THE POSSIBILITIES OF ADAPTIVE CONTROL IN METALLURGICAL PROCESSES

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Abstract

The aim of this paper is to describe adaptive control of the heating furnace with the utilization of PID type regulator. Advantages of the proposed adaptive regulator are changeable parameters of the system and/or changeable desired quantity of regulation circuit. Proposed adaptive regulator is derived from the commonly known structure of the fuzzy PID regulator which consists of PI regulator and PD regulator. Setting up of the regulator parameters of this structure takes place by the utilization of evolutional methods. Objective function for this optimization is the criterion of regulation quality (quadratic regulation area).

Keywords: Regulator, adaptive regulator, adaptive control, heating furnace, proportional system

1. CHAPTER TITLES INTRODUCTION

Regulation of the technological processes is correct only if the regulator (controlling system) is adapted to the properties of the regulated system by setting of the suitable parameters. However, properties of the system (technological process) can vary during the time in the real systems. [1] Therefore, it is necessary to adjust settings of the regulator parameters correspondingly. [2]

2. ADAPTIVE CONTROL

The basic function of the adaptive regulating circuit is explained in the example of temperature regulation in a gas-fired furnace with direct intake of combustion air - see **Figure 1.**

Figure 1 Heating furnace

During the operation of the furnace various influences arise, which cause changes in the controlled quantity - the temperature in the furnace (see **Figure 2**). They are, for example:

- change of gas pressure (causes a change in flow and hence a change in furnace temperature);
- weight change;
- change in the heat content of the batch (another heat input will be needed if the batch is cold, the other at the end of the heating);

- opening the furnace thrower gate and more.

We can not always predict and compensate for these values. These variables are called fault variables v and is therefore another fundamental function of feedback control of compensation of disturbances acting on a controlled variable.

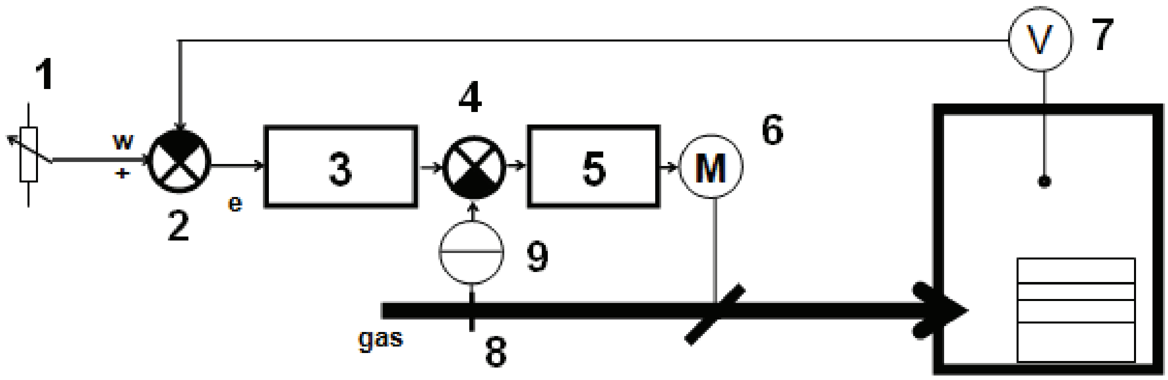

Figure 2 Regulation of temperature in furnaces of gas-fired self-priming
1 - Setpoint source 2 - Comparative member 3 - Main controller 4 - Comparator circuit 5 - Auxiliary gas volume regulator 6 - Servo drive 7 -Thermocouple 8 - Measuring aperture of the amount of gas 9 - Differential pressure gauge.

The aim of the thesis is to verify the possibility of using principles and methods of artificial intelligence for adaptive regulation. [3] We verify the possibility of adjusting adaptive controller parameters with the fuzzy PID controller structure using evolutionary algorithms.

Testing is based on the assumption that we have known the system at different time points, which varies according to system changes.

For testing adaptive control, we chose a fuzzy PID controller. [6] This block diagram can we have seen in **Figure 3.** The controller consists of PI and PD block, where parameter setting is perfomed using evolutionary methods.

