

Development of a Hardware-In-the-Loop (HIL) simulation system for a large-scale helium refrigerator

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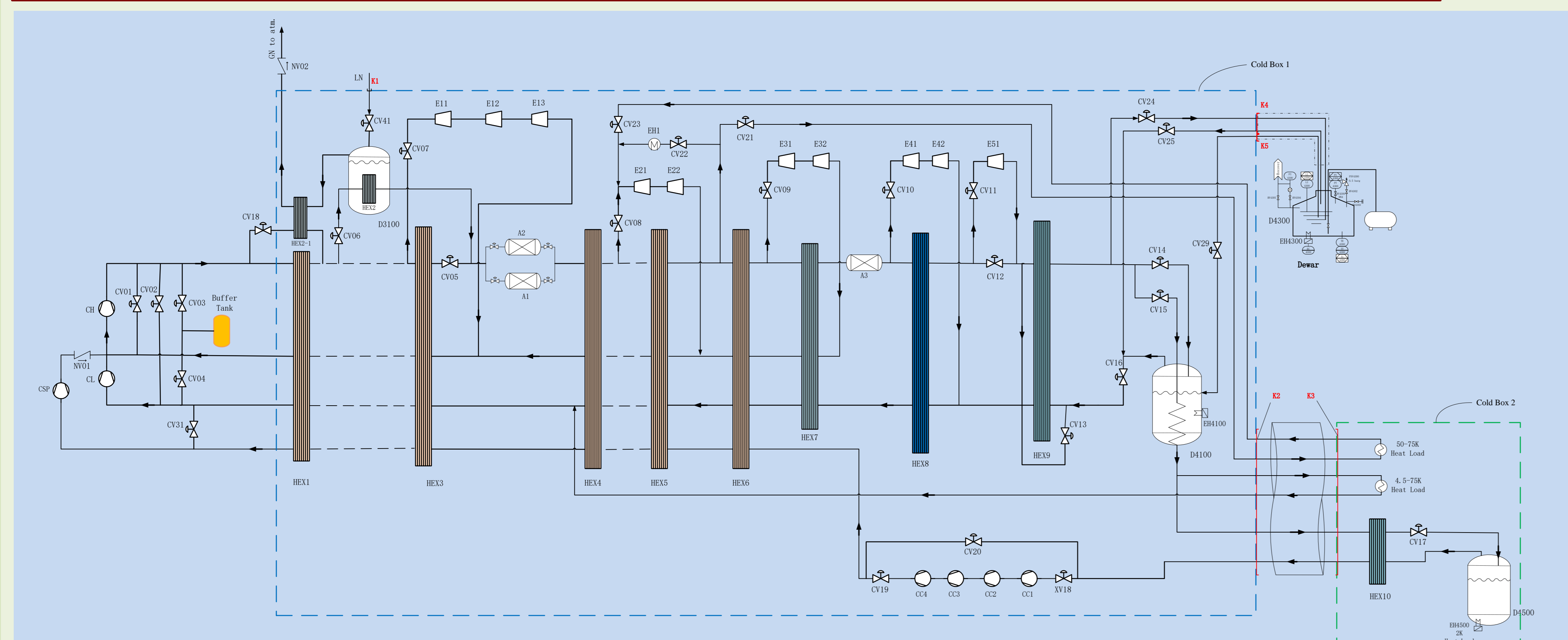
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Abstract

A large-scale helium refrigerator has been designed and is being assembled in China by the Technical Institute of Physics and Chemistry, CAS. To verify the control system program before the commissioning of this helium refrigerator, a Hardware-In-the-Loop (HIL) Simulation System has been developed. This HIL simulation system consists of three parts, namely, simulation model of this helium refrigerator performed by EcosimPro, NI Veristand to deploy the encapsulated simulation model, a real PLC control system to run control program and human machine interface. Control signals from real PLC and process parameters from simulation model have been interchanged between PLC hardware and simulation model through NI inputs and outputs hardware. This HILS improves and verifies the control system design and will reduce the time for system commissioning on site.

