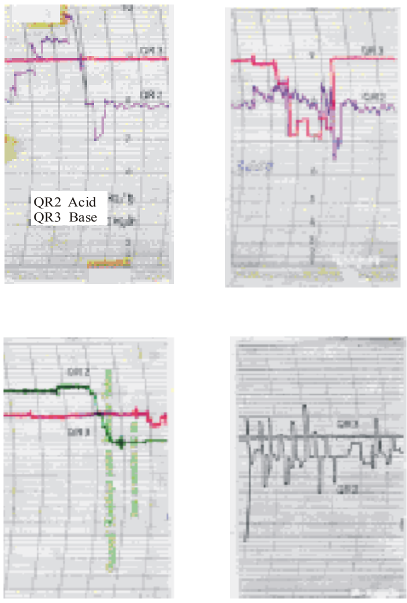

Figure 1. Marking of acid and hydroxide flows (20 mm/h)

Initial pH values are given at Figure 2.

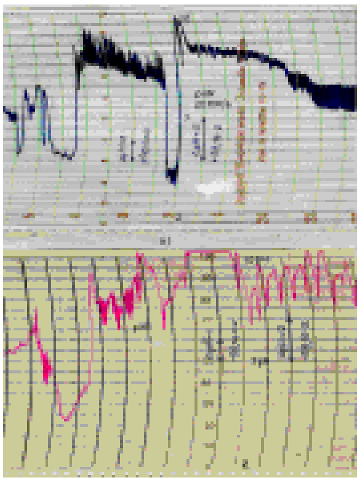

Figure 2. pH diagrams

In the Figure 3 the sample of output subsystem of pH acid is presented.

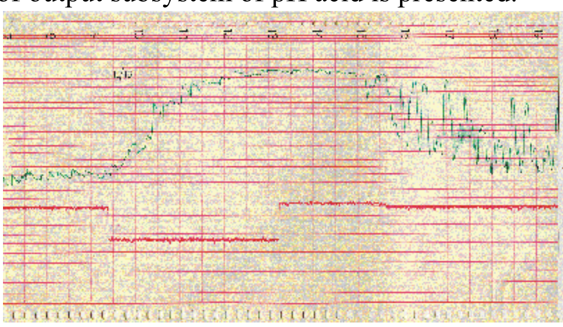

Figure 3. The sample of experimental output for subsystem of pH-acid

In Figures 4 and 5 parts of the PH neutralisator model are shown, obtained from [1].

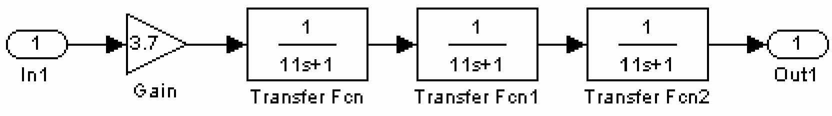

Figure 4. Model of Subsystem pH – hydroxide.

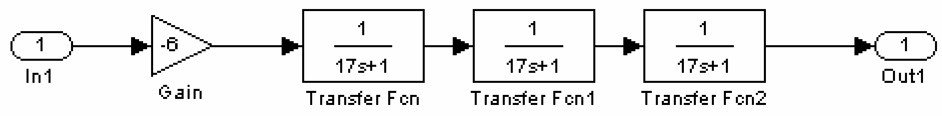

Figure 5. Model of Subsystem pH – acid.

2. SIMULATION RESULTS

For design of a fuzzy controller, we used Matlab Fuzzy Toolbox. Fuzzy controller is MIMO system, it has two inputs: error of the pH-hydorxide subsystem and multiplication of the current input and pH-acid subsystem output; and two outputs, control signals for pH-hydorxide and pH-acid subsystems, respectively. Figure 6 shows membership functions of the fuzzy controller.

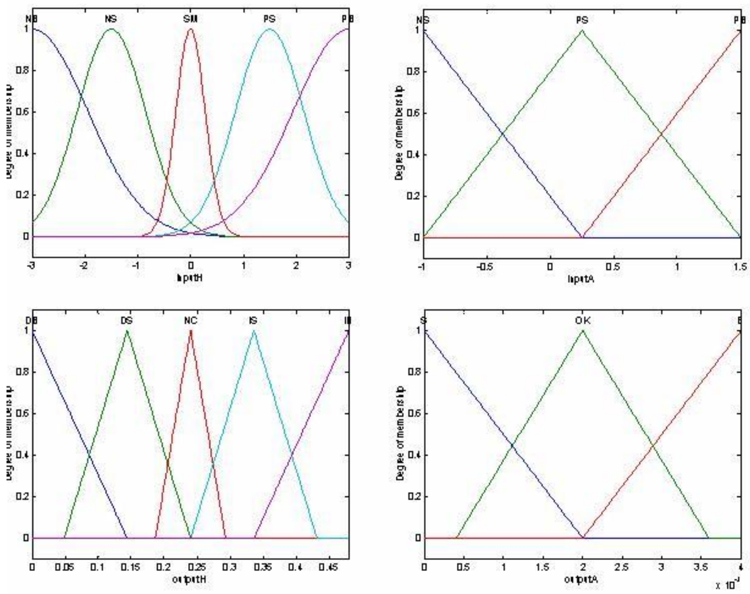

Figure 6. Membership functions of the fuzzy controller.

