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Reactor Control Program Design and Simulation Using WinCS System

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Abstract: The reaction kettle is extensively utilized across various industries such as petroleum, chemical, rubber, and food processing. However, its domestic application began relatively late, resulting in a reliance on manual operations which has hindered production efficiency and product quality. This limitation has significantly impacted its development. The WinCS control system, designed for the hybrid automatic control market, offers a comprehensive process control solution. It features advanced analog loop regulation similar to DCS, a user-friendly operator interface, and an intuitive engineering configuration software package. Additionally, it excels in high-speed logic and sequential control. This paper outlines the configuration of a reactor program using the WinCS control system, detailing the design of the material feeding valve interlock program, the material feeding flow control program, and the open-loop control program for the discharge pump and mixer. Specific simulation and debugging methods and steps are also provided.

Keywords: WinCS, program configuration, reactor, simulation.

1. Introduction

A typical mixing reactor is shown in Figure 1, which is used to mix two different liquid materials at a certain ratio in an inverse tank for reaction, which is a chemical proportioning and heating reaction production process. Container B1. The liquid level is measured by the liquid level meter LT101, in which the material A is added to the container B3 by the regulating valve DOS_A, and the feeding flow is measured by the electromagnetic Flowmeter FT101; the liquid level of the container B2 is measured by the liquid level meter LT201, and the material B is added to the container B3 by the regulating valve DOS_B, and the feeding flow is measured by the electromagnetic Flowmeter FT201. The liquid level of the container B3 is measured by the liquid level meter LT301, and the motor M301 uses the agitator to drive the B3. When the two materials are mixed and the reaction is completed at a certain temperature, the material in the B3 container is transported by the discharge pump P301 to the next process, the temperature in the B3 container is measured by the temperature transmitter TT301, and the valve V301 on the heating steam inlet pipe is used to adjust the flow rate of the heating steam so as to control the temperature of the B3 reaction tank.

2. WinConfig Programming

2.1. Interlock Procedure of Material Feeding Valve

The material feeding valve interlock program uses the LD program. Figure 2 shows the material A feeding valve interlock program. Among them, LIA101LL, LIA201LL and LIA301HH are B1 tank low and low liquid level alarm signal, B2 tank low and low liquid level alarm signal, B3 tank high liquid level alarm signal respectively. When one of these three gets the

signal, DOA_A_ST will get the signal and DOA_A will output 0.0.Realize the interlock protection of B1, B2 low liquid level and B3 high liquid level.

