1. Introduction

The LHD superconducting system consists of a pair of pool-cooled helical coils (H1 and H2 coils), 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.

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 addition, thyristor rectifiers with the output voltage of ±180 V and current capacity of 6.2 kA are added to the power supply systems for IV coils and IS coils for dynamic control of the plasma axis. They can change the plasma axis by approximately 0.1 m/s at 0.5 T. Remote switches to change the polarity of coil currents have been installed after thirteenth cycle.

The reliable operation of the large superconducting system has been demonstrated, and researches to examine properties of the superconducting coils are continued toward fusion reactors. Results of device engineering experiments and the operations in the fourteenth cycle are summarized.

2. Fourteenth Cycle Operation of LHD

The history of the fourteenth cycle operation of LHD is shown in Table 1. Main compressors of the cryogenic system started on August 27, 2010, but they were stopped on September 2 because of the increase of operation current of one compressor. They restarted on September 11 after replacement of the bearing and repair of the rotor. The reason for the accelerated frictional wear is not clear, but one possible reason is an excess load during an irregular starting of the compressors after an emergency stop.

The quick discharge from the high field was triggered twice by malfunction of one set of the quench detectors for the helical coils, which are called "HC quench detector A". Both of the malfunctions were triggered by the breakdown of NBIs. Noise-cut transformer for the detectors or noise-cut cores for measuring cables were not sufficient to prevent the malfunction. They will be replaced by another type of quench detectors.

Table 1 The history of the fourteenth cycle operation.

Operation mode	Month/Day/Year
<Vacuum pumping system>	
Pumping a cryostat	8/19/2010-2/17/2011
Pumping a plasma vacuum vessel	8/20/2010-1/28/2011
<Cryogenic system>	
Purification	8/27/2010-9/1/2010
	9/11/2010-9/16/2010
Cool-down	9/17/2010-10/11/2010
Steady state operation	10/12/2010-1/27/2011
Warm-up	1/28/2011-2/25/2011

3. Device Engineering Experiments

Excitation tests of the superconducting coils before plasma experiments were conducted on October 12, 13, and 25. Propagation of a normal zone was not observed in the fourteenth campaign. The following values were attained in subcooled helium;

(1) *#1-o, B*=2.65 T @ 3.75 m (H-O/M/I = 11.042 kA)
(2) *#1-d, B*=2.783 T @ 3.60 m
(H-O/M/I = 11.4/11.0/11.0 kA)
(3) 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%)
(4) *#1-d, B*=2.896 T @ 3.60 m (H-O/M/I = 11.8/11.75 /11.2 kA) and plasma axis shift from 3.5 m to 3.75 m at 11.4 kA of the helical coil.

The device engineering experiments were conducted on the following schedule.

December 20, 2010

(1) Fast current change under the condition that the voltage is applied on only IV or IS coil with the pulse power supply system at *B*=0.2 and 0.5 T. Fast current change of only IV or IS coils up to 300 and 500 A.

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) Analysis on Winding Motions of The LHD Helical Coils by Balance Voltage and AE Signals. (Ninomiya, A. (Seikei Univ.))
(2) Estimation of Induced Current Owing in The Support Structure of LHD. (Chikaraishi, H. (NIFS))
(3) Behavior of Cold Compressor System of the LHD Helical Coils in Quick Discharge. (Hamaguchi, S. (NIFS))
(4) Detection System for Propagating Normal-zones with Pick-up Coils in the LHD Helical Coils. (Imagawa, S. (NIFS))

(Imagawa, S.)