(9) LHD Device Engineering Experiments

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 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 seventeenth cycle are summarized.

2. Seventeenth Cycle Operation of LHD

The history of the seventeenth cycle operation of LHD is shown in Table 1. Main compressors of the cryogenic system started on August 21, 2013, and the cool-down started on September 4. They stopped on January 17, 2014. The operation hours of the main compressors in the seventeenth cycle was 3,575 hours, and the stop time was zero. The total operation hours until the end of the seventeenth cycle was 76,724 hours.

Table 1 The history of the seventeenth cycle operation.

Operation mode	Month/Day/Year
<Vacuum pumping system>	
Pumping a cryostat	8/12/2013-1/7/2014
Pumping a plasma vacuum vessel	8/13/2013-1/16/2014
<Cryogenic system>	
Purification	8/21/2013-9/3/2013
Cool-down	9/4/2013-9/29/2013
Steady state operation	9/30/2013-12/25/2013
Warm-up	12/25/2013-1/17/2014

3. Device Engineering Experiments

Excitation tests of the superconducting coils before plasma experiments were conducted on September 30 and October 1. Propagation of a normal zone and recovery was observed once in the seventeenth campaign. It was fourth propagation under the subcooling operation in which the inlet helium temperatures is below 3.5 K. Its balance voltage is shorter and lower than that of the propagation in saturated helium at 4.4 K. The following values were attained;

(1) *#1-o, B*=2.65 T @ 3.75 m (H-O/M/I = 11.042 kA) at 4.4 K.

(2) *#1-d, B*=2.896 T @ 3.60 m (H-O/M/I = 11.8/11.75 /11.2 kA), plasma axis shift from 3.5 m to 3.75 m at 11.4 kA of the helical coil, and mode transition at 11.0 kA of the helical coil (radii of the plasma axis were 3.75 to 4.1 m, quadrupole components were 72 to 200%) at inlet temperatures of 3.5 K.

4. Research activities

We have promoted device-engineering researches using the LHD. Their main purpose is optimization of the subcooling system. In order to improve the reliability of the LHD cryogenic system, two upgrading programs are proceeded. The first is the addition of redundant compressors, which were operated without any troubles in the seventeenth campaign. The second is the update of the cryogenic control system, in which update the hardware of control system from VME controllers to CompactPCI controllers + remote I/O (EtherNet/IP). The new system was fully utilized successfully in the seventeenth campaign. In addition, the refreshment of the power supplies and the replacement of their control system have been proceeded from 2013, and they will be completed in 2015.

The titles of the researches are listed in the following;

(1) Refresh plan of dc power system of LHD superconducting magnet. (Chikaraishi, H. (NIFS))

(2) Detection of a minor normal-transition in the 17th experimental cycle with the LHD superconducting helical coils. (Yanagi, N. (NIFS))

(2) Effects of subcool on lengths of propagating normal zones in the LHD Helical coils. (Imagawa, S. (NIFS))

(Imagawa, S.)