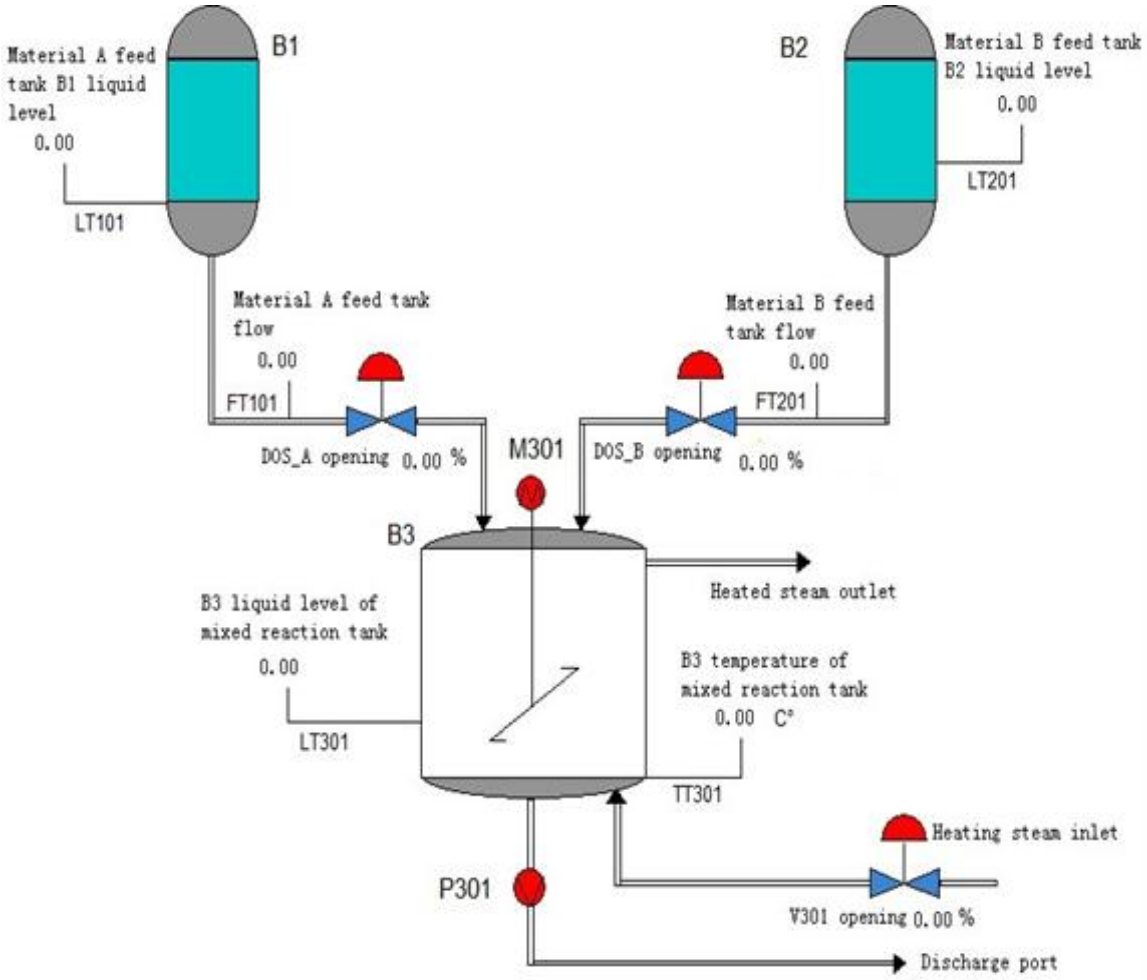


Figure 1: A typical hybrid reactor

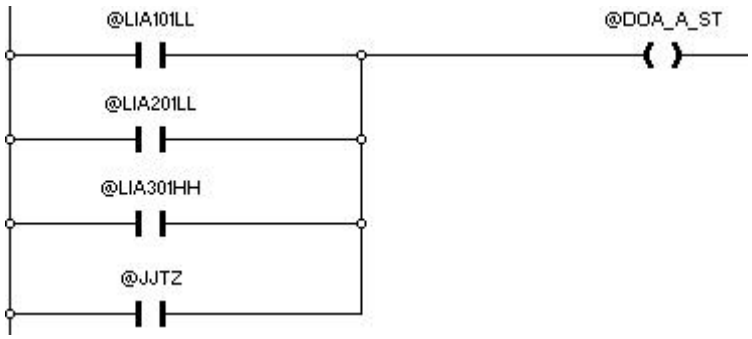


Figure 2: Material A feeding valve interlock procedure

2.2. Material Feeding Flow Control Program

The C_CU function block is used in the material A feeding flow control program, which can control the opening and closing degree of the valve according to the difference between the actual flow and the set flow so as to realize the PID control that the actual flow is infinitely close to the set flow.

The function that the function block needs to realize in the program is to adjust the DOS_A according to the difference between PV and SP when feeding is needed to achieve the actual

input value FT101 infinitely close to the value of setting the flow pin SP. The process requires that when C_CU is in automatic external mode, the actual flow rate of B3 liquid level LT301 is 10.0 ℃ / h when the liquid level Volume_Prod is less than 90%, and when the liquid level rises above 90%, the actual flow rate is 0.5 ℃ / h until LT301 equals Volume_Prod actual flow rate of 0.0 ℃ / h. After programming the value of the input SP, in the automatic external mode, the DOS_A will output the corresponding opening and closing degree under the action of the flow difference between PV and SP, and the FT101 will change under the change of the opening degree, thus changing the flow difference between PV and SP. Under the action of this cycle, the actual flow FT101 will be infinitely close to SP, and it will meet the functional requirements. Setting CP, TR and TD can change the numerical relationship between the flow difference and the output opening and closing degree. The manual automatic mode of the function block is affected by the control of MA and MM. The DOA_A_ST stops the interlock signal, and the corresponding pin is the TRC output variable OUT tracking. Because the OTA and the OTM pin are not connected with the reading block, so the input is zero all the time, so when the DOA_A_ST is 1, the DOA_A is zero, realizing the function of stopping opening the valve when the B1 tank and B2 liquid level is too low or B3 liquid level is too high. DOS_AQ is a signal of whether the DOA_A is open or not, preparing for the dynamic diagram of the process.

2.3. Open-loop Control Program for Discharge Pump and Mixer

The function block of IDF_1 unidirectional unit is mainly used in the open-loop control program of discharge pump and mixer. Used to send a control instruction to the control device. The instruction can be given in automatic mode according to the logical state of the input pin IN.

