Development of a measurement and control system for 40L/h helium liquefier based on Siemens PLC S7-300

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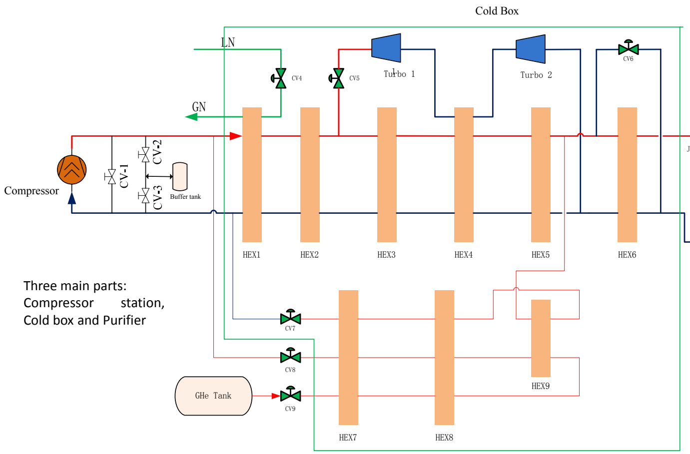
Introduction

A 40L/h helium liquefier is established at the TIPC, CAS. The designed liquefied rate of helium is 40Litre per hour. A measurement and control system based on Siemens PLC S7-300 is developed. Proper sensors and transmitters are adopted. To fill the different operating modes' requirements, a specific control logic and control strategy are developed. After several months' commissioning, the outlet temperature of the second stage turbine has reached to 8.6K and the temperature before the throttle valve has reached to 13.1K.

Helium Liquefier PFD & Temperature Sensors



- Designed liquefied rate of helium: 40 L/h
- Compressor: KAESER CSD162, 90KW, 25g/s
- Dirty helium gas: ≤1.5g/s@27bar

Sensors and Transmitters

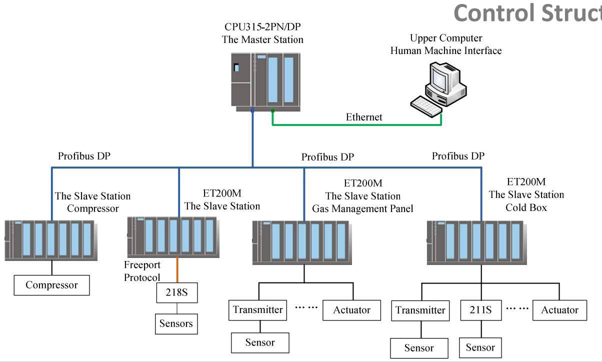
- 24 temperature sensors;
- Three types of transmitters;
- Rhodium-iron, calibrated accuracy: 0.1K;
- PT-100, calibrated accuracy :±0.1K

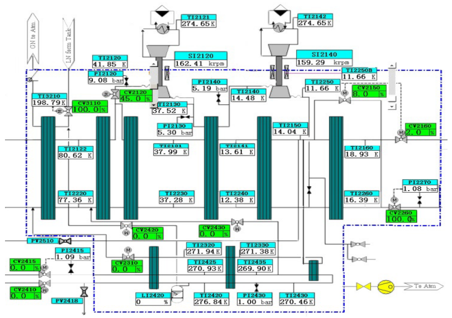
Temperature sensors and transmitters used in helium liquefier

Type	Quantity	Range Covered	Adopted Temperature Transmitter
Rhodium-iron	6	1.2K to 300K	Model 211S temperature transmitter from Lakeshore
Rhodium-iron	15	1.2K to 300K	Model 218S temperature monitor from Lakeshore
PT-100	3	77K to 323K	RTD analog input model SM331 from SIEMENS PLC

Control Structure & HMI

Control Structure and HMI of Cold Box



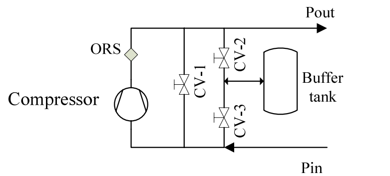


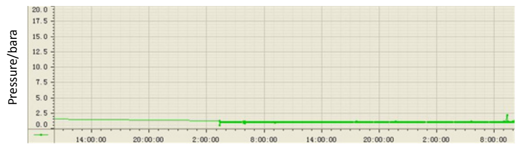
Conclusion

- A measurement and control system based on Siemens PLC S7-300 for 40L/h helium liquefier is developed.
- After several months' commissioning, the outlet temperature of the second stage turbine has reached to 8.6K and the temperature before the throttle valve has reached to 13.1K.
- This helium liquefier will be commissioned continuously, during this process, the measurement and control system, the control logic and control strategy will be verified and updated.

Control logic and strategy

Compressor Inlet and Outlet Pressure Control





Pin (the suction pressure of compressor)

Pout (the discharge pressure of compressor)

"Ganni cycle" was proposed by V. Ganni of the Thomas Jefferson National Accelerator Facility in 2009.
Ganni cycle is adopted for this project.

The suction pressure Pin is controlled by the bypass valve CV-1. The discharge pressure Pout is controlled by the discharge valve CV-2 and the charge Valve CV-3.

To control the compressor's frequency, adjusting the bypass valve of the cold box CV-6 is a smooth way.

The control program is mainly composed of sequential control and control loops. Most of the control loops can be implemented by means of a standard PID (Proportional, Integral and Derivative) controller.

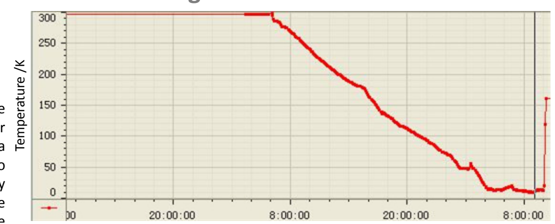
Turbo-expander Loop Control

Through controlling the inlet valve of the first stage turbo to control the turbo loops' rotary speeds.

The startup and stop period are the key periods to control the turbines.

In the startup period, the inlet valve of the first stage turbine opens linearly with a speed of 0.2% or 0.5% per second gradually. After the rotary speed reached to a value, the turbines will be allowed to stabilize for two minutes until the rotary speed reach to working rotary speed set point, then the inlet valve of the first stage turbine will be transferred to speed controlling mode (automatic mode).

Commissioning Result



Outlet temperature of the second stage turbo-expander

After several months' commissioning, the outlet temperature of the second stage turbine has reached to 8.6K and the temperature before the throttle valve has reached to 13.1K.

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