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DESIGN OF VACUUM CONTROL SYSTEM FOR SUPERCONDUCTING ACCELERATOR

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Abstract

A linear superconducting accelerator is being constructed in our institute. Its vacuum control system should be convenient and reliable. We intend to concentered the control of each vacuum unit into a control box that implement the simple hard interlocking logic and the final action output of the vacuum device and the complete interlocking logic between the vacuum devices is realized in the PLC. Operators can perform local operation through the front panel of the control box or remotely control through the computer by switching the local/remote switch. In addition, the control flow of vacuum extraction and the protection flow when leakage occurs are also given in this paper.

INTRODUCTION

Based on the introduced linear superconducting accelerator, our institute (CIAE) is carrying out technical upgrading to restore its normal working state, and further increasing the beam energy provided by HI-13 tandem accelerator to meet user's requirements.

The design indicators of this sub-item are as follows:

The average energy per nucleus of mass 25-240 heavy-ions is increased by 4 MeV.

Energy resolution $\Delta E/E<=5x10^{-4}$

Beam intensity>=20 Pn A

Bunching width T≈30 Ps

The main design work for this sub-item includes:

High frequency system

liquid helium cryogenic system

Vacuum system

Beam transport system

Accelerator control system

Beam measurement system

Superconducting acceleration module

Auxiliary system

VACUUM SYSTEM

A total of 31 sets of vacuum units are installed on the linear superconducting accelerator. Each unit consists of a pre-stage dry scroll pump, a solenoid valve, a molecular pump, a vacuum valve and a measuring vacuum gauge. The vacuum gauge provides two measured values, that is, a low vacuum resistance gauge measurement, its range is from 1×10^5 to 1×10^{-1} Pa [1], and the measurement range of the ionization gauge is from 1×10^{-1} to 1×10^{-7} Pa [1]. The connection is illustrated in Fig. 1.

The vacuum system of linear superconducting accelerator needs to consider the vacuum situation at the constant temperature cabinets and beam pipes, the pre-stage pump adopts 8 L/s turbine dry pump [2], which can pump the vacuum degree of the constant temperature cabinet from atmospheric state to about 1 Pa in one hour, and the main pump adopts 400 L/s compound molecular pump [3], which can pump the vacuum degree from 1Pa to 10^{-4} Pa in three hours.

The beam pipeline is a stainless-steel pipe with a diameter of 100 mm. The vacuum requirement of the pipeline can be satisfied if the interval between the two units is not more than 14.4 meters. At the same time, 12 vacuum valves are installed in different positions of the beam pipeline, which can isolate different parts of the pipeline.

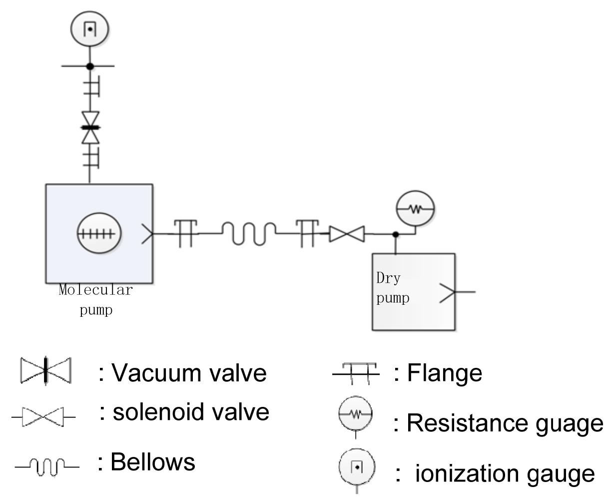

Figure 1: Vacuum unit.