As shown in Figure 3, take the mixer open-loop control program as an example. The program needs to realize the input control of OUT control command M301 with M301_IN input in automatic mode. When the B3 liquid level is too low, the OUT output of M301_IL1 can not be true, and the mixer stops rotating.

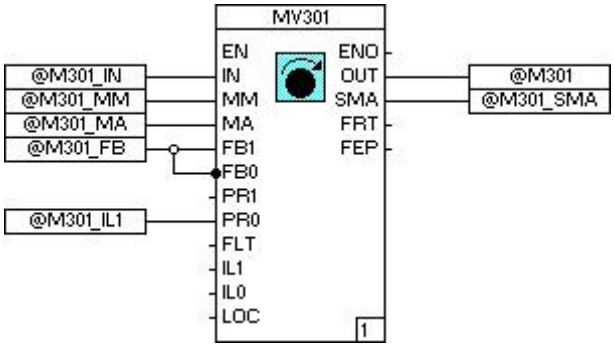


Figure 3: Open-loop control program of mixer

2.4. Counting and Button Program

In order to realize the function of counting and running, we need to use the pulse counter CT_P. The IN pin is the input signal, when there is a rising edge signal, the CTC accumulates 1 output REAL signal, the CTP is the historical count output, and the RES is the reset signal. When the RES gets the electricity, the CTC output is 0. 0pcCTP to record the last count data.

The purpose of the button program is to realize the corresponding relationship of stop running button, counting running button and continuous running button in the flow chart, and its purpose is to facilitate the operation of the operator station. In order to make it more convenient for the operator to see the status of the stop button, the count button and the continuous button, press the display is set. In order to achieve continuous run and count run

to zero when the stop button is pressed, the stop run is 1. When the stop run is 1, press the continuous run or count run button twice in a row, and press the stop run back to 0 for the first time. The second time you press the button to run continuously or count the corresponding button is 1. The stop program is shown in Figure 4.

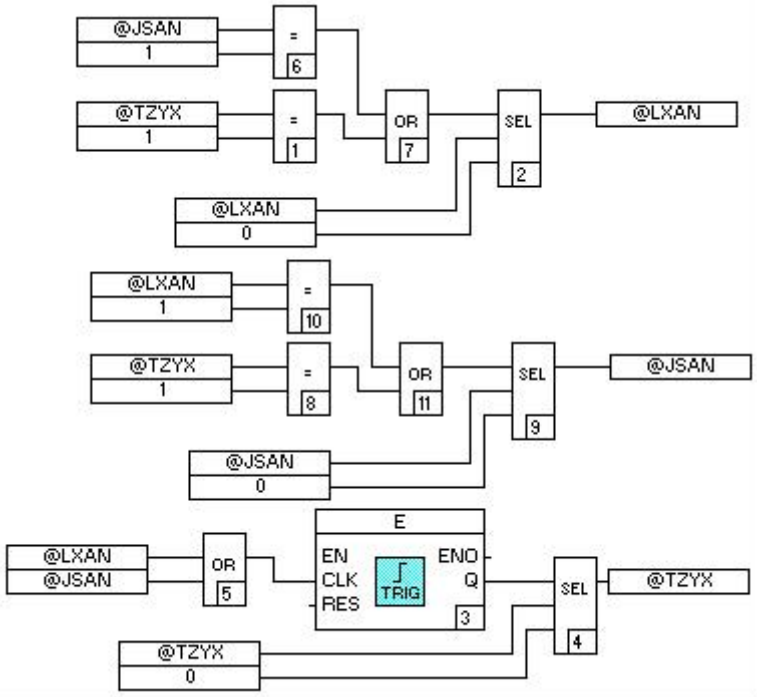


Figure 4: Stop program

3. Realization of Simulation Control

3.1. Liquid Level Simulation of Material A and Mixed Reaction Tank

LT101_R is the quantity of material A, FT101 is the flow rate of material A pipeline, the liquid level LT101 of B1 tank is equal to the quantity of material A input minus the sum of the flow rate of material A pipeline flow per second, and the cumulative CT_ANA of analog input is set to record in seconds. The LT301 level of the mixed reaction tank is the sum of the flow rate of DOS_A and DOS_B per second minus 10.0 per second when the discharge pump is turned on. When the liquid level is lower than 0, the LT301 liquid level is 0. 0. Flow Simulation Program of material A regulating Valve. According to the requirements of the C_CU multiple of the material A regulating valve flow program P, when the liquid level of the mixed reaction tank is less than or equal to 90% of the set material, P is 999.0, and when the liquid level of the mixed reaction tank is greater than 90% of the set material, P is 499.0. Set up a simple calculation comparison selection program, the Figure 5 is the material A regulating valve flow simulation program.