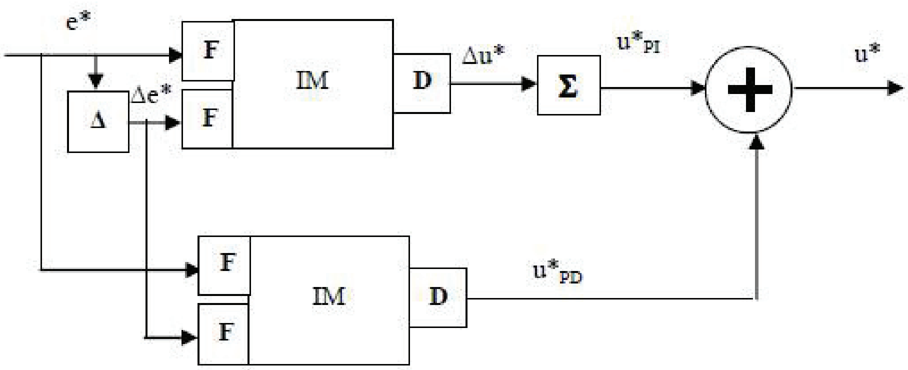

Figure 3 Structure of fuzzy PID controller

When setting the parameters, it is better to first set the PD component optimally [4], and then the PI component and debug them together. During the testing occurs to specific properties are set and find fuzzy controller parameters for correct control. [7] The design of an adaptive fuzzy PID controller, in our case, results from adaptive systems based on a heuristic approach.

3. SETTING ALGORITHM FOR ADAPTIVE PID CONTROLLER

On **Figure 4** shows the proposed adaptive PID controller adjustment algorithm. The first, controllerś parameters are set to zero, then is selected time t, required value w, constant k and time constant T.

The goal we want to achieve is to bring the regulatory deviation closer to zero. Based on the parameters of the PD controller and the PI controller, we change their action quantities. The total action variable of the adaptive controller is the output function. [5]

