METHOD OF FUZZY CONTROLLER ADAPTATION.FUZZY CONTROLLER WITH TWO BASIC RULES

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ABSTRACT

When writing the work, a fuzzy controller with a double rule base was studied; it was applied to the synthesis of an automated control system. A method for adapting a fuzzy controller has been developed. Adaptation allows the fuzzy controller to automatically compensate for parametric noise that occurs on the control object. In particular, the fuzzy controller controlled the steam temperature at the outlet of the BKZ-75-39 GMA boiler. The program code was written in the Unity Pro XL programming support environment designed to adapt the fuzzy controller.

Keywords: fuzzy controller, adaptation, values, temperature, steam.

In today's world, it is impossible to find a place where electricity is not used. All equipment at any enterprise, especially in mechanical engineering, runs on electricity received from CHP. To produce electricity, superheated steam is used, generated by boilers, which enters the turbines, where mechanical energy is converted into electrical energy.

Steam is also widely used to control the steam-air hammer. Depending on the nature of the distribution of the periods of operation of the energy source, the hammer can operate in several modes: sequential automatic shocks; single strokes with an upper pause; there is also a swing cycle that works automatically.

Thus, it can be concluded that for different modes of operation of the hammer, steam with different temperatures and different pressures is needed. The steam used in the production process is produced by boilers. Therefore, it is important to develop a boiler control system that allows obtaining steam of a given temperature and pressure.

II. BENEFITS OF FUZZY MANAGEMENT

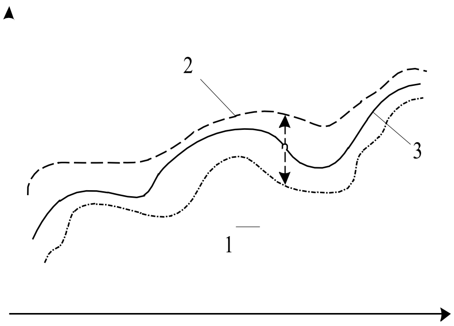
The main advantages of fuzzy management are the applicability of expert knowledge in an explicit form, high speed, smooth implementation of multidimensional essentially nonlinear dependencies.

A fuzzy regulator is a multidimensional nonlinear static element. To synthesize HP, it is enough to determine its desired static characteristic and adjust it so that it coincides with the required [2 – 4]. Now there is a problem because the fuzzy regulator is not accurate. To solve this problem, a fuzzy regulator with a double base of rules was developed.

In connection with the change in the structure of the fuzzy regulator, the task of developing an algorithm for its synthesis arose. This article discusses two fuzzy regulator synthesis algorithms, fuzzy synthesis, and fuzzy regulator training.

III. FUZZY REGULATOR WITH DOUBLE BASE RULES

A fuzzy regulator with a double base of rules can be represented as two classic fuzzy regulators using the same linguistic variables. The static characteristic of one of them is always slightly lower than the required characteristic, and the second is slightly higher. These fuzzy regulators can be represented as two "experts" (Fig. 1), one of which always reduces the control effect, and the second always slightly increases it. When you are on the right static characteristic and look at these "experts", you see them from opposite sides. "Experts" begin to "argue"; as a result, they come to a solution that will be closer to each of them to the desired value. If an "arbitration" system is introduced in the process of "dispute", then he will begin to trust some of the "experts" more. If the "arbitrator" is right, the "experts" will come to the desired decision. The weights of individual rules can be used as a "referee".



Rice. 1. Fuzzy conclusion with two "experts".
1 – "Expert 1", 2 – "Expert 2", 3 – the desired static characteristic.

As a result, while maintaining high performance, fuzzy control can be obtained with precision adjustable by the computer system on which it is performed. This new quality can be explained by the dialectical law of unity and the struggle of opposites. Unity is a single structure, goals, initial data, a similar result. The conflict of opposites lies in the fact that each base of rules pulls the result in a different direction in relation to the desired.Before proceeding to the synthesis of a fuzzy regulator (HP), it is necessary to develop its conceptual models for each output. The conceptual model shows the influence of input signals (sensor values) on the result of the fuzzy regulator - the value of its output. This model can be represented either graphically (Fig. 2), or analytically.In analytical form, it is enough to present the dependence of the output on the input as follows (for the same Fuzzy Controller):

