A Study of Chemical Reactor Simulation System Based on PCS7

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Abstract

Since 1960, the reason for the rapid development of industrial control and its systems is the rapid development of the key process control theory, and their application in science and technology is more and more extensive. In general, the factory site has a series of hazards, and people tend to take a remote, accurate approach to remote control. In this research, PCS7 software is used to simulate the remote control of chemical reactor, and reasonable and correct simulation can be obtained after PID correction.

Keywords: PCS7, PID correction, process control, chemical reactor

1. Introduction

Normal human life is inextricably linked to a series of chemical reactions.

The chemical reactor is defined as a vessel for reaction. The device is widely used in various fields, and the ultimate goal is to obtain reactants that meet the requirements while ensuring production efficiency.

However, due to the presence of a large number of harmful gases in the chemical reaction site that are not conducive to the human body and the environment, affecting the physical and mental health of the practical operator, and because of the high requirements of the chemical reaction parameters, the previous on-site operation has been transformed into a more accurate and safe remote control.

This paper mainly adopts PLC-SIM as the controller, and the controlled object and control method are realized by PCS7. Firstly, the infrastructure of chemical reactor PCS7 is introduced, and then the structural model and automatic operation are built by CFC block and SFC block. Finally, the loop is designed and PID correction is carried out to obtain appropriate graphics.

2. PCS7 Project Basic Framework

In most cases, a project has ES stations, OS stations, AS stations and buses, and each station port has its special function [1], which is shown in Figure 2-1.

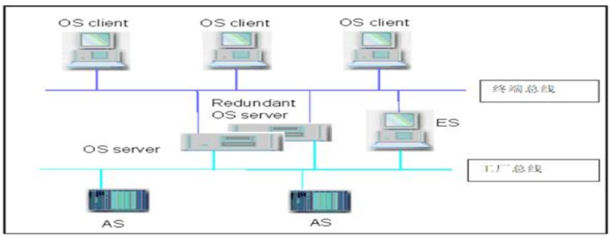

Figure 2-1 PCS7 framework

2.1. Engineer station

The engineer station (ES station) can achieve a series of operations such AS new construction, editing project files, and communication between AS station and OS station. In general, the design of ES station is completed in the software SIMATIC Mananger, and the configuration mainly consists of two links : AS station configuration and OS station configuration.

The configuration of automation station involves the compilation of continuous function diagram and sequential function diagram, factory level design, hardware configuration, communication network configuration and so on.

In the operator station, the process screen design and operation function design interface are mainly, and there are data archiving and protocol design.

2.2. Automation station

The automation station (AS station) is the control station of the Siemens DCS monitoring system, and the main modules of the station are: RACK, PS, CPU, I/O module, etc.

The CPU in PCS7 usually uses 400, in RACK, there are CP modules for the purpose of communication, but some CPU modules also have the function of communication directly, such as PROFIBUS DP interface or PROFIBUS DP serial communication module, through which to achieve device communication.

The automation station operates the system with fast industrial Ethernet access or the engineer station accesses the ET200 distributed I/O station using the Profibus-DP fieldbus. Note: The "block" in PCS7 is very critical, it is related to the work of the CPU in the software STEP7, the specific utility is shown in Table 2-1.

Table 2-1 Utility of blocks

Block	Utility
Tissue block (OB)	The function is to store the user master program and control successively.
System Function Block (SFB) and System Function Call Block (SFC)	They are stored in the S7 CPU so that they can implement some of the reserved functions.
Functional Block (FB)	It is a block that stores the user's own design.
Function call block (FC)	A subroutine that does not take up memory, but can be used repeatedly.
Background Data block (INSTANCE DB)	When a function block and a system function block are used, the block automatically connected with the block. No manual addition is required.
Data block (DB)	Its purpose is to store user data.
System Data Block (SDB)	It stores hardware configuration data.

2.3. Operator station

Most of the time operator stations are where we use the computer as a medium for control purposes. The OS configuration occurs at the engineer station, so it is feasible to consider the OS station project as part of the ES station project. Operator stations under distributed operating systems also have some basic two categories, the following is their introduction.

(1) Operator station server

The function of the operator station server is to pass the value in the program to another client that it has contact with, that is, the operator station client, and transfer the content of the OS station to the corresponding AS function block.

