Development of MgB_2 HTS Dipole Magnet with Solid Nitrogen Cryogenic System

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ABSTRACT

Aiming at the application as dipole magnets on gantries for heavy-ion radiotherapy, a dipole magnet prototype has been designed using magnesium diboride (MgB_2) material, and a batch of test coils has been manufactured and tested in order to ensure the reliability of structural and process design. Test results shows that a steady-state current of at least 250 A can be achieved at 20 K.

1. Design of Dipole Magnet Prototype

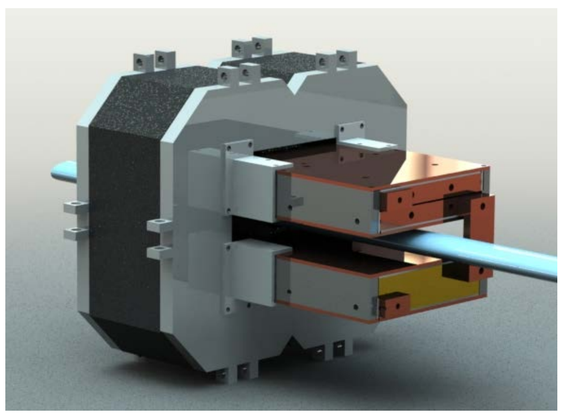

Fig. 1 Basic design of the prototype

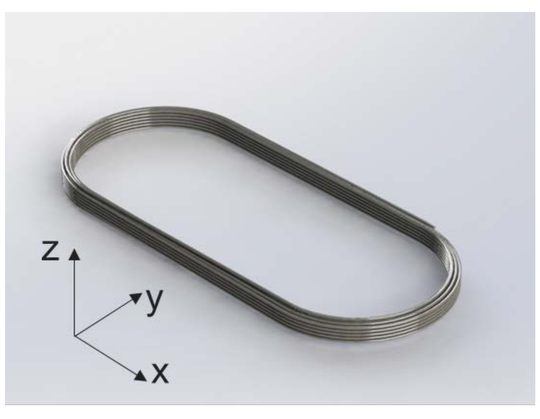

Fig. 2 Shape of the coil

Tab. 1 Key parameters of the prototype

Parameter	Value
Operating Temperature [K]	20
Central Magnetic Flux Density [T]	3
Number of Turns	22 (z direction) x 23 (y direction)
Straight Part Length [mm]	60
Curve Part Inner Radius [mm]	20
Operating Current [A]	135

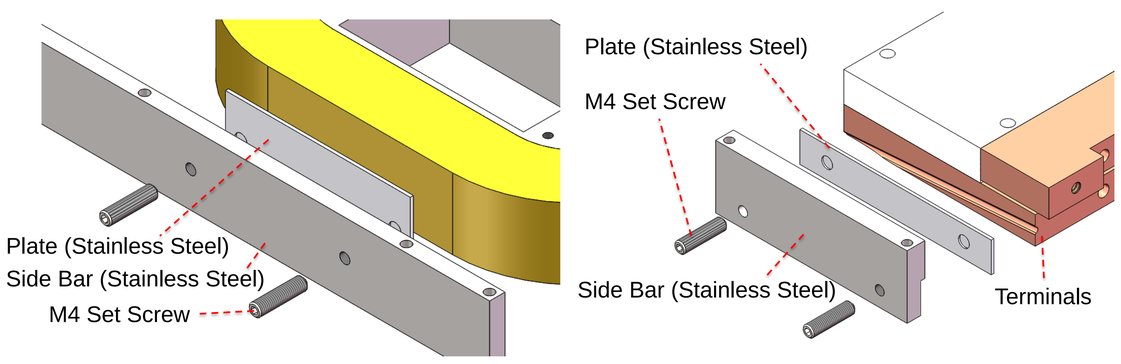

Fig. 3 Structural design of the prototype

2. Design of Test Coils

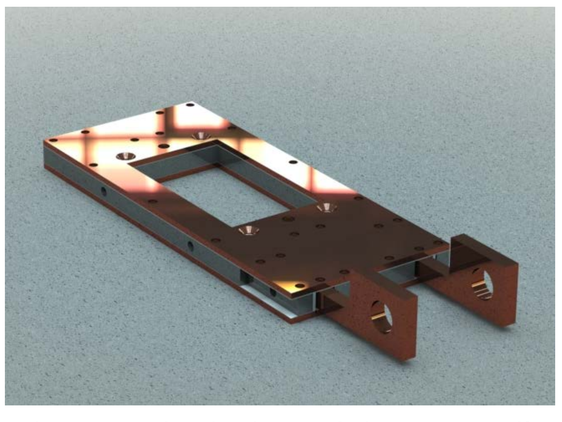

Fig. 4 Basic design of the test coils

Tab. 2 Parameters of the test coils

Parameter	Value
Operating Temperature [K]	20
Number of Turns	6 x 3
Straight Part Length [mm]	60
Curve Part Inner Radius [mm]	20

