Application of PID Controller based on PLC in Polymer Flooding Injection Station System

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Abstract

In this paper, a PID controller based on PLC is designed for the problem of automatic regulation of the pressure of three yuan injection station. The controller can automatically control the frequency of the frequency converter according to the pressure set value, and then control the high and low pressure injection manifold pressure and stable injection quantity. The control method is simple and easy to operate, the dynamic response speed is fast, and the system control effect is good.

Keywords

PLC; PID controller; Injection station; Polymer flooding; Ground process.

1. Introduction

The initial application of injection station of a polymer injection station in an oil field is proportional to the injection process, because of the low rate of failure and low time, the original technological process was transformed, Each injection stations are fitted with 2 liquid pipe, which are high and low pressure pipe, all the injection wells are connected to the high and low pressure manifold, which can ensure the continuous operation of each injection well. After a period of operation, the high and low pressure manifold pressure is found frequently. When the liquid pipe pressure is high, the viscosity loss of the whole system is affected by the pressure difference. When the liquid pipe pressure is low, it can not guarantee the injection amount of liquor. There is no liquor pipe pressure monitoring and control unit in the original measurement and control system, the operator need inspect regularly and manual adjustment of the proportion of pump output to ensure the system pressure stability. Operating personnel labor intensity is so largely that the monitoring and control system for injection station is reformed. By adjusting inverter output and studying on the solution manifold pressure control technology, to ensure the stability of the system pressure and to achieve high and low pressure automatic regulation.

2. PID algorithm

PID algorithm is used to control the amount of control by PID controller, to ensure that the deviation of E is zero and ensure the system reach a stable state. Deviation e is the difference between the quantitative SP and the process variable PV. PID control algorithm: output is a function of the error variables e proportion, integral and differential.

$$M(t) = K_C \bullet e + K_C \int_0^t edt + M_i + K_C \bullet de/dt \quad (1)$$

Among them: $M(t)$ is the output of the PID circuit; K_C is the gain of the PID circuit; e is the deviation of circuit; M_i is the initial value of the output of the PID circuit.

In order to let PLC handle this PID control formula, type (1) of the discrete formula must be dispersed. After treatment of type (1), PID control formula of PLC is as follows:

$$M_n = K_C \bullet (SP_n - PV_n) + K_C \bullet \frac{T_S}{T_L}(SP_n - PV_n) + MX + K_C \bullet \frac{T_D}{T_S}(PV_{n-1} - PV_n) \quad (2)$$

Among them: M_n is the calculated value of PID circuit output at the sampling time n; K_C is the gain of the PID circuit; T_S is the sampling time interval; T_L is the integration time; T_D is the rate time; SP_n is a given value for the first sampling time n; PV_n is the process variable value for the second sampling time n; PV_{n-1} is the process variable value for the second sampling time n-1; MX is the integral term for the sampling time n-1.

In the control system, according to the need by setting the constant parameters, we can choose the type of loop control: (1)The integral time T_L can be set to infinity, and the integral function can be neglected; (2)The differential time T_D can be set to zero, and the differential effect can be canceled; (3)The gain K_C can be set to zero, The system will be used to calculate the integral term and differential terms and treat the gain as 1.

3. Design of PID controller

3.1 System introduction

The proportional control pump in the original process is variable frequency control, manual control frequency according to pressure change, because of the pressure response is slow, employees need to adjust the inverter frequency to ensure the injection pressure effectively. We introduce the frequency conversion data and the high and low manifold pressure to the measurement and control system and output frequency value to frequency converter through the new system PID controller. According to the pressure fluctuation, the converter parameters are adjusted automatically to achieve satisfactory injection effect.

The pressure signal is stored in PLC, according to the set of pressure and actual pressure calculation deviation is e, and the introduction of PID controller, after D/A conversion into 4-20mA current signal to control the frequency, to realize the control of pipe pressure.