The simulation program of material A flow FT101 mainly realizes that the actual flow rate will be infinitely close to the set flow rate. When the liquid level of the mixed reaction tank is less than or equal to 90% of the set material, the flow rate is 10.0% / h, when the liquid level of the mixed reaction tank is greater than 90% and less than 100% of the set material, the flow rate is 0.5% / h, when liquid level of the mixed reaction tank is greater than 100% of the set material, the flow rate is 0.0% / h, And the actual flow has a certain relationship with the

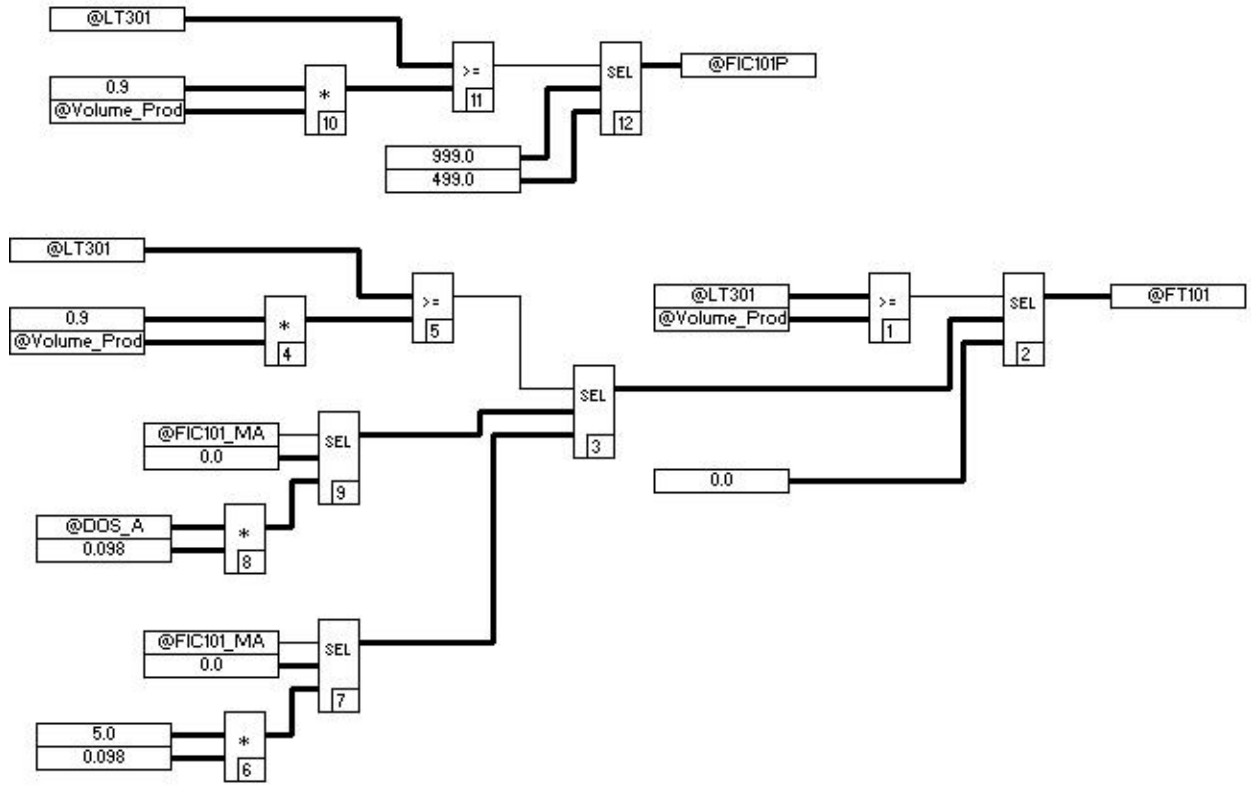


Figure 5: Flow simulation program of material A regulating valve

opening of the DOS_A control valve. Therefore, SEL is used to choose one of the two function blocks. First, SEL is used to determine whether the material is greater than or equal to 100%. If it is satisfied, the output is 0.00.If it is not satisfied, the second SEL selection is outputted, and whether the mixed reaction tank material is greater than the set production material is 90%. If it is satisfied, the third SEL selection is used to determine whether the C_CU belongs to the automatic mode. When it belongs to the automatic mode, the material output is 5.0% 0.098, where 5.0 represents the DOS_A opening. Can be replaced with the variable DOS_A. When judging whether the material of the mixed reaction tank is greater than 90% of the set production material, if it is not satisfied, another set of SEL binary selections is output.