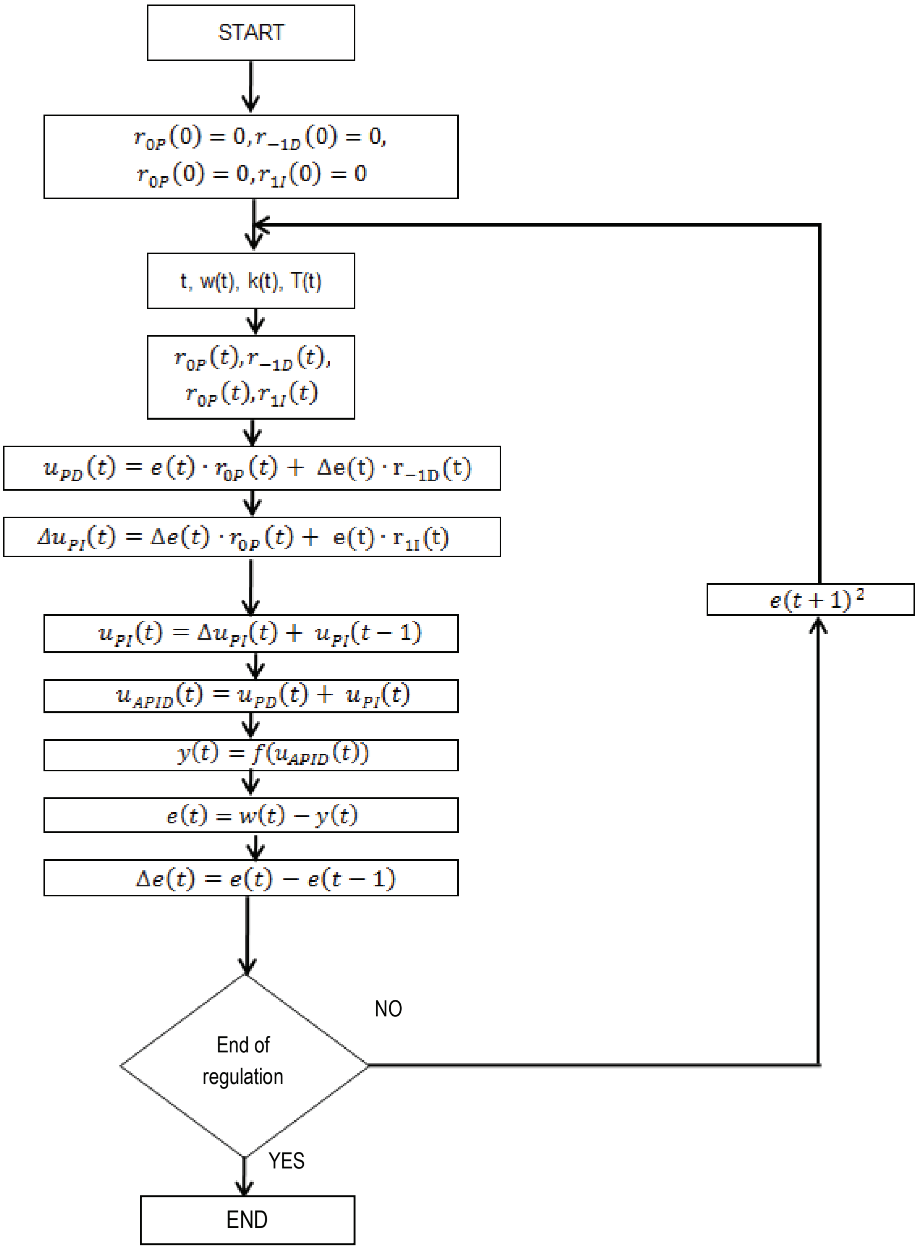

Figure 4 Setting algorithm

4. TESTING OF PROPORTIONAL SYSTEM

For example was testing a proportional system first order (1):

$$G(p) = \frac{k}{(T_p+1)} \qquad (1)$$

In order to calculate the output, it is necessary to create a picture of the transmission system first, so we must multiplication system with (2):

$$H(p) = \frac{k}{p.(T_p+1)} \qquad (2)$$

From this, we can then create a transition function using Laplace's transformation (3):

$$h(t) = k \cdot \left(1 - e^{-\frac{t}{T}}\right) \qquad (3)$$

Where t is replaced by the action variable u.

Testing of the proposed adaptive PID regulator with evolutional setting of parameters was realized at proportional system of 1st order. Stabilization of the specified proportional system was selected for the first testing experiment. **Figure 5** shows time dependent evolution of the quantities of the regulation circuit during this experiment.

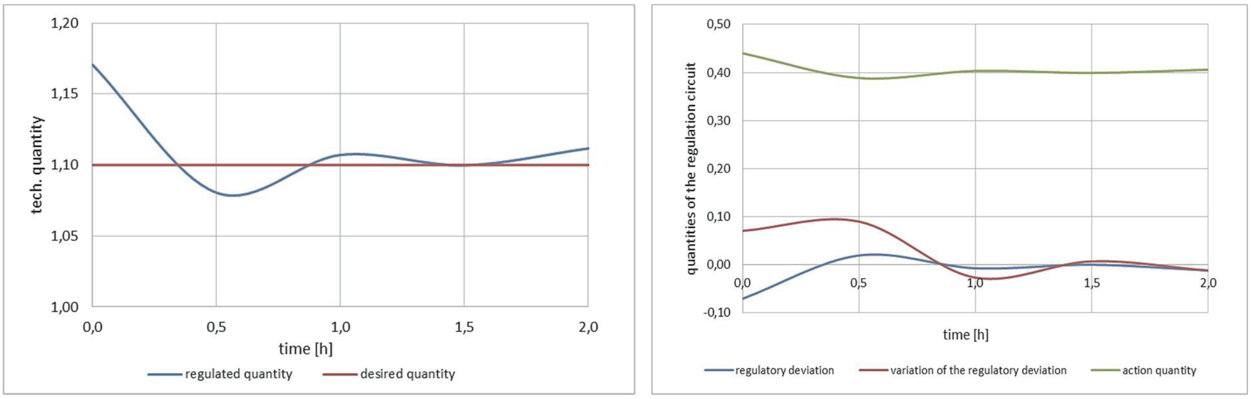

Figure 5 Time dependence of the quantities of regulation circuit during the first experiment

Second experiment was represented by stabilization of the specified proportional system but with the change of the time constant of the proportional system from value 0.5 to the value 5 during the system stabilization. **Figure 6** depicts time dependence of the quantities of regulation circuit during this experiment.

