Research on the Algorithm of Flue Gas Desulfurization System

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Abstract

In this paper, the process of flue gas desulfurization and denitrification, which is a nonlinear, time-varying, large lag and strong coupling complex variable process, is analyzed and studied in depth. Based on the analysis of the coupling characteristics of the adsorption tower, the control model of the desulfurization and denitrification process of the adsorption tower is established, and the system identification adaptive PID Decoupling control algorithm is adopted. The Simulink toolbox corresponding to Matlab software is used to simulate and verify the effectiveness of the algorithm. The RBF neural network identifier is used to identify the plant model on-line to improve the adaptive ability of the controller.

Keywords: flue gas, desulfurization, PID, RBF neural network, Matlab

1. Introduction

With the continuous development of the country's social economy, the law enforcement of environmental protection has also been strengthened. In order to improve the regional air quality, the state has vigorously carried out the work of supporting the improvement of atmospheric environmental quality. In recent years, the concentration of inhalable particles in urban air has decreased significantly, but the situation of air pollution is still very serious. The power industry, as a major pollution reduction industry, it is facing great pressure from air pollution control. Activated carbon integrated desulfurization and denitrification technology has been widely used in flue gas purification in recent years. Desulfurization and denitrification process is a nonlinear, large lag, strong coupling complex industrial process control system, domestic and foreign scholars have done a lot of research on it, and its control has basically realized digital [1]. At present, intelligent algorithm and control technology are combined, and various optimization algorithms are used to optimize it. The desulfurization and denitrification process is based on the joint action of physical and chemical reactions.

The corresponding research institutions have formed a lot of mature theoretical literature on this reaction mechanism. However, for different projects, the process adopted is different, the diversity of equipment and the difference of process flow. So far, the desulfurization and denitrification system have not formed a unified mathematical model, nor has a complete set of intelligent control algorithm. In recent years, there are more and more researches on Modeling and control of flue gas desulfurization and denitrification system. The research direction is mainly divided into the following aspects: process improvement, updating and adjustment of desulfurization and denitrification chemical equipment, optimization of control and prediction algorithm.

The most important part of activated carbon desulfurization and denitrification system is adsorption tower. In this paper, the intelligent control combined with neural network and PID control is used to control the adsorption tower, which can overcome the problems of nonlinearity, large lag and coupling in the complex industrial process of desulfurization and denitrification.

In this paper, the control system of sintering flue gas desulfurization and denitrification in a domestic steel plant are taken as the research object.

2. Overall scheme design

First of all, this paper in-depth understanding of activated carbon integrated desulfurization and denitrification technology process, system structure, purification principle. Through the analysis of desulfurization and denitrification system, the main variables and internal coupling relationship are determined. The identification model is established by recursive factor least square method. The identification model of desulfurization and denitrification of adsorption tower under the integrated process of activated carbon is established.

Secondly, based on the combination of neural network and PID control, an intelligent decoupling control algorithm, namely RBF online identification adaptive PID Decoupling control algorithm are designed [2]. The basic adaptive controller NNC is composed of a single neuron PID with self-learning and self-adaptive ability. The object model is identified online by RBF neural network identifier to improve the adaptive ability of the controller. The intelligent decoupling control algorithm is simulated to verify the robustness and feasibility of the decoupling control scheme combining neural network with PID control.

Finally, the network structure of the desulfurization and denitrification control system is described. The designed self-tuning PID Decoupling Algorithm Based on RBF model identification is programmed. The algorithm is programmed. The control effect of the algorithm and the integrity of the algorithm function block are verified by simulation [3].

3. Composition of desulfurization system

The flue gas desulfurization and denitrification system mainly includes three parts: flue gas system, activated carbon system and ammonia supply system.

3.1. Flue gas system

The flue gas system is the main part of the desulfurization and denitrification process. The sintering flue gas is firstly heated by the heater at the inlet. Then it was sent to the adsorption tower through the adsorption tower. It is also sent to the chimney channel through the booster fan at the tail, and it is the main exhaust fan. After the reaction treatment in directly discharged to the atmosphere [4].

