§17. Dynamic Behaviors of a Large Scale Cryogenic Plant

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The dynamic behavior of a large scale cryogenic plant, LHD cryogenic system, has been investigated, utilizing the dynamic simulator: C-PREST. Previous study shows that as increasing the complexity of model induces heavy CPU load for the process calculation. As a result, the simulation speed is actually deviated from the real time basis. To improve the computational speed, the process calculation PC workstation has been upgraded with efficient data marshalling scheme between the workstation and the VME modules for the process control. Furthermore, the unit model such as, expansion turbine and heat exchanger has been reviewed and optimized to reduce the CPU load.

LHD cryogenic system consists of a 10kW class helium refrigerator/liquefier and two cooling objects: a helical coil system and a Poloidal coil system as shown in Fig. 1. So, the system is fairly complex but the figure only reveals the primary control valves and objects. Entire cryo-plant was modeled and implemented to the PC workstation. As for the process control in VME modules, the sequence and feedback programs are identical to the real operation system of LHD. Thus, the LHD cryo-plant is successfully modeled in the C-PREST and its operations are equivalent to the real plant. Meanwhile, the superconducting bus-line system was omitted since its cold-mass is negligible compared with other cooling objects. Still, the cold mass of the model ends up to 834 tons. Data I/O's are AI/AO:714/180, DI/DO:529/325 and IA/ID:838/1759.

The cooldown process was simulated with the sequence programs developed for the LHD cryo-plant. Therefore, the process is almost identical and Fig. 2 shows the simulation data compared with the actual operation. The simulation results reveal the comparable results with the operations. Scattering of data points in the actual operation were caused by mass-flow balance within the system, while the simulation data are relatively close because of the lumped capacitance model for the cooling objects. The simulation was completed with a real-time basis except the accumulation of liquid helium in the five reservoirs. The mass balance calculation of each reservoir increase the CPU load.

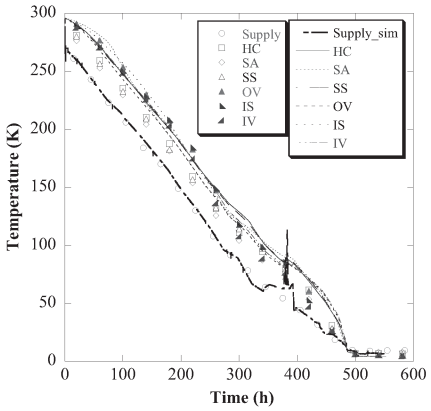

Fig. 2. Comparison of cooldown curves.

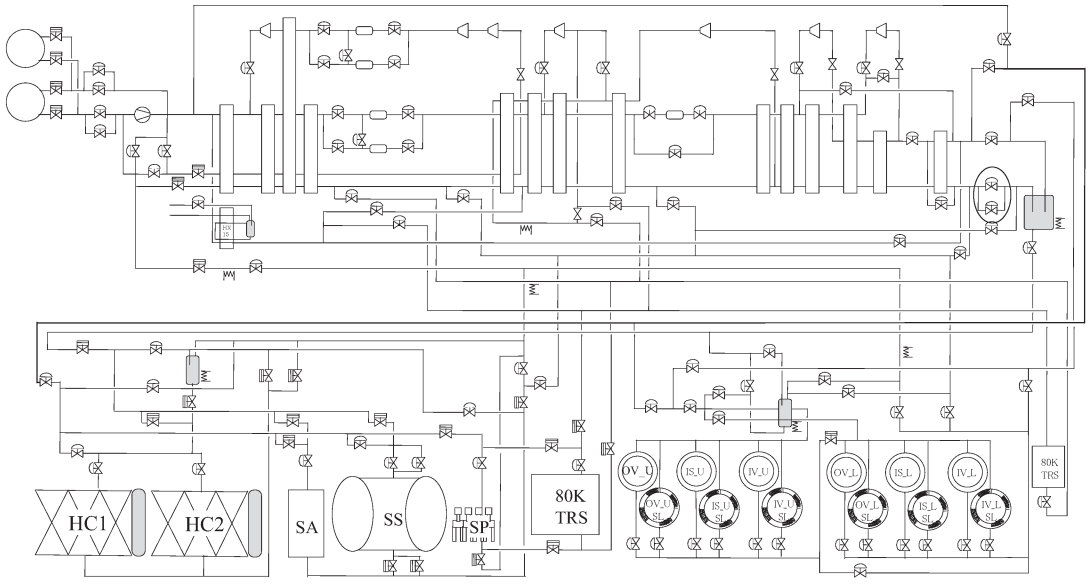

Fig. 1. Simplified version of a P&ID of LHD cryogenic plant. Abbreviations in the Figure are as follows; SA: Shell Arms, SP: Support Post for the SS, SL: Sleeve for P/Cs. U and L in P/Cs imply Upper and Lower positions respectively. Enclosed valves are referred to the thermal disturbance section.