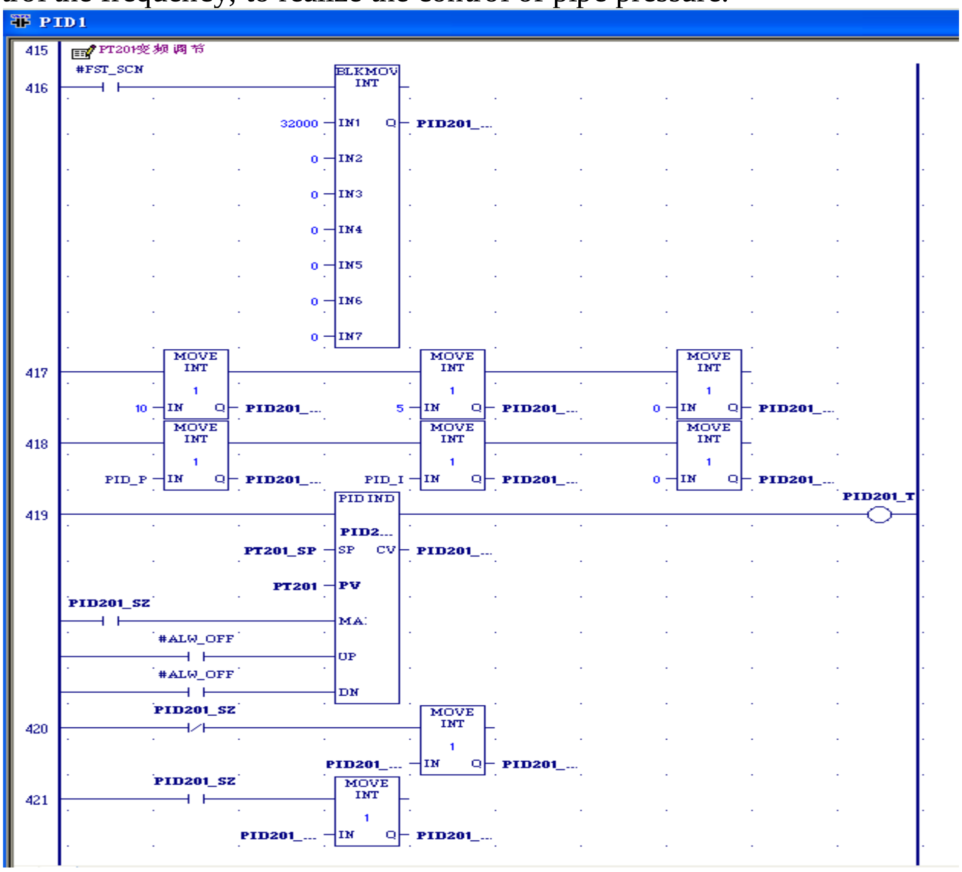

Figure 1 PID controller program in GE PLC

3.2 Software design of PID controller

The data management and interface display of Upper monitor is completed based on the GE FANUC ifix5.0 and FactoryTalk_View_SE6.0 software. The data acquisition and control of lower monitor is completed based on the GE PLC(Proficy Machine Edition6.5) and AB PLC(RSLogix5000v16). Both of them achieve data exchange through TCP/IP communication.

Each system is installed in the high and low pressure manifold pressure transmitter, each of high and low voltage select two sets with the ratio of the inverter control pump as the adjustment object, AI module and AO module is added, the pressure signal and the 4 frequency conversion feedback signal are introduced into AI, and the automatic frequency value of the hand is output through the AO to the frequency converter. PLC programming shown in figure 3.

