Study on fuzzy decoupling control system

Jing ZHAO
Xi'an Mingde Institute of Technology. Xi'an, China
351057219@qq.com

Abstract. There is a strong coupling effect between the pressure and flow in the industrial process control. In order to eliminate the coupling, an intelligent control called fuzzy decoupling control is proposed. The unit matrix method is used for decoupling design, which makes the pressure and flow coupling system become two independent subsystems. The simulation results show that the fuzzy decoupling control effectively solves the pressure flow. The quantity has strong coupling effect in the control process, and the control effect is satisfactory.

1. Introduction
Intelligent control technology mainly studies the simulation of human intelligent activities and control laws, which is a new branch of human simulated intelligent control system[1]. Intelligent control is based on artificial intelligence, control theory, operational research and other disciplines, and expands the corresponding concepts and principles. Among them, fuzzy control, neural network control, expert control, humanoid control, genetic algorithm and other technologies are widely used in industrial process control system, robot control system and traffic system. In many complex control system fields, conventional control often can not meet the control requirements that people expect. Therefore, adopting intelligent control technology is an inevitable trend of advanced control development. The object of intelligent control research is no longer the controlled object, but the controller itself and control algorithm. Intelligent control theory is a computer control based on the reasoning and intelligent decision-making of simulation human knowledge and expert experience of dynamic system.

In the industrial process control, there is a strong coupling between the pressure and flow of the pipeline[2]. The traditional PID control can not control the coupling between the pressure and flow. In this paper, a fuzzy decoupling intelligent control is proposed. The simulation results show that the fuzzy decoupling intelligent control can effectively solve the pressure flow strong coupling control, and the control effect is good.

2. Decoupling Control
Decoupling control is to make the change of each control variable in the process of coupled control only affect the matched control parameters, but not the other control loop parameters[3]. In this way, the multivariable coupled control system is decomposed into several independent single variable control systems. The block diagram of the two variable decoupling control system is shown in Figure 1.
The unit matrix design method is to design a decoupling link for the decoupling control system shown in the figure, so that the product $\hat{G}_{1}(s)$ of the transfer function $\hat{N}(s)$ of the decoupling link and the transfer function $\hat{G}(s)$ of the controlled process becomes the unit matrix.

$$\hat{G}_{1}(s) = \hat{G}(s)\hat{N}(s) = E$$

If $\hat{G}(s)$ is not singular, it can be obtained from the formula (1):

$$\hat{N}(s) = \hat{G}^{-1}(s) = \frac{1}{|\hat{G}(s)|} \text{adj} \hat{G}(s) = \frac{1}{\Delta} \text{adj} \hat{G}(s)$$

$$\hat{N}(s) = \frac{1}{\Delta} \text{adj} \hat{G}(s) = \frac{1}{\Delta} \begin{pmatrix} G(s) & -G(s) \\ -G(s) & G(s) \end{pmatrix}$$

The decoupling link obtained by the unit matrix can make the control system shown in Figure 1 equivalent to the two independent transfer functions shown in Figure 2. The decoupling device designed by the unit matrix design method not only eliminates the coupling between control loops, but also improves the dynamic characteristics of each control process, making the transfer function 1 of the decoupled independent controlled process, improving the stability of the control system. The decoupling design of unit matrix can not only achieve excellent decoupling effect, but also improve the control quality, reduce the dynamic deviation, speed up the response delivery and shorten the regulation time.
3. Fuzzy Control

Fuzzy control[4] is a series of control rules summarized by human experts for the control strategy of a specific controlled object or process. The control action set is obtained through fuzzy reasoning, which acts on the controlled object or process.

The fuzzy control is designed as two fuzzy controllers of pressure and flow, and one-dimensional fuzzy controller is used in the fuzzy controller. The quantization domain of input variable error $E$ and output variable $U$ of fuzzy controller are $\{-3, -2, -1, 0, +1, +2, +3\}$. The fuzzy subsets of fuzzy controller are \{NB, NM, NS, Z0, PS, PM, PB\}. The language variables are expressed as \{negative large, negative medium, negative small, zero, positive small, positive medium, positive large\}. All of them adopt symmetrical triangle membership function. For the fuzzy controller, to complete a control action, it is necessary to input the measured value into the fuzzy controller. After fuzzy, fuzzy reasoning and defuzzification, an exact control quantity is obtained and applied to the controlled object.

4. Fuzzy decoupling control

For the coupling effect of the pressure and flow control system in the pipeline, the fuzzy decoupling control as shown in Figure 3 is adopted[5]. The system can automatically add the compensation amount to the original pressure and flow control output according to the coupling effect between the pressure and flow. It has both the stability of the traditional control system and the adaptability, which can effectively solve the control accuracy of the pressure and flow.

![Figure 3. Fuzzy decoupling control block diagram](image)

5. Conclusion

In this paper, MATLAB software is used to establish the simulation model of the pressure and flow control system in the pipeline, and fuzzy decoupling control is adopted for the pressure and flow. The simulation curve is shown in the figure 4.
Figure 4. Fuzzy decoupling simulation curve of pressure and flow

From the simulation curve, it can be seen that the fuzzy decoupling control can eliminate the coupling of pressure and flow control variables and make them equivalent to two independent control systems. The control parameters can be adjusted online and modified dynamically, the control accuracy can be improved significantly, the response speed of the system is fast, the steady-state performance is good, the adjustment time is fast, and the fuzzy decoupling control effect is good.

References
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