The control system of a 2kW@20K helium refrigerator

Wei PAN 1,2, Ji hao WU 1,2, Qing LI 1,2, Li qiang LI 1 and Qiang LI 1
1. State Key Laboratory of Technologies in Space Cryogenic Propellants, TIPC/CAS, Beijing, 100190, China
2. University of Chinese Academy of Sciences, Beijing, 100049, China
*Email: panw@mail.ipc.ac.cn

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Technical Institute of Physics & Chemistry/CAS

Two alternative modes to start and stop the refrigerator: In "manual" mode, the user can manually start and stop the refrigerator independently through their own "start" and "stop" buttons. In "auto" mode, the entire system can be started and stopped automatically just through one button — "start" and "stop" button.

The refrigerator’s automatic start order is: cold-erosion—large-scale-refrigeration—cycle—middle-scale-refrigeration—large-scale-in-compression.

In order to meet the needs of different stages of the experiment, and also to operate the refrigerator in a better order, we divide the system into four modes.

1. Compressor mode. The compressor and three control valves (CV1101, CV1102, CV1105) in the gas management panel, and makes the system’s high and low pressure reach to the set value and remain stable.
2. Middle cycle mode. Turbine’s bypass valve (CV1201) and cold box’s bypass valve (CV1205) act on the base of the last mode. It breaks through the whole system (connect the cold box and room temperature part), and makes the system’s high and low pressure stable.
3. Coldbox refrigeration mode. Turbine’s control valve (CV1201) and turbine act, on the base of the last mode, meanwhile CV1205 closes, which makes system’s refrigeration begin.
4. Large cycle mode. The cold box’s gas supply valve (CV1201) and gas return valve (CV1205) act, on the base of the last mode, meanwhile CV1205 closes, which supplies the interface to users.

Position-type PID Control Algorithm

All the control loops of the 2kW@20K refrigerator use the FR41 [CONC.Y digital controller in Step 7. And the FR41 controller uses a position-type PID control algorithm as follows.

\[
\frac{\Delta u}{\Delta e} = \frac{K_p}{1+T_d s + T_i s} (e(t) - e(t-1)) + M
\]

Sequence control strategy for the refrigerator’s one-button start and stop

The Test Result of Cold Refrigeration Pressure

In 2kW@20K refrigerator, we use six PID control loops in total.

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