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Synthesis Of An Electric Drive Control System With A Fuzzy Controller

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ABSTRACT

This article analyzes the increasing demand for DC electric drives with the development of manufacturing and the emergence of new technologies. Modern technological processes require the development of electric drives that have increased speed, accuracy and the ability to quickly adapt to changing operating modes. The transition process, in a standard system, meets the requirements of optimal quality indicators corresponding to the third point of adjustment. In a system with a fuzzy controller, a transient process similar to that calculated in a standard three-circuit system is obtained. This fact indicates that the use of a fuzzy controller allows you to provide control that meets the required optimality criteria. In relation to the studied SPP ACS, the current loop and the mechanical part of the electric drive in the standard structure (thyristor converter and the armature circuit of the electric motor) should be considered as the control object. To eliminate the influence of EMF feedback, a compensatory positive feedback is introduced into the system.

Recently, new non - traditional management methods, including fuzzy logic, neural networks, expert systems and other control tools with elements of artificial intelligence, have been applied in the world practice.

The dynamics of an electric drive with a fuzzy controller is analyzed. The structure and knowledge base of the fuzzy controller are proposed to reduce the number of control loops and the number of sensors by eliminating the speed loop. Analysis of the dynamics of the two-circuit automatic control system of a tracking electric drive with a fuzzy controller has established that the quality indicators of the dynamics of the electric drive when working out large control actions are better in a system with a fuzzy controller.

KEYWORDS

Technology, process, development, electric drive, industry, mechanics, controller, model, system, controls, analog, chip, adaptive, standard, quality, logic, link, part, contour, structure, dynamics, circuit, object.

INTRODUCTION

With the development of production and the advent of new technologies, the requirements for DC electric drives are becoming more stringent. Modern technological processes require the development of electric drives that have increased speed, accuracy and the ability to quickly adapt to changing operating modes. Recently, new non - traditional management methods, including fuzzy logic, neural networks, expert systems and other control tools with elements of artificial intelligence, have been applied in the world practice.

For many industrial processes, it is difficult to provide precise control, as they are usually multidimensional, nonlinear, and time-varying. Fuzzy logic control can be successfully applied to such processes. In addition, fuzzy controllers can work with systems with unknown dynamics that are not fully described, since they (unlike many traditional adaptive controllers) do not require an a priori mathematical model of the control object. Another advantage of fuzzy controllers is that they can be easily implemented on digital or analog chips, in which information can be transmitted over a parallel-distributed circuit.

METHODS

In relation to the studied SPP ACS, the current loop and the mechanical part of the electric drive in the standard structure (thyristor converter and the armature circuit of the electric motor) should be considered as the control object. To eliminate the influence of EMF feedback, a compensatory positive feedback is introduced into the system.

RESULTS AND DISCUSSION

The dynamics of an electric drive with a fuzzy controller is analyzed. The structure and knowledge base of the fuzzy controller are proposed to reduce the number of control loops and the number of sensors by eliminating the speed loop. Analysis of the dynamics of the two-circuit automatic control system of a tracking electric drive with a fuzzy controller has established that the quality indicators of the dynamics of the electric drive when working out large control actions are better in a system with a fuzzy controller. Recently, new non - traditional management methods, including fuzzy logic, neural networks, expert systems and other control tools with elements of artificial intelligence, have been applied in the world practice.

The movement of the feed table L is considered as a controlled value. Figure 1 shows a simplified block diagram of the SEL ACS with a fuzzy controller and a closed current loop as the object of the op-amp control. The input of the system receives the task of the Back end, which is compared with the current state of the Dos object, passing through the feedback loop. The received value of the error D os comes to one of the inputs of the fuzzy controller HP. The second input

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receives the derivative of the error dl/dt. In accordance with the input values and the adopted control strategy, the fuzzy controller HP forms a control action Uupr applied to the control object of the op-amp. The control object of the op amp processes the applied signal Uupr. As a result, a closed nonlinear self-propelled gun with a fuzzy position controller is obtained.

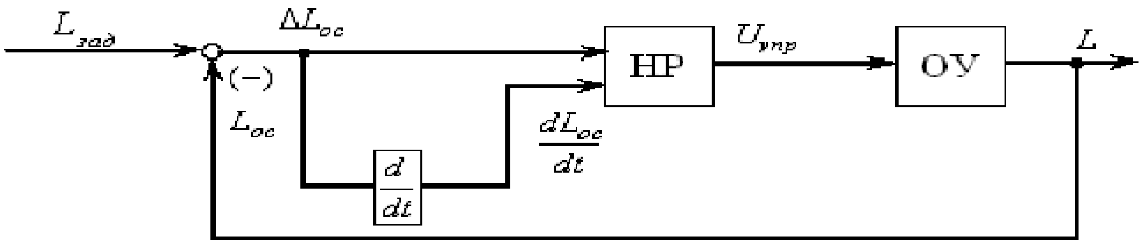

Fig. 1. Simplified block diagram of the SEP ACS with a fuzzy 1 controller

According to the theory of fuzzy ACS, the operation of a fuzzy controller can be divided into three stages:

1. Fuzzification-conversion of input absolute values into linguistic values.
2. Logical conclusion using a pre-compiled knowledge base.
3. Defuzzification-conversion of output linguistic values to absolute values.