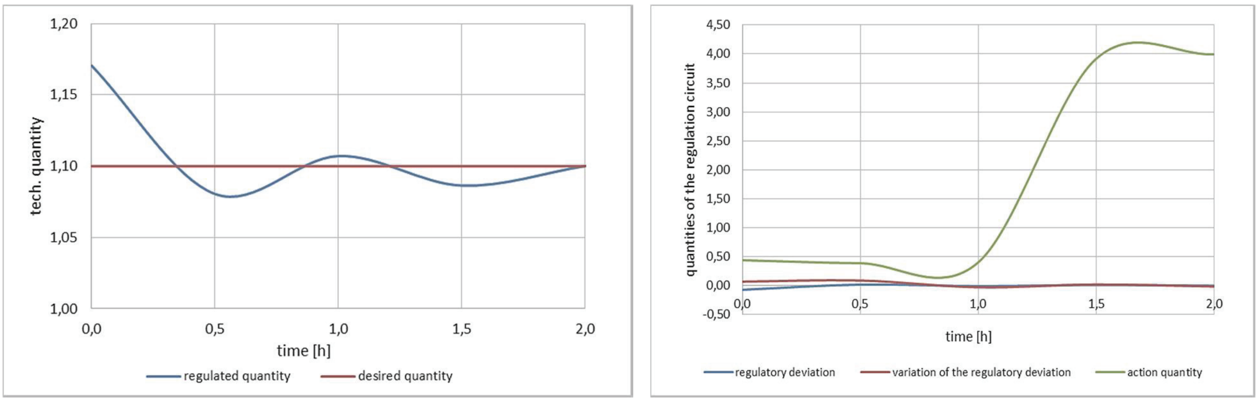

Figure 6 Time dependence of the quantities of regulation circuit during the second experiment

Stabilization of the specified proportional system was subject of the third experiment, as well. Change of the desired quantity from the value 1.1 to the value 1.4 was realized during the system stabilization. **Figure 7** shows time dependence of the quantities of regulation circuit during this experiment.

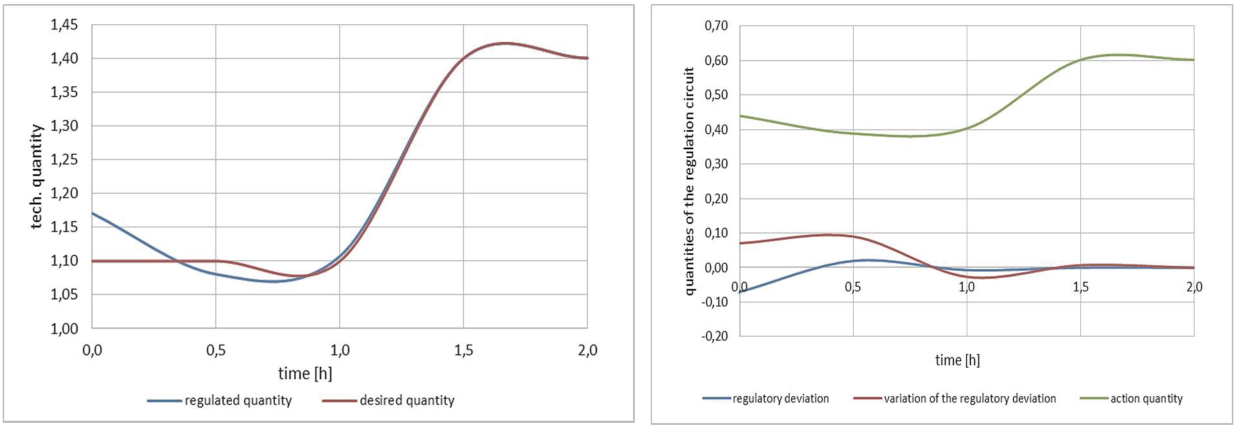

Figure 7 Time dependence of the quantities of regulation circuit during the third experiment.

5. CONCLUSION

Regulation is successful only if the regulator is adapted to the properties of regulated system by suitable setting of its parameters. However, properties of the system can vary during the operation in the real systems. It is necessary to change the settings of the regulator parameters as well, which is difficult. Adaptive regulation algorithm represents suitable solution. It evaluates automatically course of the regulation process and it adjusts values of the regulation parameters according to the obtained data.

Whole range of the adaptive regulators was proposed. Proposed and tested adaptive PID regulator with the structure of composite fuzzy PID regulator with evolutional setting of the regulator parameters represents one member of the group of adaptive regulators. It is evident from the obtained results of the experiments with proportional system of the 1st order that proposed conception of creation of the adaptive regulator is correct. However, it is necessary to test this proposed adaptive regulator at other and more complex systems.

ACKNOWLEDGEMENTS

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