Control Scheme of Vacuum Unit

An on-site control box is designed, which integrates the start and stop functions of each device. The operator can operate the vacuum device through the buttons on the front panel. At the same time, the status signal and control signal of the device and the control signal of the PLC are connected into the control box, in which the basic interlock logic and control outputs of the device are implemented, while the status signals of the device are transferred to the PLC. The system control provides three modes: debugging mode, local mode and remote mode. The debugging mode is to operate the vacuum device in the field to verify the validity of the device without PLC; the local mode is to transmit the operation signal of the site to the PLC. After the interlock logic is executed in the PLC, the action command is sent to the execution relay in the control box to make the device operate, such as starting and stopping; The remote mode means that the operator sends an instruction through the operation interface on the remote computer, performs the same action as the local mode in the PLC, and finally controls the running state of the device. At the same time, after the local mode and the remote mode are

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switched, the current state of the device cannot be changed. This function can be realized by a self-locking circuit.

The switch between local mode and remote mode is realized by the local/remote ping-pong button in the control interface. When the local control signal or the control signal coming from the remote computer arrives, it is making AND operation with the current mode state, and the result is A or B, and then A and B make OR operation, a middle process variable quantity is output, which is used in the control circuit to decide whether to respond to the control signal or not.

The vacuum control system provides independent control and automatic control of equipment. Independent control is to independently operate a single device, which responds to commands from the operator according to interlocking conditions; During automatic control is performed, the vacuum unit is started according to a predetermined process until the system vacuum is established or the unit is completely stopped.

Equipment Interlocking Relationship

The interlocking relationship of each device is shown in Table 1.

Table 1: Interlocking Relationships

Action	Dry pump	Elec Valve	Molecular pump	By PASS Circuit	Vacuum degree
Dry Pump Start		Closed			
Dry Pump Stop		Closed			
Molecular pump start	&Started	&Opened	&No error		& <10 Pa
Molecular pump stop	||Stopped		||Error		|| >10 Pa
vacuum valve open				||Opened	||<10^{-4} Pa
vacuum valve close					
BY Pass Circuit close					<10^{-4} Pa
Remark: &: AND, ||: OR					