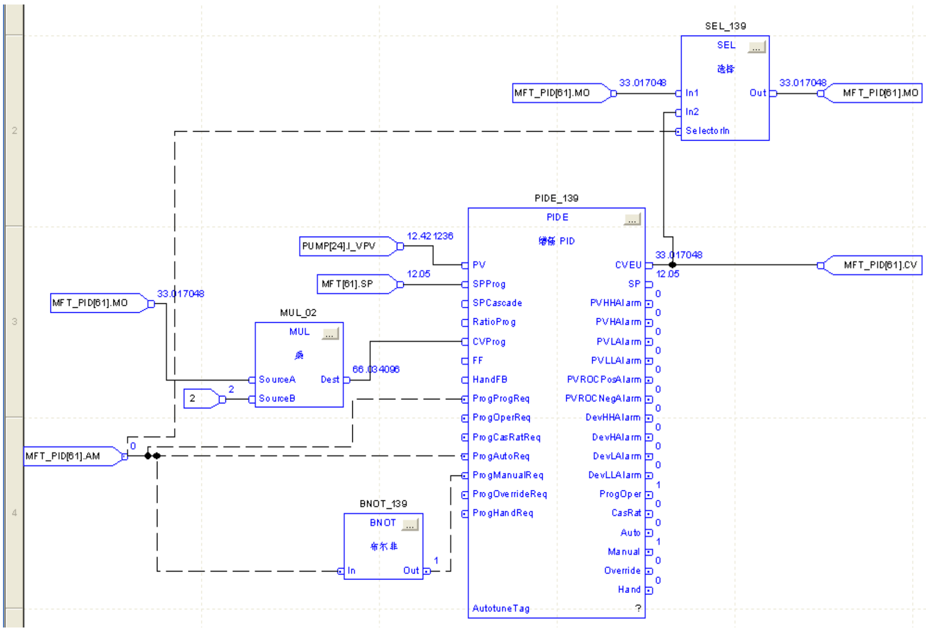

Figure 2 PID controller program in AB PLC

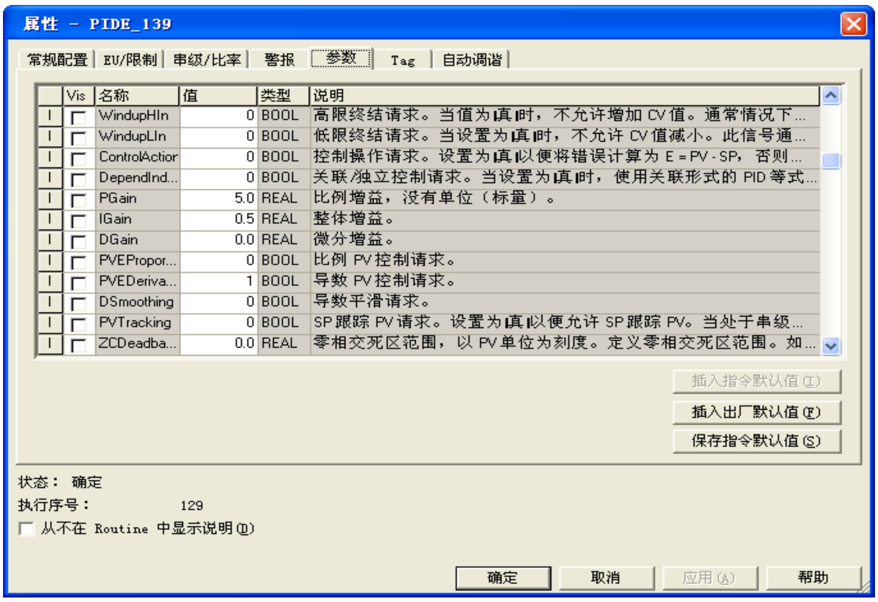

Figure 3 PID parameter table

The PT201 and PUMP[24].I_VPV of PID controller in Figure 1 are actual pressure value, the PT201_SP and MFT[61].SP are the pressure set value, the PID201.CV and MFT_PID[61].CV are the automatic state frequency output, The PID201.AQ and MFT_PID[61].MO are the manual state frequency output.

In Figure 2, corresponding to the PID algorithm, the deviation is SP-PT201 (PUMP[24]. I_VPV)=e= $SP_n - PV_n$;The ratio coefficient K_C corresponding to the PGain in PID module;The integral coefficient T_L corresponding to IGain. PID parameters are shown in figure 3.