3. Test Results of the Test Coils

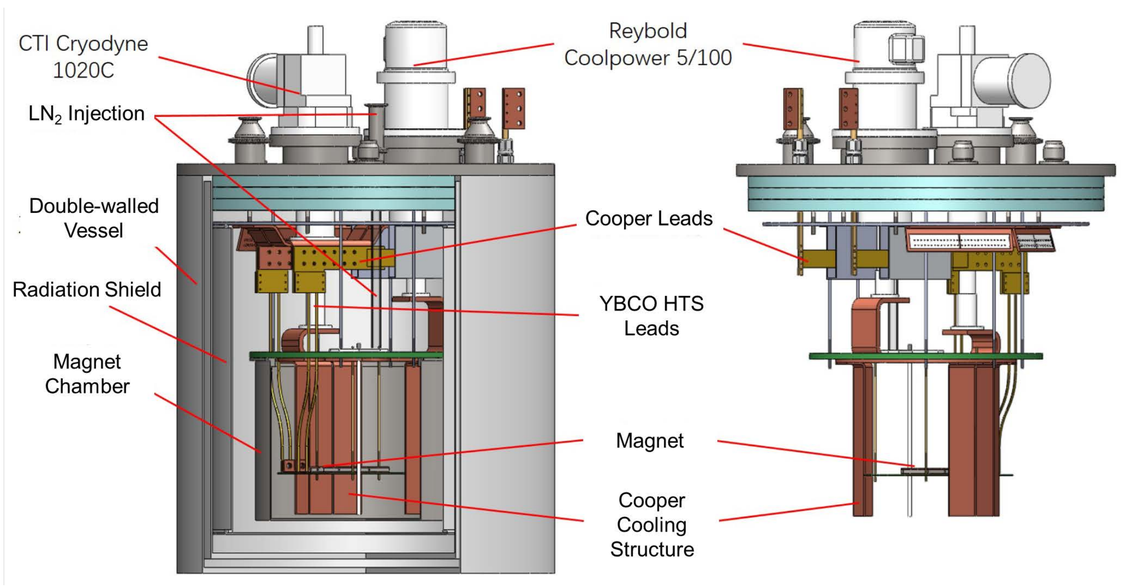

Fig. 5 Solid nitrogen cryogenic system for test

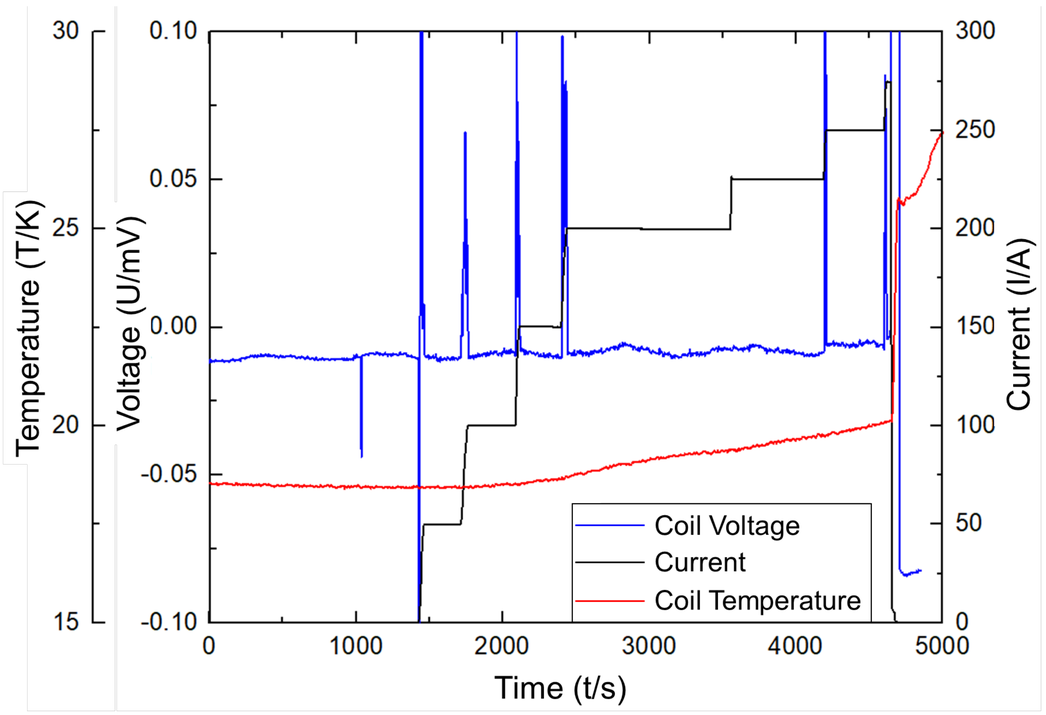

Fig. 6 Test results of a test coil at 17~20 K

- Test at ~20 K temperature range using a solid nitrogen cryogenic system developed earlier by the research team;
- Increasing the current step by step, 50 A/step under 200 A and 25 A/step over 200 A;
- The coil voltage was stable when current was steady, and showed an inductive signal when current increased;
- The temperature was basically stable at low current, and rise slightly at high current because of the Joule heat of the cooper parts;
- The system was quenched at the end of test, but the coil was not damaged.

4. Conclusion

- In this study, a MgB_2 dipole magnet prototype was designed. Special coil structure was designed to make sure the wire is not removable.
- By designing, manufacturing and testing a batch of test coils in a solid nitrogen cryogenic system, it is proved that at least 250 A can be achieved using our design, ensuring the feasibility of the structure and process design.

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