(2) Operator station client

The Data connection between the operator station client and the operator station Server is established through the Terminal Bus, and the data in the operator station server is accessed through Server Data.

The operator stands on the design, the configuration design of the above machine screen is the main work, should have the switch, operation panel CFC and SFC block writing and other functions, simulate the factory screen equipment diagram, in addition, there are data to archive and so on.

2.4. Factory bus and terminal bus

Plant Bus and Terminal Bus adopt Industrial Ethernet, which is consistent with IEC 802.3. This communication mode is mainly applied in network structure, most of which use optical fiber network as communication structure. Both the factory bus and the terminal bus will have good stability, and its role is to achieve reliable communication between various industrial communication buses.

For some medium or large specifications of industrial actual sites, it will have a high ball, for some industrial sites require a relatively smooth, fast contact device, PCS7 to provide it with optical fiber network and equipped with industrial Ethernet technology to achieve fast communication. The system uses advanced optical fiber connection technology and high-speed optical interconnection equipment, making it a new milestone in the field of communication. Among them, the latest and fastest Ethernet communication technology combines the scalable performance of switching technology with the high security of optical fiber ring network, and has a high data transfer rate and 1Gbit/S transfer rate, industrial twisted pair (ITP) and optical cable (FOC) can be used.

3. Mathematical Modeling and Automatic Operation of the Controlled Object

In PCS7, an engineering application, there are many ways to construct mathematical models.

3.1. CFC block

Also known as continuous function diagram, it is based on the function block to establish a numerical model of the controlled object, which has the function block of the configured proportion, integration, differentiation, delay and operation, such function block is configured on the PCS7 has been programmed.

CFC block is used to build the object model, and operation block is used to construct the mathematical formula, so as to realize the mathematical modeling process of the controlled object.

For the establishment of the mathematical model of chemical reactor, the mathematical modeling of liquid level object, pressure object, feed object and temperature object was obtained by referring to the data and using CFC block.

1. Liquid level objects

Mainly: integral link and inertia link.

$$G(S)=\frac{3.25}{1+5.47S}*\frac{2.13}{0.97S} \tag{3-1}$$

2. Objects of stress

Mainly: inertia link and integral link.

$$G(S)=\frac{2.78}{1+5.29S}*\frac{0.91}{5.58S} \tag{3-2}$$

3. Feed flow

Mainly: the inertial link of its principal and subordinate reactants.

$$G(S)=\frac{1.87}{1+5.49S} \tag{3-3}$$

$$G(S)=\frac{2.39}{1+4.68S} \tag{3-4}$$

4. Temperature object

Mainly: the second stage of the lag time [2].

$$G(S)=0.6*\frac{1}{4.29S}*\frac{1}{3.93S} \tag{3-5}$$

3.2. SFC block

In the process of running, the simulation system automatically executes the sequence control program, uses SFC to initialize the initial value of the control parameters required by the whole control system, and executes each control loop in turn, which is shown in Figure 3-1.

Each control loop enters the automatic control state according to the initial value, and after the implementation of the END step, the system will automatically enter the stable operation state, and the operation switch guide operator mode is fully controlled, that is, the operator can complete the automatic control according to the initial control target value, so that each control loop enters the automatic control state after the parameter initialization.