The greater the K_C, The faster the deviation decreases, But it is very easy to cause oscillation, especially in the case of relatively large hysteresis link. The K_C decreases, the probability of occurrence of oscillation decreases but the adjustment speed becomes slow. However, the simple proportional control has the disadvantage that the steady state error can not be eliminated. There is a need for integral control which will increase with the increase of time. It drives the output of the controller to increase and further reduce the steady-state error, until it is equal to zero. The essence is to control the cumulative deviation until the deviation is zero. Differential terms can predict the trend of error variation, but it is easy to amplify the high frequency noise, so that the ability of the system to suppress interference is decreased. So in PLC, the differential terms are generally set to zero, the formula 2 can be simplified as:

$$M_n = K_C \bullet (SP_n - PV_n) + K_C \bullet \frac{T_S}{T_L} (SP_n - PV_n) + MX \tag{3}$$

This system is designed for single input and double output control, as shown in figure 5. That is given a pressure value input, through PID to control the two sets of frequency converter parameters on high (low) pressure tube.

It is confirmed by field test that when the pressure fluctuations, the required stability time as shown in table 1. the pressure stabilization time is about 1 hours in the way of original manual field adjustment frequency; When the two sets of frequency are set to automatic control, the pressure stabilization time is about 30 minutes, the control response speed is faster; When one is set to automatic, one is set to manual, the pressure stable time increases. The length of stability time is also related to the setting of PID parameters, and the determination of parameters needs to combine with repeated testing and field experience.

Table 1: Stable time comparison table Unit: Min

Original manual regulation	Automatic regulation of two sets of frequency conversion	A manual and one automatic regulation
≥ 60	10~30	20~40
Daily regulation, average 2~5 times	No manual adjustment	No manual adjustment

3.3 Upper computer function design

The upper computer system mainly completes the function of data centralized management, reads the monitoring data of each point in PLC and focus on display, make the state of the system absolutely clear, the control is simple and easy to understand, continuously optimize the PID parameters to achieve the best control effect; Taking into account the stability and reliability of the system, set up a manual / automatic frequency conversion control switch. When the pressure difference between the actual value and the set value is larger, we can manually adjust the frequency to the pressure close to the set value, and then turn to automatic control, which can save adjusting time and the control is more convenient. The effect as shown in Figure 6.

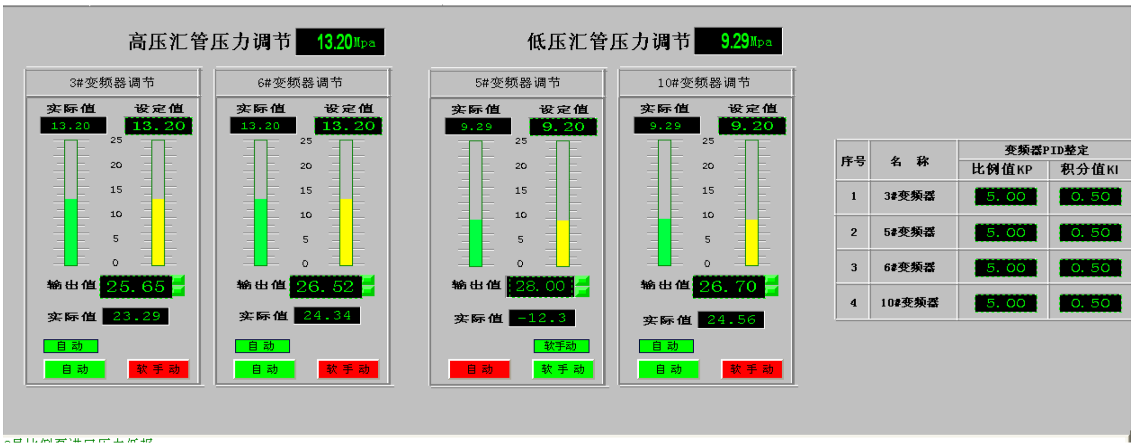

Figure 4 Effect diagram of the monitoring system of the host computer

4. Conclusion

This paper combines the injection station mother liquor injection control flow in the process of oil field production, analyzes the direct reason and the characteristic of the field that cause the fluctuation of injection quantity, designs the PID controller program and configuration program, and sets up high and low liquor pipe monitoring system. PID control method is small fluctuations, through the optimization of parameters, control the dynamic response fast, which makes the whole pressure adjustment process to achieve automatic control, replacing the staff of the daily repeated adjustment frequency. Automatic control so far, employees do not need to manually adjust the scene, the control effect is good, has a certain practical value.

References

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