

## § 2. Design and Operation of the Sub-cooled R&D System for the LHD Helical Coils

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The helical coils of the Large Helical Device (LHD) are pool-cooled superconducting magnets. The operating current is restricted below the design current due to the observation of a dynamically propagated normal-zone. In order to increase the cooling stability of the helical coils, an upgrade of the cooling scheme is planned from 4.4 K pool-boiling to 3 K sub-cooled helium of flow rate of about 50 g/sec. Then we designed and constructed the R&D coil made of the same superconductor for the helical coils and a sub-cooling test unit, and then the sub-cooling R&D experiment was carried out from 15 to 20, December 2002.

Fig.1 shows the configuration of sub-cool R&D system. This unit is composed of decompression tank for the sub-cooled helium generation, the R&D coil, a current lead storage tank, etc., and it was installed in a cryostat with a liquid nitrogen shield. Table.1 indicates the design of the two stage cryogenic compressors installed R&D unit. This is designed on the assumption of the LHD system, and two stage cryogenic compressors are installed in the top flange. Sub-cooled helium is generated by decompressing of saturated liquid helium from 0.12 MPa to 24 kPa. Liquid helium of 4.4 K and 0.12 MPa is heat exchanged by the sub-cooled helium in the decompression tank and supplied to the R&D coil from the bottom.

As the results of experiment, we found that the coil could be cooled down to 3.1 K in 7 hours and stably kept at 3.1 K. The rotation speed of the first and second stage cryogenic compressors were 87,000 and 88,000 rpm,

respectively. These values agreed well with the designed values of the two-stage cryogenic compressors. Finally, this system operated stably during the sub-cooling R&D experiment.

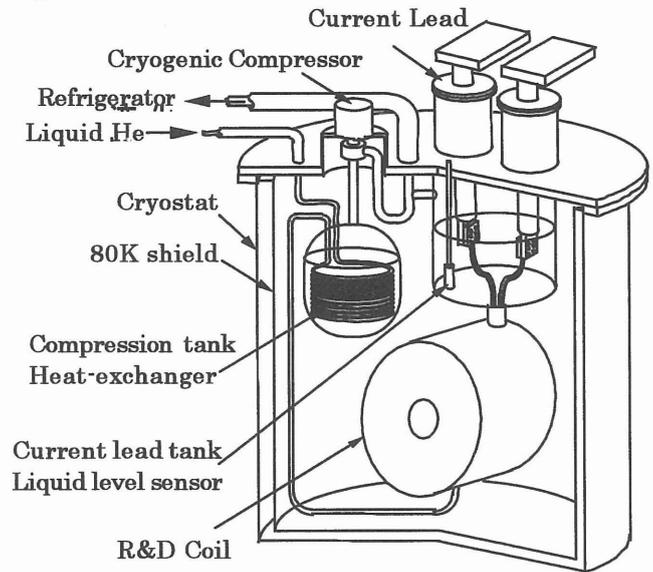


Fig.1 The configuration of sub-cool R&D system

Table.1 the design of the two stage cryogenic compressor

	1st stage	2nd stage
Type	Two steps series centrifugal type (centrifugal compressor)	
Inlet Condition	23.0 kPa, 3.0 K	64.4 kPa, 5.13 K
Outlet Condition	64.4 kPa, 5.13 K	120.0 kPa, 7.39 K
Flow Rate	15.9 g/s	15.9 g/s
Adiabatic efficiency	over 65 %	over 60 %
Refrigeration load	below 168 W	below 179 W

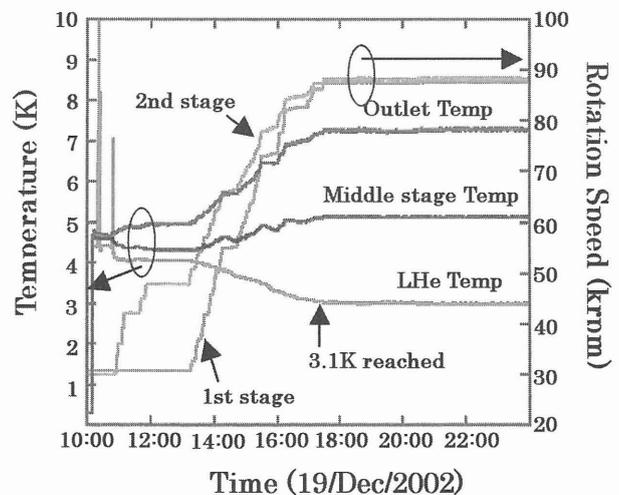


Fig.2 The cooling curve of sub-cool R&D system