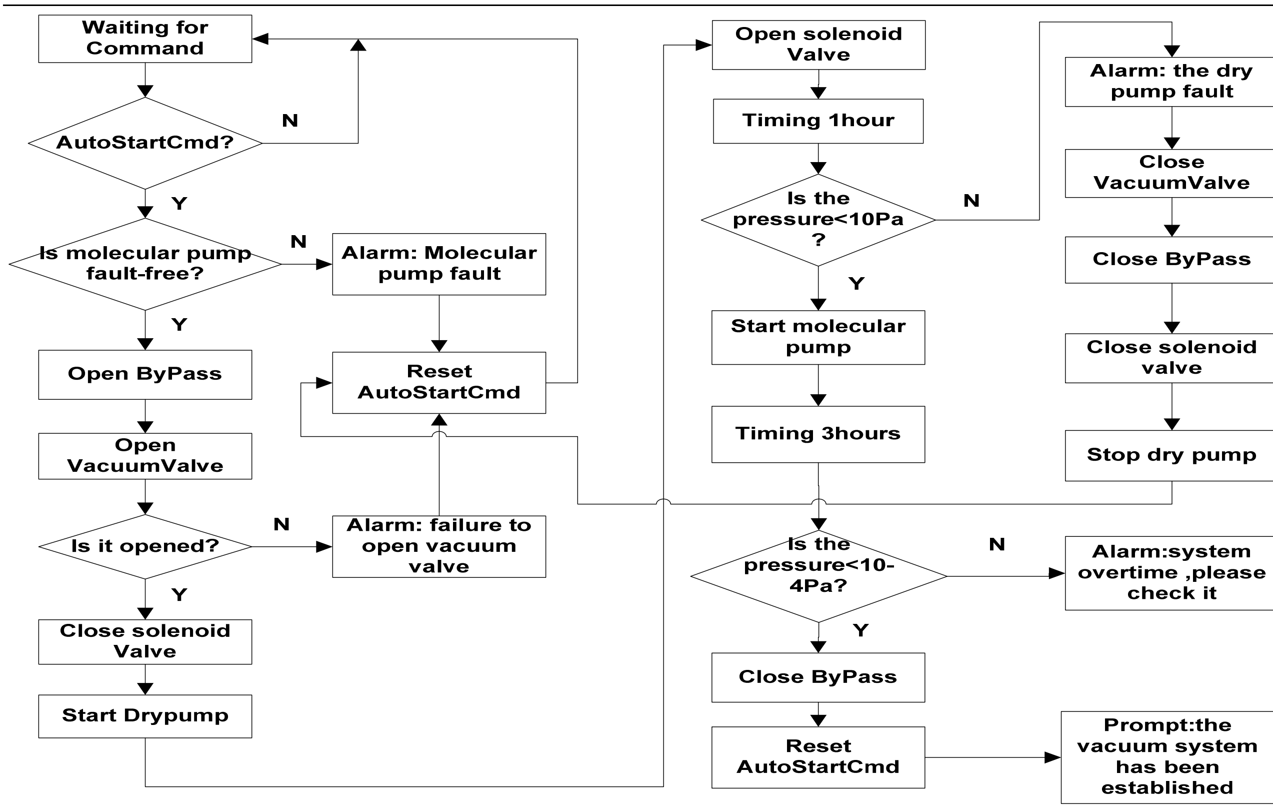

Figure 2: Automatic process.

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System Control Flow

Vacuum automatic establishment process: When the system adopts automatic process to extract vacuum, the operator issues an automatic start-up command in the operation interface of the upper computer. Taking the constant temperature cabinet as an example, the unit operates according to the process of Fig. 2. In this process, it is necessary to judge automatically whether the vacuum degree meets the requirement and whether the valve is opened correctly in the anticipated time, so as to decide whether to continue the next operation.

Vacuum protection process: After the vacuum of the system has been established, the vacuum of the system becomes worse and worse because of leakage or other reasons. In order to protect the equipment and vacuum of other parts of the system, the system should be isolated and the vacuum unit in this section should be stopped and alarmed. The protection process is illustrated in Fig. 3.

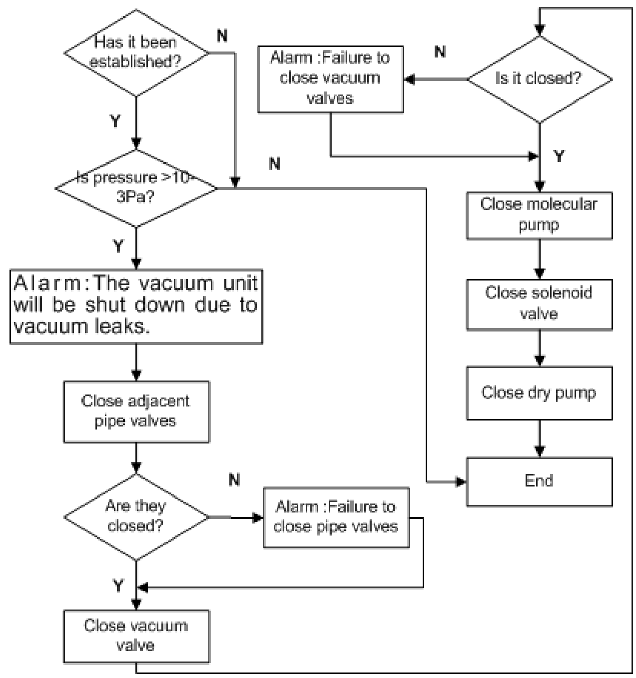

Figure 3: Protect process.

CONCLUSION

The vacuum system has been designed and tested. The control software adopts EPICS architecture. The RS485 protocol interface is connected to the IOC through StreamDevice and displayed in the host computer. The bottom digital quantity is collected and controlled by Siemens s7-1500 PLC. Interlocking logic is implemented in the PLC, and the automatic control flow and protection process can meet the needs of the system.

REFERENCES

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