Fuzzy inference system is Mamdani system. In the most cases, it is best to follow Min-Max principle, so chosen fuzzy implication method is Mamdani (Min) method and fuzzy aggregation method is Max method. Defuzzyfication method is centroid. Rules are given in the Table 1.

Table 1. Set of fuzzy rules

If *inputH* is NB and *inputA* is NS then *outputH* is DB and *outputA* is S
If *inputH* is NS and *inputA* is NS then *outputH* is DS and *outputA* is S
If *inputH* is SM and *inputA* is PS then *outputH* is NC and *outputA* is OK
If *inputH* is PS and *inputA* is PB then *outputH* is IS and *outputA* is B
If *inputH* is PB and *inputA* is PB then *outputH* is IB and *outputA* is B

Figure 7 shows Simulink model of the system. From Figure 8, it can be seen improvement of the system response on the step input by using fuzzy controller instead of the PID controller. Overshoot, settling time and the steady state error are considerably less.

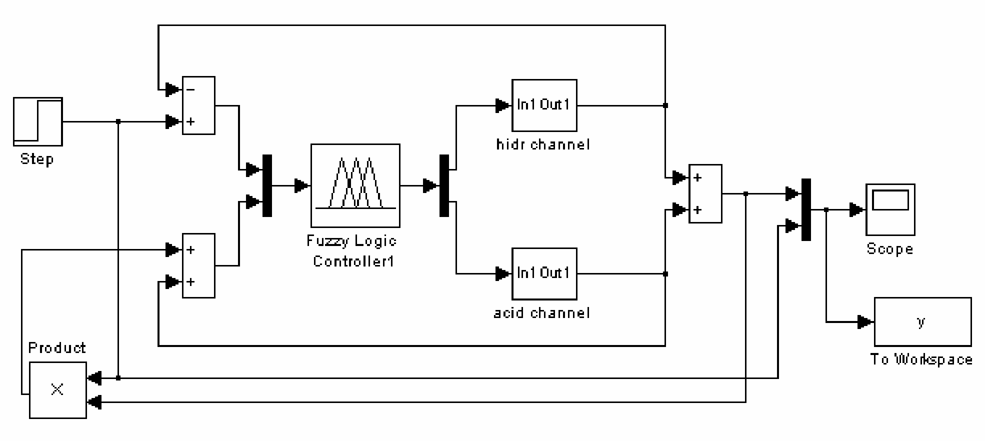

Figure 7. Simulation model

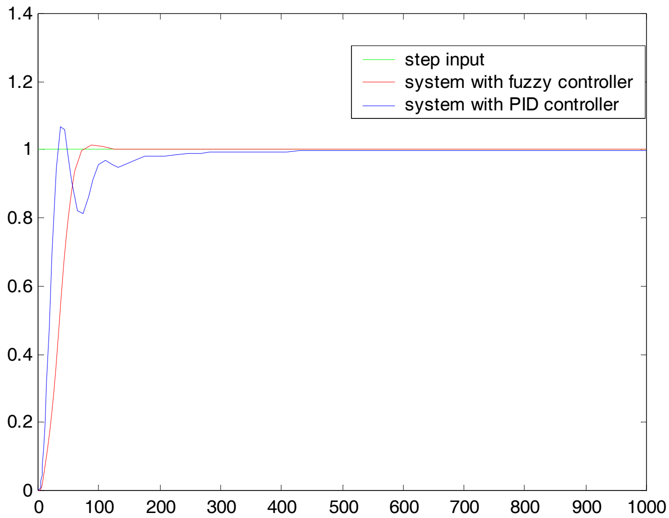

Figure 8. Response of the system on step input

3. CONCLUSIONS

Simulation results shows that using fuzzy approach to system control it is possible to achieve considerably small settling time, small overshoot and a small steady state error. Results obtained by system with fuzzy controller are compared with the results obtained in [1] for the system with PID controller. In future work we plan to implement a parameter optimization via genetic algorithms for fuzzy controller of the pH neutralisator.

4. REFERENCES

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