Neuro-Fuzzy systems for Automatic Temperature Drying Aggregate

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Abstract - In article questions of the synthesis of neuro-fuzzy control system temperature mode drying aggregate. Present an efficient algorithm for the synthesis of neuro-fuzzy controller and fuzzy automatic temperature control of the drying process of raw cotton, which is invariant to changes in a wide range of parametric and external disturbances.

Keywords – uncertainty of the information, intellectual management, indistinct logic, robust control system, a synthesis algorithm.

I. INTRODUCTION

Control of technological units functioning in the conditions of uncertainty of information connected with certain difficulties [1,2] and is, from the point of view of classical theory of automatic control (TAC), a rather complex and, in most cases, unsolvable problem. In these cases, to solve the problem of creating a control system specifically focused on the construction of models that take into account the incompleteness and inaccuracy of the original data, it is appropriate to use the methods of intellectual control.

Consider the process of operation of drying aggregate, which is the process of drying the raw cotton. Rotary dryers 2SB-10 used in the cotton industry include feeder, drum chimney. The drying agent passes from pipeline (length 15 m) and get into the drum. Cotton comes using a feeder into the drum which rotates at 10 rev/min (10 m length of the drum). When speed of air of 1 - 1.5 m/s is cotton in a tumble dryer maximum of 2 minutes. Inside the drum there are longitudinal blades which provide mixing cotton, while rotating the drum, which promotes cotton along the drum axis.

Basic input parameters of the process are: flow of heated air flow and flow of drying cotton, as well as the initial humidity and infestation of cotton, the ambient temperature. The rest of the effects are disturbing, as the main disturbance can take degree of friability cotton.

The input to the regulatory impact of the temperature of the drying aggregate is a flow of heated air, while the rest are perturbing effects [3,4].

An analysis of the literature [3,4,9] and experience industrial exploitation have shown that for a given quality of cotton fiber is necessary to maintain a certain temperature in the drying aggregate. Therefore, as the output parameter is selected temperature at the inlet of the drying aggregate. The air inlet temperature of the drying aggregate which in turn, is controlled parameter which is controlled by changing the temperature generated by heat generator.

Simulation results of the existing automatic control system show that the overshoot in the system is about 20%, and the transient time equals 385 seconds.

In the presence of the facility or external parametric disturbances (such as changing humidity dried up cotton by more than 15%, the change in volume of heated air by 10%), significantly worse quality indicators of the transition process. In the case of a wide range of changes in these parameters, this aspect may cause the control system to an unstable state. This is due to the fact that the automatic control systems with fixed values of the quality control parameters of the transition process varies depending on the disturbance and technological modes of drying aggregate [5-9].

Therefore, the solution of such problems is proposed to search using the theory of fuzzy logic, which allows to operate with linguistic fuzzy statements. Thus, the task of synthesis of robust fuzzy control system temperature mode of a chemical reactor, which is invariant to external disturbances and parametric.

Consider the closed system of automatic temperature control of the drying aggregate with fuzzy logic controller (FLC) (fig. 1).

This system differs from the existing cascade ACS with classic PI control so that the control loop has a single fuzzy logic controller type MISO with two inputs and one output. In the fuzzy controller tasked generation control in the range of dynamic control error and its derivative relative to its threshold values.
According to this scheme, the $E^i = (e^i_1, e^i_2)$ input vector fuzzy logic controller (FLC) is converted into the form using fuzzy fuzzification block $F$, and then executes a fuzzy inference rule base, resulting in a fuzzy output variable $u^*$. Transfer the values of the vector control $u^*$ from a fuzzy area in clear carried defuzzification block $(DF)$.