3.2. Activated carbon system

The activated carbon system is mainly composed of three parts: adsorption tower, desorption tower and activated carbon transportation system. The main task of the analytical column is to separate the decomposable substances adsorbed in the activated carbon at high temperature, so that the activated carbon can be fully recycled. Activated carbon transportation system involves the addition and transportation of activated carbon in adsorption tower and desorption tower.

3.3. Ammonia supply system

The main components of ammonia supply system include liquid ammonia storage facilities and ammonia injection facilities. The liquid ammonia from the storage tank enters the evaporator by its own pressure and it is heated and it is evaporated into ammonia. Ammonia and air from the dilution fan are mixed and diluted in the air mixer. Next it was injected into the flue through the injection system for chemical reaction, and nitrogen oxides are removed.

4. Design of desulfurization system

4.1. Multivariable desulfurization system

The multivariable system structure diagram, which represents a multivariable system with N inputs and N outputs [5]. It is supplemented by task list module, distribution plan module, task analysis module and personal center module. The desulfurization and denitrification process control of adsorption tower are a typical dual input and double output multivariable control system, where r_1 and r_2 are the set values of desulfurization and denitrification, and y_1 and y_2 are the conversion values of desulfurization and denitrification respectively. Multivariable system structure diagram is shown in Fig.1.

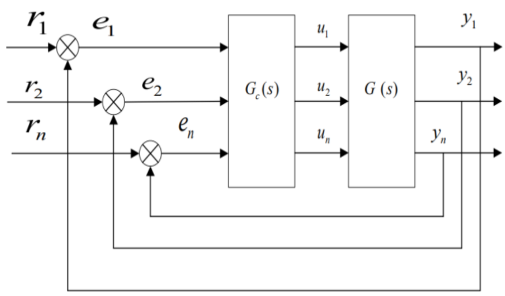

Fig.1. Multivariable system structure diagram

4.2. Analysis of denitration characteristics

Under the steady-state condition, the reaction conditions and the whole reaction process of the desulfurization and denitrification system are relatively stable. The relevant parameters in each reaction process have no obvious fluctuation, and the corresponding relationship between controlled variables is relatively clear.

The variation characteristics of generator power at a certain time, the load of sintering unit is stable in time period (0-t). It changes into transition state (t1-t2), and starts to stabilize at t2. It keeps stable for a period of (t2-t3). Finally it starts to change around t3 and restabilizes at t4.The actual steady-state diagram of desulfurization is shown in the Fig.2.

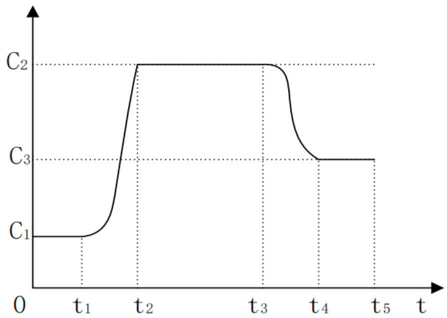

Fig.2. Actual steady state diagram of desulfurization

4.3. Data processing method

The actual process data contains a lot of industrial object information, so the amount of data collection should be as comprehensive as possible, so as to facilitate the later modeling and model verification. Data processing mainly includes data conversion and data error processing. Conversion includes scale, conversion and weight function. Conversion has a direct impact on the process accuracy, nonlinear mapping ability and numerical optimization algorithm.

4.4. Model of desulfurization and denitrification

System identification is to determine the model equivalent to the measured system according to the input and output data of the system. The purpose of system identification is to estimate the model structure and unknown parameters. It can be divided into two categories according to the model form, one is non parametric model identification method, and the other is parametric model identification method. This paper is based on the second model identification method, namely parameter model identification. The recursive factor least square method is used to identify the activated carbon desulfurization rate of the channel, and the identification curve is shown in the Fig.3.