We will consider fuzzification by the example of converting the error value, Fig. 2. The absolute value of the error is converted to a linguistic value, represented by five terms. A term is usually called the membership function of a certain set defined on a specified interval. As applied to Fig. 2, this means that the linguistic variable “error” is defined by five sets: “large positive” (BP), “positive” (N), “zero” (N), “negative” (O), “large negative” (BO).

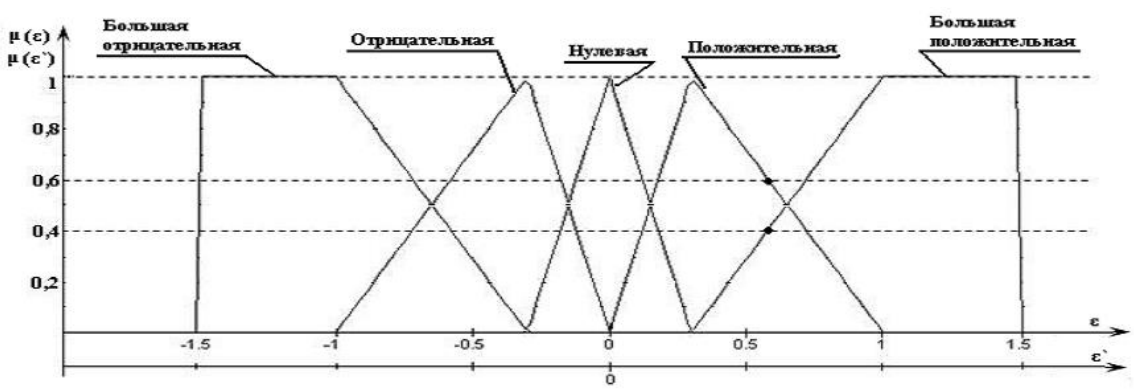

Fig. 2. Fuzzification of the error and the rate of change of the error.

Each absolute error value defines a combination of degrees of membership for these sets. For example, in Figure 2, the error is 0.6 in relative units. This means that the degree of belonging of the term "positive" is 0.6, and the term "positive large" is 0.4. For this case, the degrees of belonging of the other terms are zero. All input variables that the fuzzy controller works with are fuzzified. The number of terms, their form and the domain of definition are formed from the conditions for obtaining the required control law. The knowledge base is compiled on the basis of associative rules and conclusions that a human operator would use when managing this process. As a rule, such a problem is solved by drawing up fuzzy associative rules, designed in the form of a table or text form. In the matrix of the knowledge base, the so-called "burning" rules are highlighted. These are the intersections of columns and columns corresponding to the current topics of the input linguistic variables. Moreover, the degree of belonging of the "burning" rule is determined by the minimum operator, i.e. it is assigned the lower value of the compared terms of the input linguistic variables. Next, the corresponding term of the output linguistic variable is cut off in accordance with the previously defined degree of belonging. Thus, the degrees of belonging of several terms of the output linguistic variable are formed. The final stage involves the translation of the output value from the linguistic to the absolute form. In practice, the most widespread method is the center of gravity. The value of the output variable is the coordinate (abscissa) of the center of gravity of the area of the resulting term set of the output linguistic variable. The coordinate of the center of gravity is calculated using the following formula:

$$U_{ynp} \approx \frac{\sum_{i=0}^{k} \mu_i \cdot \eta_i}{\sum_{i=1}^{k} \mu_i}$$

The transition process, in a standard system, meets the requirements of optimal quality indicators corresponding to the third point of adjustment. In a system with a fuzzy controller, a transient process similar to that calculated in a standard three-circuit system is obtained. This fact indicates that the use of a fuzzy controller allows you to provide control that meets the required optimality criteria.

CONCLUSIONS

1. The dynamics of an electric drive with a fuzzy controller is analyzed. The structure and knowledge base of the fuzzy controller are proposed to reduce the number of control loops and the number of sensors by eliminating the speed loop.
2. Analysis of the dynamics of a two-circuit automatic control system of a tracking electric drive with a fuzzy controller has established that the quality indicators of the dynamics of the electric drive when working out large control actions are better in a system with a fuzzy controller.

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