$$and_2=f(x\ 1.x_{\ 2.x\ 4})\ (1)$$

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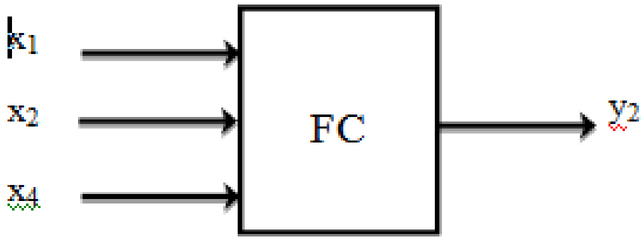
In either case, you only need to specify the fuzzy controller inputs that should affect its output. At the same time, the input of the woofer regulator, if necessary, can be fed the values of its outputs, as well as derivatives (or increments of the value per 1 cycle) to the input of the woofer regulator to give them certain dynamic properties. fuzzy controller. Once all conceptual models have been compiled, they can be combined into a fuzzy regulator. If the inputs of different HP do not match, the feasibility of combining should be checked experimentally (system performance is chosen as a criterion).



Rice. 2. Conceptual model

VI. CREATING A PROCESS MODEL

Fuzzy regulators generate control signals based on the application of fuzzy logic [1]. Over the years, fuzzy regulators are increasingly used in modern automatic control systems [2]. Fuzzy controllers can be used to control all parameters of complex process objects. In this work, a fuzzy regulator is used to control one of the parameters of the process of obtaining superheated steam in the boiler unit BKZ-75-39 GMA. The steam temperature at the outlet of the boiler is selected as a parameter, the value of which is selected to control the valve opening clearance. Since this parameter could be affected by parametric interference, such as a change in the steam capacity of the boiler and therefore a change in the steam temperature behind the first stage of the superheater, as well as a change in condensate temperature, it is assumed that it is necessary for a fuzzy controller to be able to automatically compensate for the above interference without supervision.

Thus, the main task of this article is the synthesis and adaptation of a fuzzy regulator. The adaptation of the fuzzy regulator is designed so that it can be controlled automatically so that it corresponds to parametric interference.The steam temperature at the outlet is regulated by changing the injection flow rate of the "internal" condensate into the steam cooler located between the first and second stages of the superheater. The consumption of condensate "injection" is regulated by the 6S-13-1 control valve. The clearance of the valve 6C-13-1 depends on the steam temperature behind the first stage of the superheaterc I, on the steam temperature behind the second stage of steam at the outlet of the superheater; that is, on the final steam temperature and the temperature of the condensate t_c , respectively.To adjust the adaptation of the fuzzy regulator, it is necessary to have a clear idea of how the process is arranged, that is, to build a model that characterizes the operation of the steam spray steam cooler. The model is built with using regression analysis, a statistical method of research. This is the most widely used method to demonstrate the dependence of any of the parameters on one or more explanatory variables. Thus, a regression model can be used to show the effect of three parameters: the steam temperature after the first stage of the steam cooler t_{sI}, the condensate temperature t_c and the valve opening clearance α(%) on the steam temperature at the outlet.

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VII. АДАПТАЦИЯ НЕЧЕТКОГО РЕГУЛЯТОРА

For the developed HP, an adaptation will be made using a training algorithm. As a training algorithm, a gradient descent algorithm was chosen, in which HP Mamdani can be used as the starting point of the algorithm.

If we denote the "left" term, which is used in the consequents of the production rule, as the integer N t, then the "right" term will have the number (N + 1) [5]. The left term is the term with a lower number, that is, in Fig. 7. the left term in relation to the other member of the production rule. Therefore, the right term is a term with a large number located in relation to the other member of the rule on the right side.

Введем обозначение: W=N+v, (2)

where W is a characteristic of the production rule derived from the values of the degree of truth of the main and additional consequences; that is, on the basis of this characteristic, it is possible to return to the production rule;

N – number of the left term;

v is a number defined by the formula:

$$v = \frac{C + r}{2}$$

where r = 1 if the subsequent "right" term is used, and r = 0 if the "left" therm is used;

C is an additional consequential degree of truth.

Рассмотрим определение характеристик продукционного правила по первому правилу: если $t_v = t_{V1}$ и $t_c = t_{c1}$, то $\alpha = \alpha_2$ и $\alpha = \alpha^{0,12}$.

The number of the left term is 2. An additional consequential degree of truth is 0.12, r = 0, since it is the left term that is the main one. Thus, the characteristics of the production rule are obtained: $W_1 = 2 + ((0.12 + 0) / 2) = 2.06$.

Using formula (2), we now obtain the characteristics of the remaining production rules from Table V: $W_2 = 2 + ((0.17 + 0) / 2 = 2.585$; ...; $W_{65}=5+((0,12+0)/2 =5,06$.

