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2022-09

SoLID Magnet Controls – Heat Exchanger Valves Controls

The control and monitoring of the heat exchanger valves are critical to ensure proper cooling down, warmup, and steady state of the magnet. There are two valves, type Joule Thomson (JT), one valve is used to control the flow of the gas helium mixed and the other is used to control the inlet liquid nitrogen flow to the heat exchanger.

The heat exchanger valves can be operated locally through a switches located in the valve panel at the instrumentation rack or remotely through the programmable logic controller (PLC). A key switch at the valve panel is used to switch between local and remote control modes. In the remote mode the valve can be controlled in manual mode or automatic mode. The manual mode allows to set the valve aperture by just entering the desired position values and the automatic mode the valve aperture is controlled by a PID algorithm based on the process variable, set point and maximum and minimum parameters. I modified two PLC routines used to control the valves, the PLC program allows the selection of the valve operation in ether remote automatic or remote manual modes.

In remote automatic mode, to control the valve voltage set point to the valve actuator, I implemented and configured a RSLogix-5000 predefined process instruction named Enhanced Proportional-Integral-Derivative(PIDE) instruction, which provides enhanced capabilities over the standard PID instruction. The instruction uses the velocity form of the PID algorithm. The gain terms are applied to the change in the value of error or process variable. Another RSLogix-5000 predefined instruction named Position Proportional (POSP) was implemented to the program to opens or closes a the valve by pulsing open or close contacts at a user defined cycle time with a pulse width proportional to the difference between the desired and actual positions.

- **Written PLC code to control two valves of the heat exchanger**
- **Developed HMI screens to monitor and control valves in remote automatic and remote manual modes**
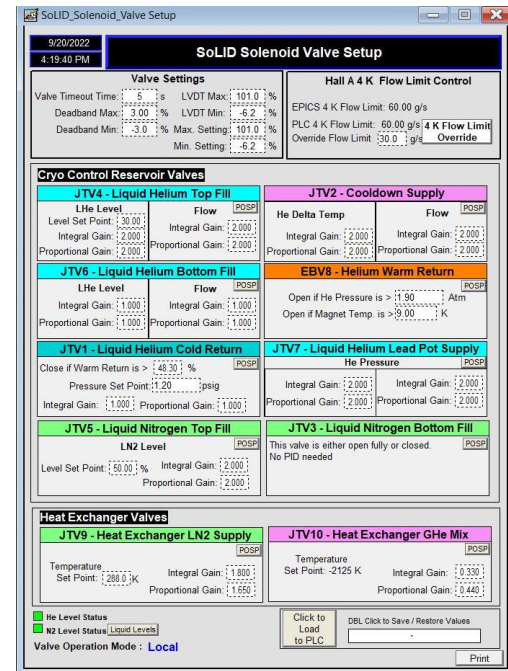- **Implemented valve variables to data log system**

Fig.1. *Solenoid Valve Setup* HMI screen

   I written additional PLC code to set the conditions and determine if the heat exchanger is enabled, both heat exchanger valves only operates in the remote automatic mode if the heat exchanger Boolean is enabled (set at 1).

   I developed multiple a Human Machine Interface (HMI) screen to allow the controls and monitoring of the valves. The *Solenoid Valve Setup* HMI screen allows to the expert users to enter PID parameters and set point variables to control the valves located in the heat exchanger and cryo control reservoir.

   The heat exchanger valves can be monitored and operated from the *Solenoid Cryo Control Reservoir* HMI screen by clicking the valve symbols. Valves symbols colors were based on cryogenic line colors to indicate that valves are open or close. I configured the gas helium mix JT valve on magenta color to indicate when the valve is open and gray color when it is close; the liquid nitrogen JT valve has green color when it is open and gray color to indicate when it is close. Each valve has indicator readout position box configured to blink in red when a fault is present for the valve position readout; for both heat exchanger valves, the readout position box is set to yellow color to indicate that the valve is being operated in remote manual mode and it is set to purple color to indicate remote automatic mode. I created a HMI screen named *Solenoid HX JTV Page* to provide detailed information of the valve readout faults, switch between remote manual to remote automatic mode and enter the maximum and minimum parameters for the valve aperture. I developed *Trend* HMI screen to monitor the valve position over the time.

   The valve positions readout values were implemented to the data logger system to be archived.

   I tested successfully the PLC program and HMI screen operations for the heat exchanger valves
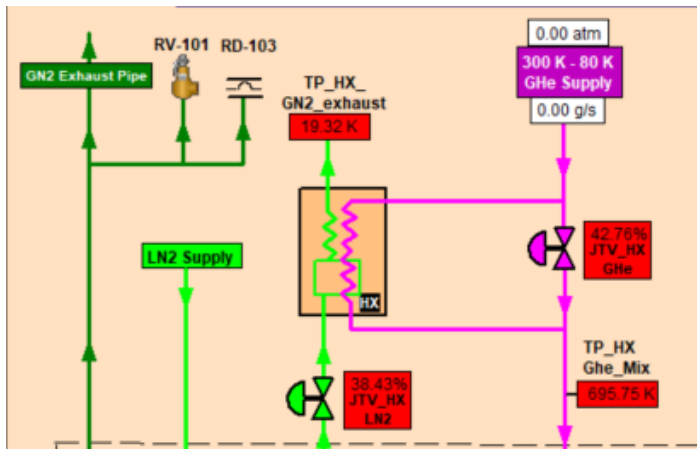

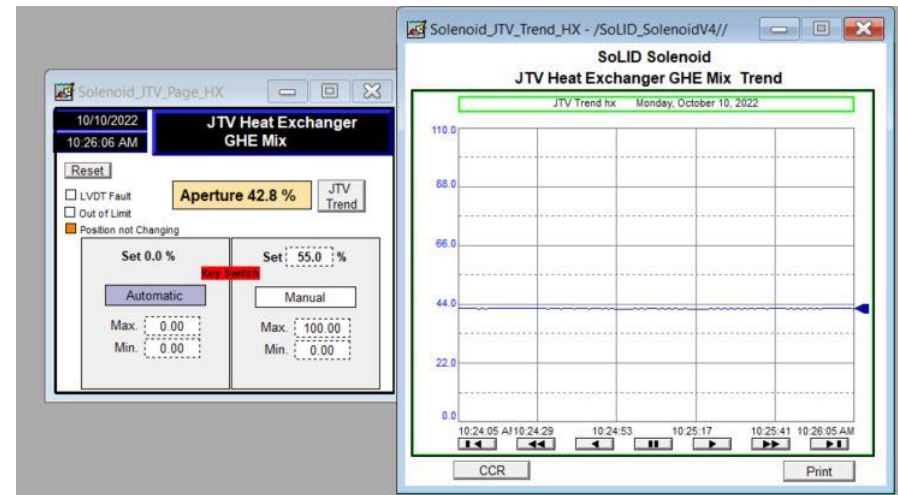Fig.2. Section of *Solenoid CCR Expert* HMI screen shows heat exchanger valves symbols and position readout indicator boxes

Fig.3. *Solenoid HX JTV Page* and *Trend* HMI screens