Overview of this large-scale helium refrigerator



- 2 K heat load > 4400 W; 4.5-75 K heat load > 4300 W; 50-75 K heat load > 13500 W.
- Service three different consumers with different cooling capacity at the 50-75 K, 4.5-75 K and 2 K levels.
- Two cold boxes: the main cold box and the thermal loads test cold box. The main "all-in-one" cold box combines a 4.5 K refrigerator cycle with a 2 K subcooler cycle.
- 11 heat exchangers, 10 turbines, 4 cold compressors in series.

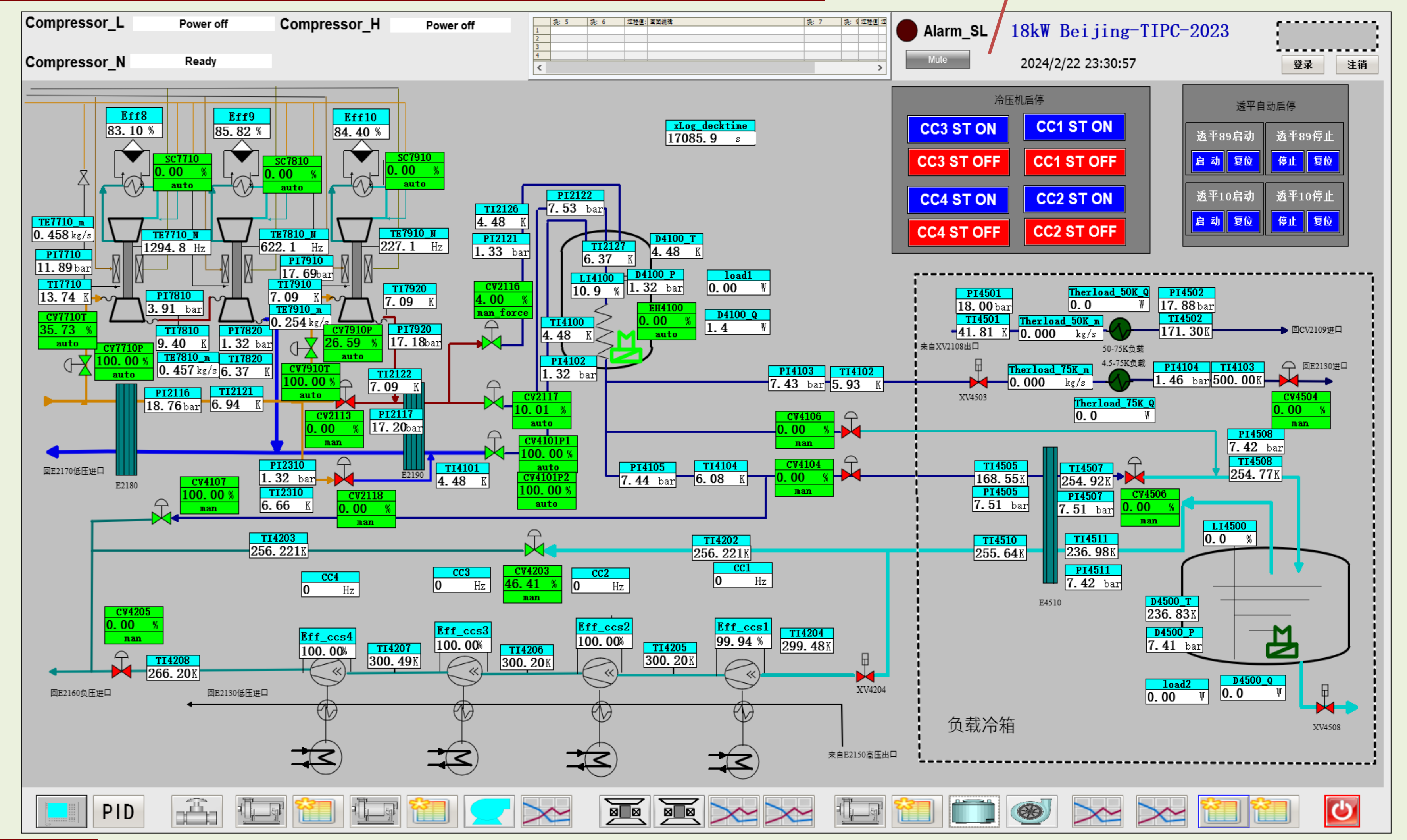
HIL simulation test rig



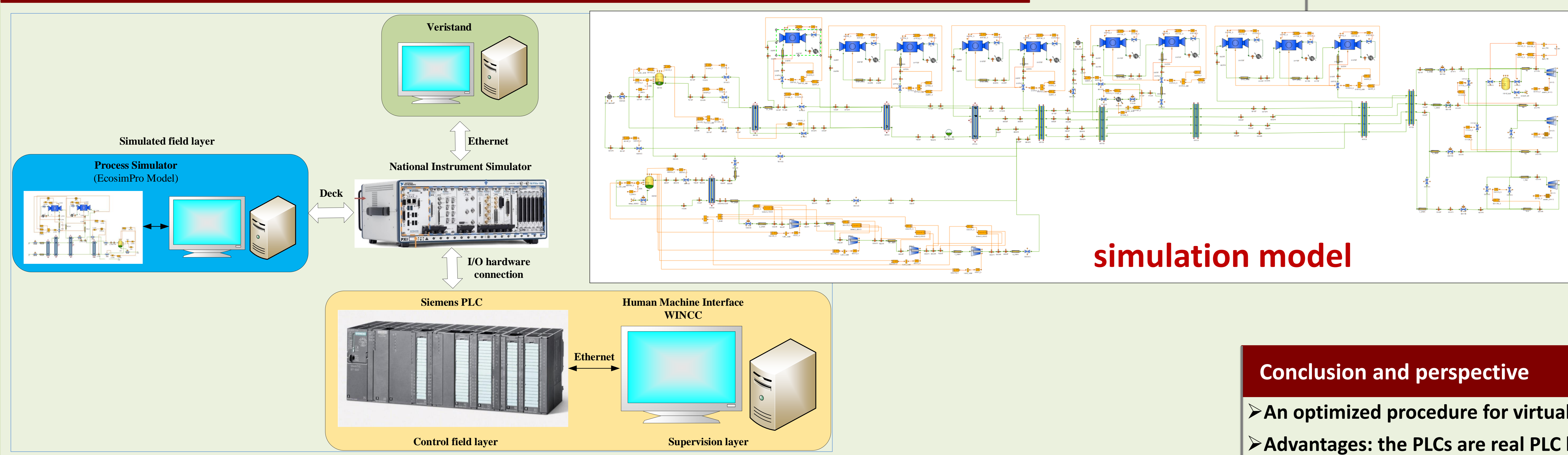
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- HIL simulation test rig has been developed for virtual commissioning and operator training.
- Real PLCs; I/O hardware connection between PLCs and NI I/O modules;
- Real PLC control system to run control program and Human Machine Interface.

Simulation result



The HIL simulation control architecture



- Veristand deploys the encapsulated simulation model to run simulation model in the NI simulator.
- NI simulator connects Siemens PLC through I/O hardware connections.
- PLCs exchange data with simulation model through I/O hardware connection.

Conclusion and perspective

- An optimized procedure for virtual commissioning and a starting project for setting up an HIL operator training station.
- Advantages: the PLCs are real PLC hardware, PLCs collect standard electrical signals.
- Disadvantage: diseconomy, each variable is equipped with one PLC channel and one corresponding NI channel. It can raise cost of the customer.