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Research Investigation on Automatic Control System of Drying Apparatus Based on Fuzzy Logic

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Abstract

The paper describes current problems of residual moisture control loop of drying material in a dryer, for automation of drying processes and their solving by means of fuzzy controller. The paper also presents the results of realization of automatic control system of different configurations, as well as their comparative analysis. The effectiveness of using fuzzy controllers is shown by an example of a drying apparatus control system.

Keywords: Drying Apparatus, Control System, Fuzzy Logic, Cascade System, Simulation Modeling, Performance Criterion, Controller.

Introduction

Rigorous mathematical description of technological processes in modern production is not always possible. The dynamics of drying of different materials' calculation is a laborious and complex process that complicates its automation. (Bardavelidze & Bardavelidze , 2002). Theory of management and its modern achievements offer us more and more opportunities to improve automatic control systems, including the methods of neuro fuzzy management. Therefore, the analysis of methods for the requested control performance quality assurance of the automatic system is relevant for drying of materials (Yegupov , 2002).

Most controlling systems of a complex structure contain the cross couplings. Setting of each loop is much dependent on the characteristics of the other loop, including the parameters for setting of the controllers of these loops. A determination in advance of a controller for such loop is a very complicated task. Ultimately, we can conclude that setting of the mentioned systems is a very complicated task (Bardavelidze & Bardavelidze , 2007).

Fuzzy control implies the field of applying the general methodology of fuzzy set and logic theory, for practical solution of management problems. The use of fuzzy management can be effective in that case where no clear model of process existed, or when the analytical mathematical model is very complex (Yegupov , 2002).

The Structural Scheme of Fuzzy C ontroller

Based on the foregoing, in the paper we propose the improvement of the quality of a system control performance by way of using the optimal controller, which changes the setting parameters of the controllers. In this case, the object model is described by linear equations. The task is assigned to study various control systems.

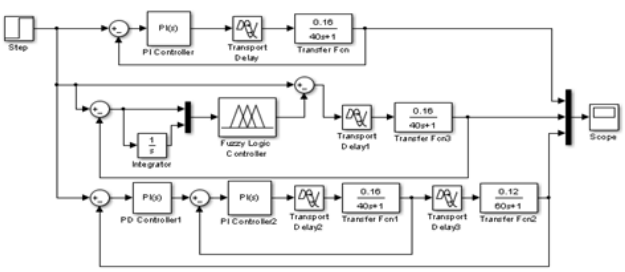

Figure 1. *The structural scheme of control system with a single-loop, cascade and fuzzy controller*

The schematic structure of a model of the above-mentioned control system, which is developed using Matlab programming language, is illustrated in Fig. 1. The controllers of the controlled objects were designed in an interactive system. The given system is a Matlab programming product and represents a graphical environment of simulation modeling, which allows for constructing a dynamic model by means of block-diagram.

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In case of the single-loop and cascade control systems, there were determined the control parameters, which provide control of the output values of the object with the accuracy required.

The Setting of a Fuzzy Controller

A fuzzy control system is implemented by using five rules of the known algorithm. At that time, each subsequent phase at the inlet accepts the value obtained from the preceding step (Shtovba , 2007). In addition, we have introduced the X1 and X2 input and <<Out>> output variables, for the used variables term, we have constructed the membership functions (Fig. 2).The rules of fuzzy controller setting are given in Table 1.

Table 1. *Fuzzy controller setting parameters*

№	Fuzzy controller rules
1	If (X1 = good), then (Out = Z)
2	If (X1 = low), then (Out = LP)
3	If (X1 = high), then (Out = LN)
4	If (X1 = good) and (X2 = positive), then (Out = SP)
5	If (X1 = good) and (X2 = negative), then (Out = SN)

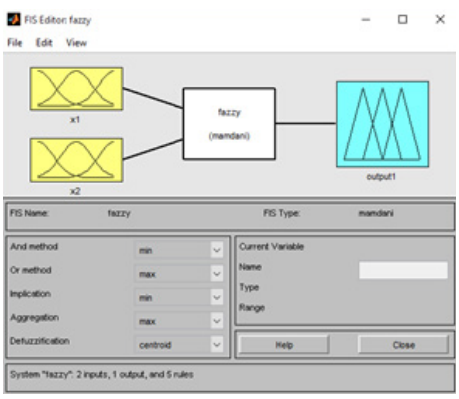

Figure 2. *Input and output variables of a fuzzy controller*

After this, the designation rule has been formed within a FuzzyLogic package block (Fig.3).