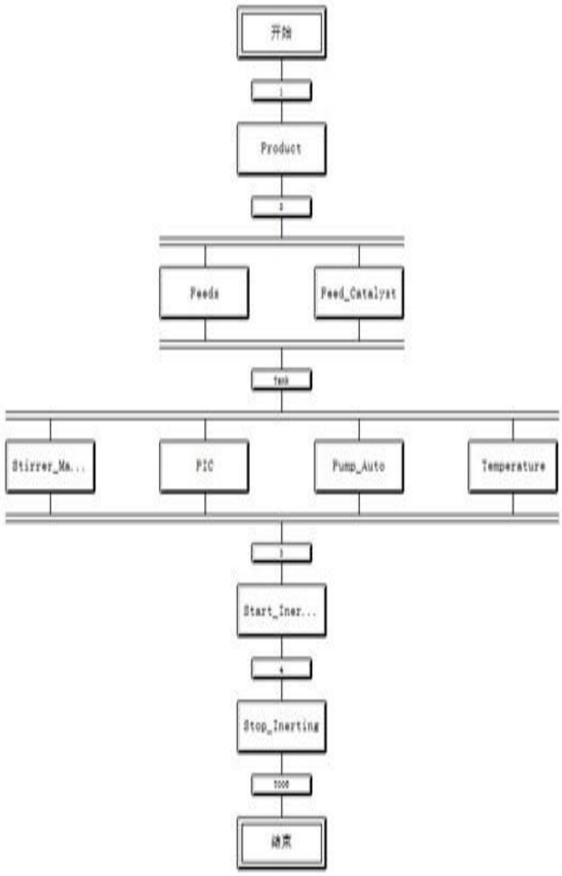

Figure 3-1 Simulating the SFC starting sequence

4. Design of Advanced Control Scheme for Simulation System of Chemical Reactor

The PID controller is used to control the reactor. The PID controller here uses the APL library of PCS7.

This topic has the feed part, the pressure part, the liquid level part and the temperature part.

The feed part is realized by a relatively simple ratio module, in which there are two modules, the master module and the slave module. The former controls the flow rate of the main reactant, the flow rate of the auxiliary reactant is controlled by the set value of the main module, the ratio controller provides two PID controls, and the latter controls the catalyst part of the reactant independently.

The pressure part is controlled by a separate PID module. To achieve this task, an initial setting value is set first. In actual simulation, if the running value exceeds our initial setting, the exhaust valve will be started; otherwise, if the running value is insufficient, the inert gas intake valve will be started until the process value each the set value. Then the feedback control of the whole system is carried out by proportional integral and differential control method. In the liquid level part, a separate PID module is used to realize it.

In the temperature part, cascade control is used. The inner ring of cascade control adopts PID module to control the flow rate of hot and cold water valves to realize the control of jacket temperature [3]. The output MV of a PID module is adopted in the outer ring as the given value of the PID controller in the inner ring.

4.1. Liquid level control scheme

For the control of liquid level in the loop, a negative feedback closed-loop loop is used, as shown in Figure 4-1.

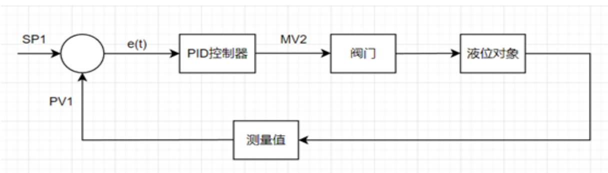

Figure 4-1 Pipes and devices

The value of the set value SP1 can be given by an external or internal PID controller whose parameters are tuned by the PID Tuner.

The liquid level control model, as shown in Figure 4-2 is built using the CFC block of PCS7.

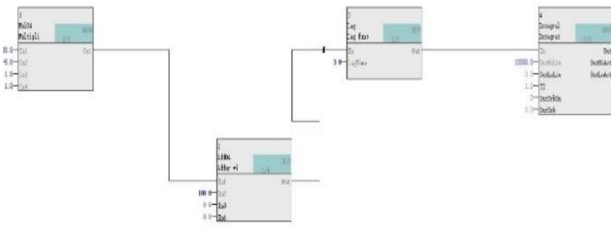

Figure 4-2 Liquid level simulation objects

For these four parts, it is usually used in a user-defined closed-loop control system set by users, integrating the input values according to the ladder rule, and output the results.

Figure 4-3 shows the pipe diagram and function block of the liquid level control loop. A control loop is provided in the figure. The CFC block in Figure 4-4 is the liquid level control loop pipe.

