§24. Update of the Cooling System for NIFS Superconducting Magnet Test Facility

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The NIFS superconducting magnet test facility has been upgraded to conduct excitation tests at various temperature and a higher magnetic field[1]. In the upgrade, the main compressor, the helium refrigerator/liquefier and the control system of the cooling system were updated. Fig. 1 shows the updated test facility. The new main compressor is an oil injection type screw compressor of Kaeser Kompressoren GmbH with the discharge pressure of 0.95 MPaG and the helium mass flow rate of 101.7 g/s. The energy consumption has been reduced from 450 kW to 239 kW. The helium refrigerator/liquefier was replaced with a variable temperature helium refrigerator/liquefier, which is the modified LR280 of Linde Kryotechnik AG. The new refrigerator/liquefier can supply liquid helium, supercritical helium and variable temperature helium gas. The DePICS of Taiyo Nippon Sanso Corporation was applied to the control system. The CPU of the controller, LAN and remote I/O are duplicated for the high reliability. The remote monitoring is provided via NIFS-LAN for improvement of safety and convenience[2].

The nominal performance of the cooling system is as follows; the helium liquefaction rate is 250 L/h, the refrigeration capacity is 600 W at 4 K, the cooling capacity is 1 kW when the supply temperature is 20 K and the return temperature is 30 K, the cooling capacity is 1.5 kW when the supply temperature is 40 K and the return temperature is 50 K and the cooling capacity of supercritical helium is 350 W at 4.55 K with the mass flow rate of 50 g/s. A series of the commissioning tests of the cooling system were carried out after the update. The results are listed in table 1. In all operational modes, the measured performance of the cooling system exceeded the required one.

Table 1. Performance of the cooling system.

Operational mode	Measured performance
Liquefaction	278.9 L/h
Refrigeration @4K	670 W @4.38 K
20 K supply	1085 W @20.0 K/27.9 K
40 K supply	1603 W @40.1 K/49.3 K
SHe supply	407 W @4.42K w/51.3 g/s

In JFY2016, the large bore high magnetic field test cryostat with the back-up magnetic field of 13 T will be assembled. Utilizing both the cooling system and the test cryostat in the upgraded NIFS superconducting magnet test facility, the development of large scale superconducting magnets for fusion reactors with advanced superconductors such as high temperature superconductors and MgB_2 will be promoted strongly.

1) Hamaguchi, S. et al., Plasma and Fusion Research **10** (2015) 3405020.
2) Hamaguchi, S. et al., IEEE Transactions on Applied Superconductivity **26** (2016) 9500404.

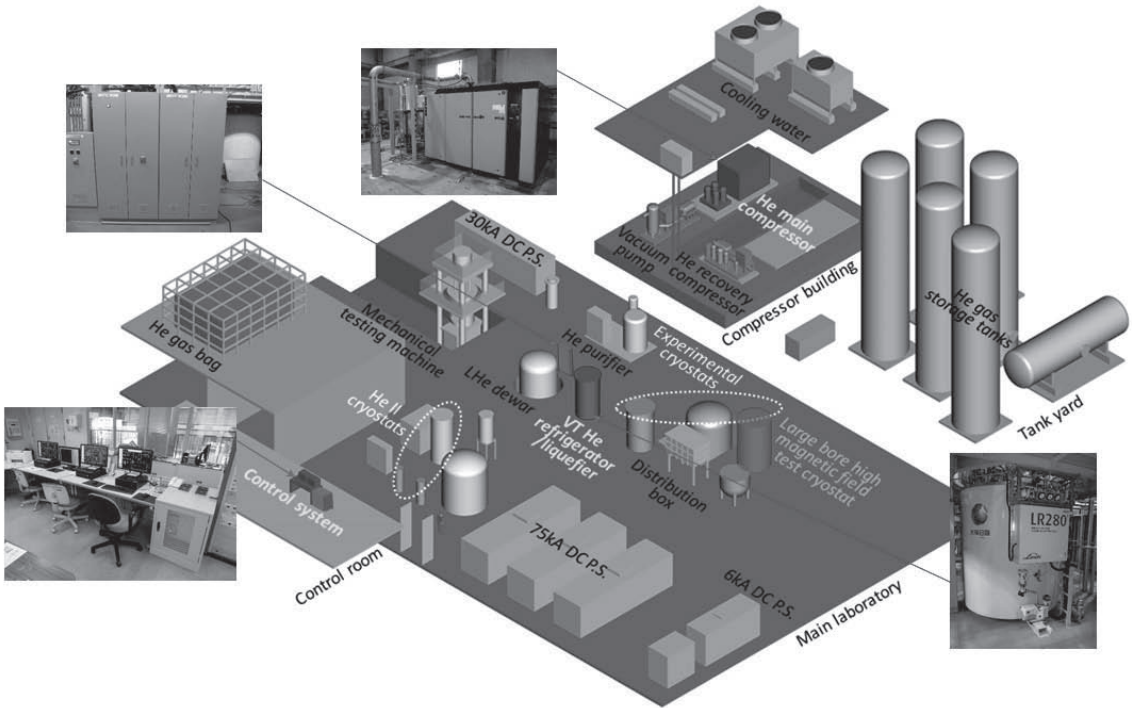

Fig. 1. Updated cooling system for the NIFS superconducting magnet test facility.