In the process of HP synthesis, both basic and additional consequents were determined, as well as the degrees of truth of additional consequents [2, 3]. When determining the degree of truth of the additional sequence, reference points were taken as a basis (Table. V), which are the maxima of the terms of the input linguistic variables (Figs. 6, 7) [2, 3]. It should be understood that in practice the input parameters can take different values; therefore, it is necessary to adapt the fuzzy controller to ensure that the regulator is automatically adjusted to match parametric interference. On the basis of experimental data, a model (2) is built that characterizes the operation of a vapor sprayer.

With the help of the developed model, the synthesis of HP was carried out, production rules with their characteristics were obtained, on the basis of which HP adaptation will be made. During the adaptation, arbitrary values of the steam temperature behind the first stage of the t_{Ist} superheater in the range from 360 ° to 400 ° C and the condensate temperature tk from 50 ° to 110 ° C, the steam temperature at the output tW can be set in the range from 270 ° to 400 ° C.

Arbitrary values of the steam temperature, condensate temperature t_{sI} and set steam temperature at the outlet t_{sII} are introduced into the model (1); the regulator, in turn, automatically adjusts to the changes and produces the current valve foropening the valve α (table I).

Table I. Values calculated using the model

№	tvI	tc	tsII	A
1	363	54	362	18
2	365	56	345	40
3	368	58	310	86
4	372	63	327	68
…	…	…	…	…
45	399	109	340	68

Let's enter the designation:

$$W^* \square\ W \square\ \square W \square\ \square(C_p)\ \square\ \square(\ C_k)\ ,(3)$$

where W* are the characteristics of the new product regulations derived from Table I;
W – characteristics of the production rules from Table II;

Table II. Production rules

Rule No.	Production rules
1	*If t_v= T_{v1} and t_c=Tc_1, then α= $α_2$ and α= $α_3$*
2	*If t_v= T_{v1} and t_c=Tc_2, then α= $α_2$*
…	…
65	*If t_v= T_{v1} and t_c=Tc_2, then α= $α_2$*

□ (C)□□ (C) – cccecca,cp - cccecсca…сина,cocaccacct $_{sIst}$, C_k – cccecca… e.e. C_p нео.
ΔW is an adaptation step, which is determined by the expert to clarify the accuracy of the regulator.
To create both new production rules and their characteristics by selecting alternately the lines from table. I it is necessary to determine among which components lie the vapor temperature behind the first stage of the superheater t_{Ist} and the condensate temperature t_k. Further, from the previously obtained rules (Table. (ii) Regulations can be found where the conditions of the vapour temperature t_{sI} and the condensate temperature tc coincide with those of table I.
The process of obtaining a new rule:
1) By selecting the 1st line from I, it can be determined that the vapor temperature behind the first stage of the tsIst superheater lies between the conditions TS1 and TS2 (Fig. 3), the condensate temperature tc is also between the conditions TS1 and TS2. II, where the

temperatures are among the same thermo numbers. Now you need to select the first production rule from Table II.

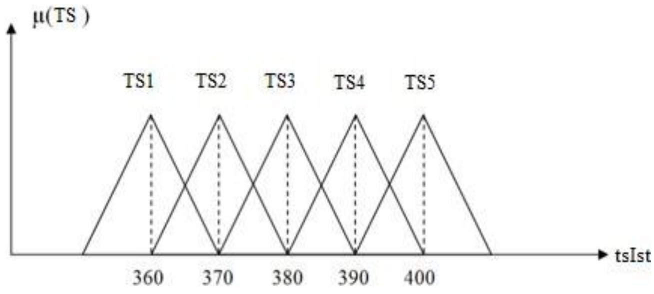

Рис. 3. Входная лингвистическая переменная t_{sIst}.

2) First, it is necessary to determine the characteristics of the new product rule: W1 * = 2.06 – 0.15 · 0.7 · 0.1 = 2.0495.
3) It can now be calculated to move to the new production rule: If $t_v = T_{v1}$ and $t_c = T_{c1}$, then $\alpha = \alpha_2$ and $\alpha = \alpha^{0.099}$. Similarly, the remaining 44 production rules are calculated.
The steam temperature control program at the output t_{sII} and, as well as the adaptation of the fuzzy regulator, is developed in the Unity Pro XL program using the ST language based on the PLC Modicon M340. The controlled parameter is the steam temperature at the outlet of the steam cooler.
Thus, this paper considers the synthesis of a fuzzy regulator designed to control the temperature of tsII steam at the outlet of the boiler. In addition, the fuzzy regulator is adapted on the basis of the method of selecting sequences in production rules with a double sequence optimal for the current values of the boiler parameters.

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