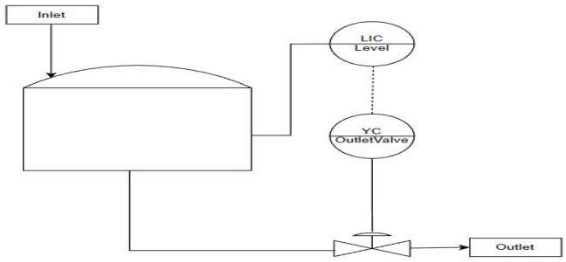

Figure 4-3 Pipes and functional blocks of the liquid level control loop

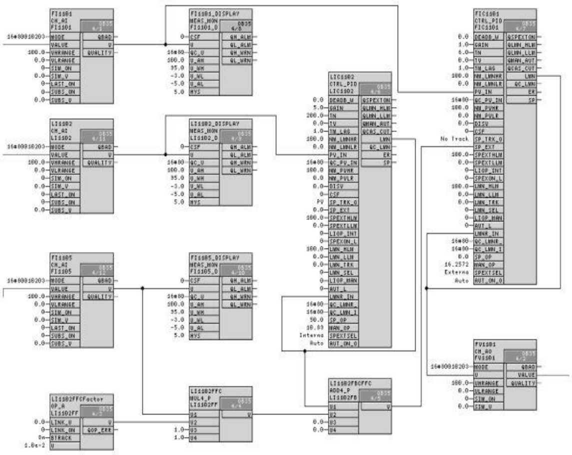

Figure 4-4 Connection structure of each CFC block in the liquid level control loop

In addition, for the feed flow, pressure, temperature three parts, also to design the corresponding control scheme. Among them, the feed part is controlled by ratio, the pressure part is controlled by division, and the temperature is controlled by cascade.

4.2. Tuning of controller PID parameters

Using PID module to control the controlled object is very important for the parameters, and only appropriate parameters can meet our purpose. This topic only takes 4 control loops for example to study the liquid level control loop.

The PID Tuner tool is developed based on PCS7 software, and the data is collected and recorded through the background data block of PID function block, and the ideal data is obtained by simulation and applied in the controller. Different adjustment effects under various control modes can be achieved by setting. The tool provides synchronous real-time data curve display of initial, median, and final values, and intuitive overall optimization functions are displayed.

Below, after proper PID tuning, the appropriate tuning pattern is obtained, which is shown in Figure 4-5.

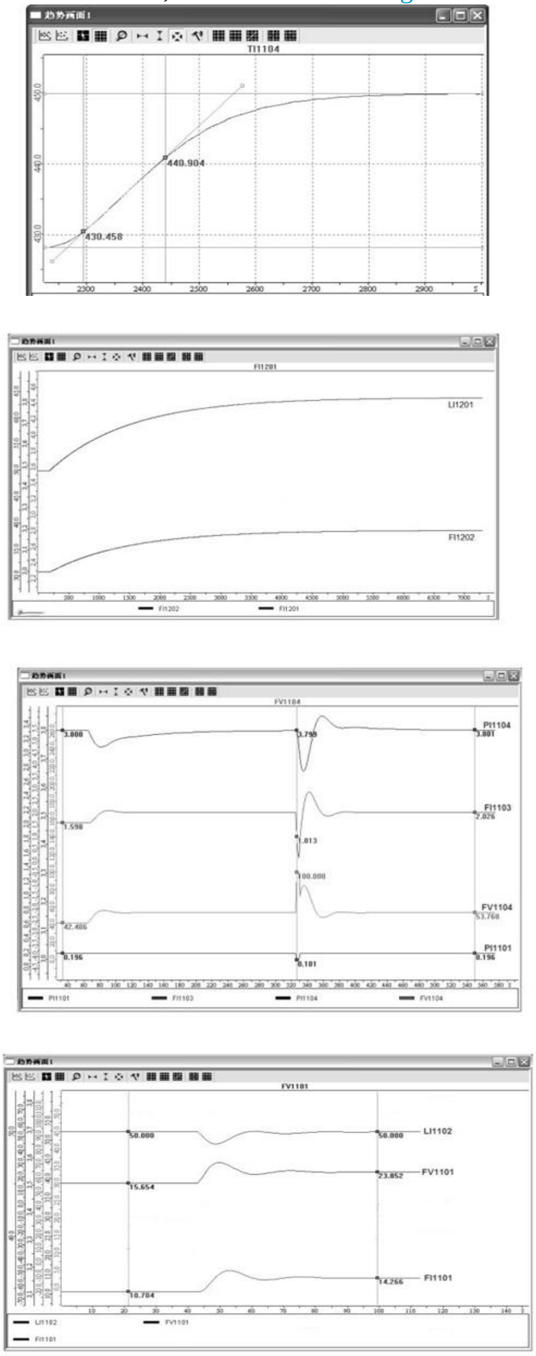

Figure 4-5 Setting results of liquid level, flow rate, pressure, and temperature

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Authors Introduction

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He is a first-year master candidate in Tianjin University of Science and Technology.