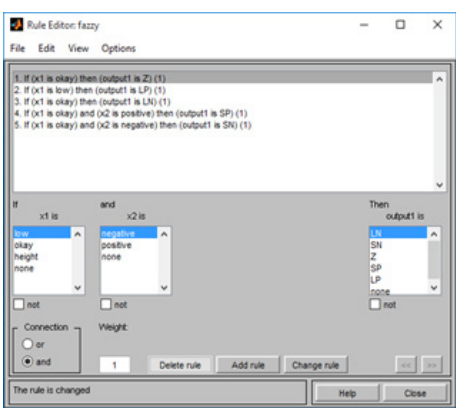

Figure 3. *Rule setting block*

Exportation of fuzzy controller parameters was carried out within a Matlab programming working environment, then in a Simulink model, we attached to a fuzzy controller the setting parameters and ultimately obtained a fuzzy control management system (Shtovba , 2007).

At the next stage, we carried out a comparative analysis of the designed control system, for which we obtained the transient curves, which are implemented by a <<Step>> block in a Simulink programming environment.

In addition, graphical representation of transient processes is illustrated on a one plane of coordinates, for which there was used a <<Mux>> multiplexer, but as the receiver of signals, we used a <<Scope>> oscillography (Yegupov , 2002).

By exerting a single step impact on the single-loop, cascade and fuzzy controllers we will obtain transient processes illustrated in Fig. 4.

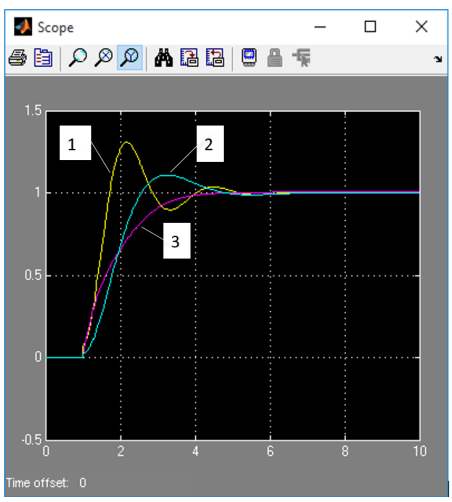

Figure 4. *The diagrams of transient processes:*

1 – single-loop controller, 2- cascade and 3 – fuzzy controller control systems

The analysis of transient characteristics was carried out by using the basic direct quality indicators, and the obtained results are given in Table 2.

Thus, by selecting the form and the type of the function of system, as well as by using the fuzzy controllers, it is possible to improve the quality of the automatic control system.

Modeling of the automatic control system of dynamic material's residual moisture by a classical and fuzzy algorithm, has shown that a fuzzy system – is non-linear with algorithm, and the type of transient process depends on the form and the intensity of the disturbing action.

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Table 2. *The basic direct quality indicators of transient characteristics.*

Quality indicators	**Single-loop control system**	**Cascade control system**	**Fuzzy control system**
Static error	0	0	0,02
Control time	5	4.5	4,05
Excessive correction (%)	27	9	0
Damping ratio	0,75	1	1
Quality indicators	Single-loop control system	Cascade control system	Fuzzy control system
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Control time	5	4.5	4,05
Excessive correction (%)	27	9	0
Damping ratio	0,75	1	1

Conclusion

Based on the analysis of quality indicators of transient characteristics of the obtained drying process, it has been established that the system of controlling the object under examination by a fuzzy controller, unlike the single-loop and cascade control systems, is distinguished by zero excessive correction and short control time. However, control by means of a fuzzy logic apparatus is characterized by a smaller static error than a classical analogue control system.

The fuzzy controllers can be used in a system independently, as well as in the composition of the traditional PI and PID controllers, with a view to improving their characteristics.

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