3.2. Temperature Control Simulation

Temperature simulation is the use of the accumulation of ANA, so that the input MUX, finally output different input data output the corresponding temperature value. Figure 6 shows the temperature control simulation program. TT301 is the current temperature, when the current temperature is greater than or equal to 70.0, the cumulative output of the output 0.0ANA will change, when the current temperature is less than 70.0, there will be SEL selection, the condition is that when the liquid level of the mixed reaction tank is greater than the set liquid level, the output is 1.0, when the liquid level of the mixed reaction tank is not greater than the set liquid level, The content of this program will be completed when the TT301 is greater than
70.0 and the liquid level meets the production requirements, continuously input 1.0 Magna to ANA and continuously output values in seconds, then convert them into IN format through the conversion block, and input them into MUX. According to the corresponding input and output values, a simulation of the limit temperature of 80 degrees is formed.

4. Conclusion

In this paper, a simulation control system of reactor is designed based on WinCS, which is easy to operate. The stirring reaction control of two kinds of material mixing reactor is realized, and the configuration function of the program is perfect.

The mixed reaction of the designed reactor has two forms of control, one is counting operation, the counting operation is the operation mode of the target quantity of mixed materials, and the required quantity can be set to ensure that there will be no production of excess mixed materials. The second is continuous operation, which can make the reactor run continuously. However, in the actual production process, due to the complexity of the field environment, anti-interference performance must be considered. WinCS control can use industrial Ethernet to achieve remote control, but in the face of more and more complex field control system, how to improve the communication rate and communication distance is also worth studying.

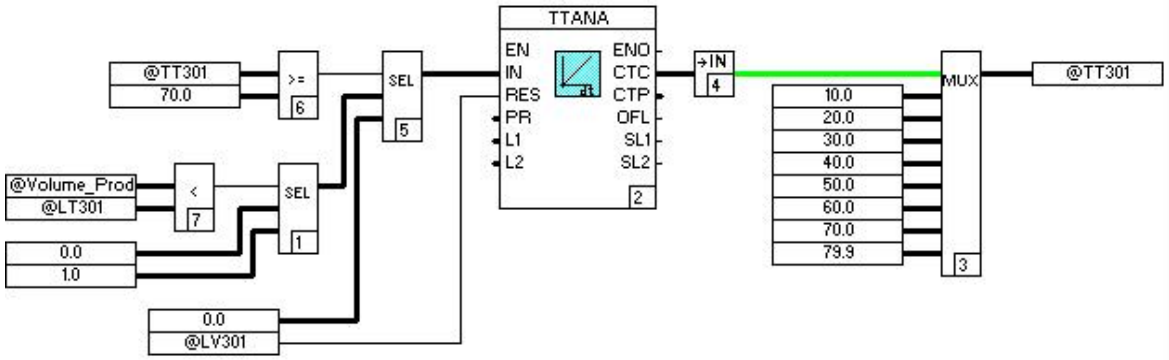


Figure 6: Simulation of temperature control

References

[1] DANG Cun-lu, WU Wen-cheng, HU Kai-wei,et al: Medium and Low Voltage Distribution Network Monitoring System Based on LoRa Technology,Automation&Instrumentation, Vol. 34(2019) No.11, p.18-22.

[2] WANG Hua-qiang,XU Qiu-tian: Remote Monitoring System of PET Reactor Based on Internet of Things and Cloud Platform,Instrument Technique and Sensor, (2016)No.12,p79-82.

[3] SUN Wenjun: Design and research of industrial electric monitoring system based on DCS control,Industrial Instrumentation&Automation, (2019)No.6,p.78-82.

[4] Shilei Wang: Development and Application of Simulation Teaching Project of "Intelligent Electric apparatus principle and Application",*Advances in Social Science, Education and Humanities Research* (Qingdao, China, December 29-30, 2018), Vol. 300,p.51-54.

[5] WANG Shi-lei, WU Bi-miao: Development of Intelligent Low-voltage Electrical Apparatus Experiment Island Based on WinCS Control,Metallurgical Industry Automation,(2019)No.3,p35-39.

[6] Information on https://new.abb.com/control-systems/zh/essential-automation-cn/wincs.