

## §2. Experimental Plan of a 7-T Force-Balanced Helical Coil

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Force-Balanced Coil (FBC) is a helically wound toroidal coil that can minimize the required mass of its structure by selecting an optimal number of poloidal turns per toroidal turn. A 7-T Force-Balanced Coil (7-T FBC) was designed in order to demonstrate the feasibility of the FBC concept for high field superconducting magnets. Fig. 1 shows a schematic illustration of the 7-T Force-Balanced Coil (7-T FBC) using NbTi superconductor. The 7-T FBC with an outer diameter of 0.53 m will have 270-kJ stored magnetic energy at maximum magnetic field of 7.0 T. Based on the virial theorem, the maximum working stress of the 7-T FBC is estimated to be 52 MPa[1]. This stress is lower than the elastic limit of the Cu matrix so that the 7-T FBC can be excited up to the rated magnetic field of 7.0 T without reinforcing materials for the NbTi strand. Then the winding of the 7-T FBC will be carried out without reinforcing materials for the NbTi strand.

The winding form made of aluminum alloy is constructed by using a numerically controlled (NC) lathe as shown in Fig. 2. The NC lathe has 5 driving axes: a horizontal movement of the table (X axis), up and down movements of the spindle head (Y axis), forward and backward movements of the column (Z axis), tilting the table (A axis), and rotating the table (B axis). These axes are controlled by the NC data of the helical winding pitch.

The experiments will be conducted with pool boiling liquid helium cooling in order to measure the quench properties of the 7-T FBC and evaluate the working stresses in the helical windings. Fig. 3 illustrates a schematic diagram of the cryostat for the 7-T FBC. The 7-T FBC is set on the board made of fiberglass reinforced plastic (FRP). The liquid helium level is monitored with a level meter. If the 270-kJ stored energy of the 7-T FBC is discharged into the coil windings due to a quench, the evaporation of liquid helium is estimated to be 104 liters from the latent heat of helium (2.59 kJ/liter). In this case, the liquid helium level of the Dewar vessel is lowered by 280 mm because of 690-mm inner diameter of the vessel. Then, since the coil height of the 7-T FBC is 130 mm, the liquid helium level should be higher than 410 mm from the FRP board during quench tests in order to keep the pool boiling liquid helium cooling.

## References

- [1] S. Nomura et al.: Construction of a 7-T Force-Balanced Helical Coil, IEEE Trans. Appl. Superconduct. 15(2) (2005) 1911-1914.

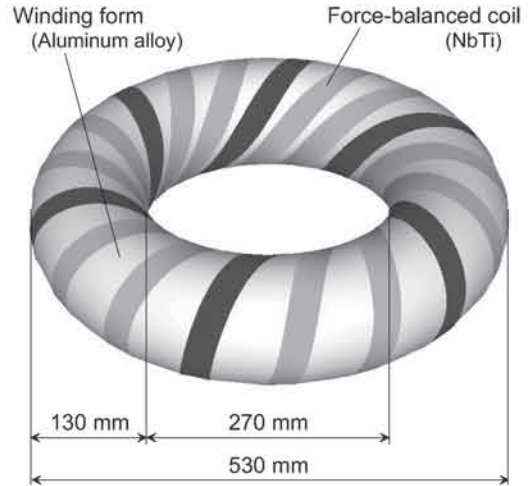


Figure 1: Schematic illustration of the 7-T force-balanced coil (7-T FBC).

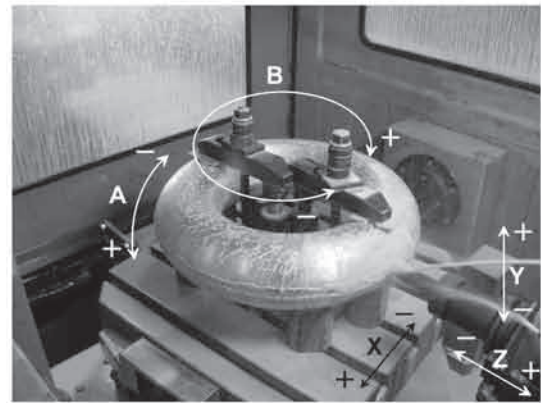


Figure 2: Construction of the winding form for the 7-T FBC by using a numerically controlled (NC) lathe.

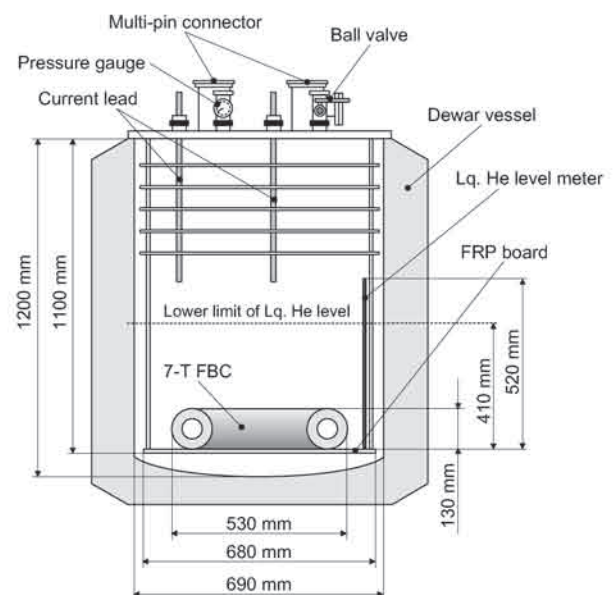


Figure 3: Schematic elevation view of the cryostat for the 7-T FBC.