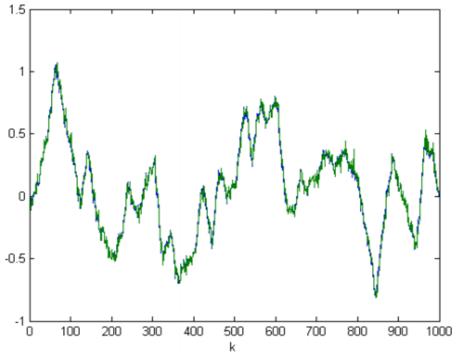

Fig.3. Comparison of fitting value and real value

4.5. Structure of neural PID control

The working principle of neural PID control is as follows: on the basis of online identification of controlled object by NNI, the weight coefficient of NNC is adjusted in real time to make the system adaptive and achieve effective control [5].

The adaptive PID control algorithm is as follows:

$$\Delta u(k)=K_p(k-1)x_{c1}(k)+K_i(k-1)x_{c2}(k)+K_d(k-1)x_{c3}(k)$$

A single neuron is used to construct PID controller, and its structure is shown in the Fig.4.

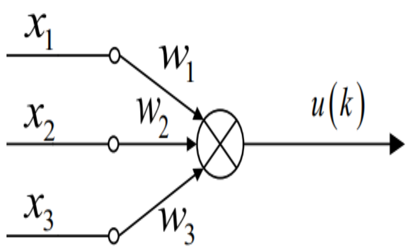

Fig.4. Single neuron PID controller

4.6. RBF adaptive model design

The basic idea of RBF neural network is that RBF as the "base" of hidden layer node constitutes the hidden layer space.n the case of over weight connection. The input vector is directly mapped to the hidden space. After the parameters of the neural network are determined, the nonlinear mapping relationship is determined.

The transformation from the input layer space to the output layer space is linear, and the output of the network is the linear weighted sum of the outputs of the hidden layer nodes. Neural network weights can be solved by various linear optimization algorithms. RBF neural network is a three-layer feedforward network, which is mainly composed of input layer, hidden layer and output layer [6]. The neuron structure of RBF neural network is shown in the Fig.5.below.

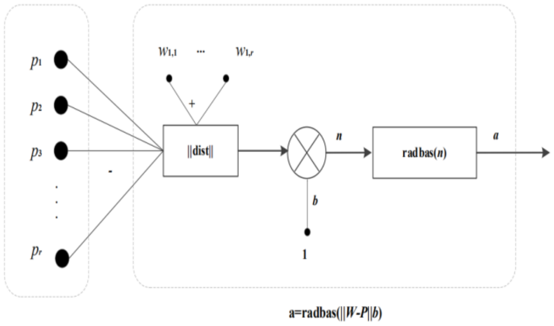

Fig.5. Neural structure of RBF neural network

5. Conclusion

This paper mainly analyzes the common methods and principles of decoupling, and uses RBF to identify adaptive PID online. Decoupling control is studied by control algorithm. In this paper, firstly, the classical feedforward decoupling controller is designed according to the identification model. Then, an adaptive single neuron PID identification based on RBF model is proposed [7]. The design and Simulation of intelligent decoupling controller are carried out to verify the effectiveness and superiority of the scheme.

Step signal is used to trigger the two channels at the same time, and R1 = 1 and R2 = 1 are set to simulate the triggering of the two channels. The simulation results are shown in the Fig.6.

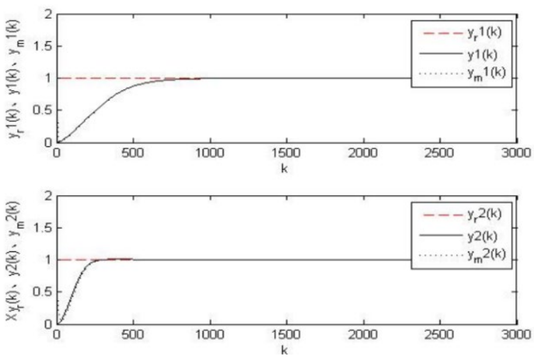

Fig.6. Y1 and Y2 output curves

According to the analysis of the above Fig.6, the two channels can respond quickly and achieve good steady-state results. The steady-state error is small. PID realizes the adaptive adjustment process. According to the image analysis, RBF realizes the online identification and adaptive adjustment of the model [8].

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