1. Introduction

The LHD superconducting system consists of a pair of pool-cooled helical coils (H1 and H2 coil), three pairs of forced-flow-cooled poloidal coils (IV, IS, and OV coils), nine superconducting bus-lines, a helium liquefier and refrigerator in the 10 KW class, and six DC power supplies. Availability higher than 99% has been achieved in a long-term continuous operation both in the cryogenic system and in the power supply system since the first cool-down in February 1998.

The output voltage of the main power supplies for the helical coils and poloidal coils are ±45 V and ±33 V, respectively. They have capacities to charge all the coils to the full currents within 15 minutes. In order to control the plasma axis dynamically, two sets of thyristor rectifiers with the output voltage of ±180 V and current capacity of 6.2 kA were added to the power supply systems for IV coils and IS coils before the twelfth cool-down. They can change the plasma axis by approximately 0.1 m/s at 0.5 T. Since the operation time of the added thyristor rectifiers is limited within 120 s, they are switched in series to the main power supplies while the currents are rapidly changed.

A subcooling system was installed before the tenth cool-down to improve the cryogenic stability of the helical coils by lowering temperatures. Its continuous operation has been demonstrated, and plasma experiments at the higher field have been carried out. Results of device engineering experiments and the operations in the twelfth cycle are summarized.

2. Twelfth Cycle Operation of LHD

The history of the twelfth cycle operation of LHD is shown in Table 1. Main compressors of the cryogenic system started on August 15, 2008 and stopped on January 30, 2009. The total operating time was 3,856 hrs, and the availability in this cycle was 99.99%. The main compressors were stopped for several minutes due to the stop of the water-cooling system for the repair of the leakage from the thermo-sensor.

Table 1 The history of the twelfth cycle operation.

Operation mode	Month/Day/Year
<Vacuum pumping system>	
Pumping a cryostat	8/4/2008-1/23/2009
Pumping a plasma vacuum vessel	8/5/2008-1/19/2009
<Cryogenic system>	
Purification	8/15/2008-8/26/2008
Cool-down	8/27/2008-9/22/2008
Steady state operation	9/23/2008-12/25/2008
Warm-up	12/26/2008-1/30/2009

3. Device Engineering Experiments

Excitation tests of the superconducting coils before plasma experiments were conducted from September 24 to 30. Propagation of a normal zone was not observed in the twelfth campaign. The following values were attained;

(1) *#1-o, B*=2.65 T @ 3.75 m (H-O/M/I = 11.042 kA)
(2) Slow charge and discharge to *#1-d* 2.85 T, γ=1.258 (H-O/M/I = 11.823/11.628/10.749 kA) for strain measurements,
(3) *#1-d, B*=2.783 T @ 3.60 m (H-O/M/I = 11.4/11.0/11.0 kA)
(4) Mode transition at 11.0 kA of the helical coil (radii of the plasma axis were 3.42 to 4.1 m, quadrupole components were 72 to 200%)
(5) *#1-d, B*=2.883 T @ 3.60 m (H-O/M/I = 11.8/11.4 /11.4 kA) and plasma axis shift from 3.5 m to 3.75 m at 11.4 kA of the helical coil in subcooled helium.
(6) *#1-d, B*=3.017 T @ 3.53 m in subcooled helium (H-O/M/I = 12.4/12.0/11.1 kA)

The device engineering experiments were conducted on the following schedule.

October 6, 20, and November 10, 2008

(1) Auto ramp up and down of round speed of the cold compressors of the subcooling system.

December 2, 2008

(1) Measurement of AC losses of the IV coils at the ramp speed of 44, 111, 222, and 231 A/s with using the new pulse power supply system.

December 3, 2008

(1) Series excitation of H-I, M, O blocks to *#1-o, B*=2.5 T @ 3.75 m for the research of mechanical disturbance.
(2) Fast shift of the plasma axis with the new pulse power supply system at *B*=1.0 and 1.5 T.

4. Research activities

We have promoted device-engineering researches using the LHD. Their main purpose is optimization of the subcooling system. The titles of the researches are listed in the following;

(1) Optimization of the control of the subcooling system of the LHD. (Okamura, T. (Tokyo Tech.))
(2) Monitoring and state estimation of LHD coils. (Ishigohka, T. (Seikei Univ.))
(3) Results of lowering temperatures of the LHD helical coils by subcooling system. (Imagawa, S. (NIFS))
(4) Operation and control of helium subcooling system with cold compressors for LHD helical coils. (Hamaguchi, S. (NIFS))
(5) AC losses in poloidal coils of the Large Helical Device. (Takahata, K. (NIFS))
(6) Voltage enhancement of the DC power supplies of LHD superconducting coils. (Chikaraishi, H. (NIFS))

(Imagawa, S.)