$N$ block is designed for pre-processing the input control error and its derivative:

$$e^N_i = \begin{cases} e^i_1, & |e^i_1| < e^i_{1\text{max}}; \\ e^i_{1\text{max}} \text{sign}(e^i_1), & |e^i_1| \geq e^i_{1\text{max}}. \end{cases}$$  \hspace{1cm} (1)

Post-processing the output signal $u$ of the control unit carried DN, which solves the problem of de-normalization $u$:

$$u = u_N \cdot DN = u_N |u_{\text{max}}|.$$  \hspace{1cm} (2)

Where $u_{\text{max}}$ – maximum control value applied to the object.

If one considers that the basic equation of the PID-controller can be written as

$$u(t) = u_0 + K \left( e(t) + \frac{1}{T_1} \int_0^t e(\tau) d\tau + T_2 \frac{de(t)}{dt} \right), \hspace{1cm} (3)$$

the PID-control law can be presented as a regulator of the variable gain:

$$K_{\text{PID}} = K \cdot K^*.$$  \hspace{1cm} (4)

Where $K^*$ – the variable portion of the gain that depends on the current value of the derivative and integral control error.

This allows you to implement fuzzy logic PID-controller type in the form of two series-connected modules: "FLC PD" and the module "fuzzy correction" with $\alpha$ and $\beta$ adjustable coefficients (fig. 2).

Thus, in the case of the completeness and consistency of the rule base of a fuzzy inference law of the operation of FLC’s may be represented as the sum of the product of two functions, determined by the type and distribution of a range of control functions and supplies the selected algorithm fuzzy inference.

Based on the aforementioned theoretical considerations can be formulated in the following algorithm synthesis of fuzzy logic PID - controller:

1. Defines the input and output linguistic variables FLC’s, each of which contains the 7 term - sets with uniformly distributed triangular membership functions.
2. Determines the scaling factor and the coefficient of denormalization fuzzy controller $(N,DN)$.
3. Forming the base of the rules of inference as FLC’s.
4. The system is activated consistently standard linear FLC PD with 7 terms for each FR and 49 rules, whose task is to suppress vibrations.
5. Optimized law of the operation of a non-linear FLC’s by shifting the centers of intermediate terms LR input "control error" $e_i^j: \mu^j_\text{le}(x,a_j^1,b_j^1,c_j^1)$.
6. Selection of adjustment parameters $\alpha$ and $\beta$, allowing a decrease in the static error

Considered synthesis algorithm fuzzy logic PID - controller is simple, because it allows to use a standard form describing linguistic variables and a minimum set of control rules.

The fig. 3 shows the results of a comparative analysis of the synthesized system of fuzzy control system with the existing system with the classical PI and PID controllers.

Fig. 4 shows the results of simulation of fuzzy ACS temperature drying aggregate in the conditions when the parameters of the control object, as well as an external disturbance signal.
As seen from the graphs of the transition process (fig. 4a, b, c and d), when the system noisy external disturbing signal and changing its level to 30%, and changes the parameters of the control object (the $K_1^{OT}, K_2^{OT}$ gain and $T_1^{OT}, T_2^{OT}$ time constant) to 25% (in the direction of increasing and decreasing), fuzzy system retains the stability properties.
Fig. 3  Transition processes in systems ACS with fuzzy logic controllers

1- the temperature of the drying agent
2- moisture of cotton

\[ T_1 = 1.19 \text{ c}, \quad T_2 = 1.85 \text{ c}, \quad K = 0.72 \]
\[ T_1 = 0.91 \text{ c}, \quad T_2 = 0.85 \text{ c}, \quad K = 0.72 \]

1- the temperature of the drying agent

2- moisture of cotton

\[ T_1 = 1.19 \text{ c}, \quad T_2 = 2.35 \text{ c}, \quad K = 0.72 \]

1- the temperature of the drying agent

2- moisture of cotton
Thus, on the basis of computational experiments, we can conclude that a synthetic fuzzy logic controller gives the entire system of automatic control of the ability to maintain the temperature at a given level of the drying aggregate with external disturbances, as well as quality control of process of drying of cotton in a wide range of its settings over time.

REFERENCES