The Design of a curved Cryostat for the 90° DCT Superconducting Magnet

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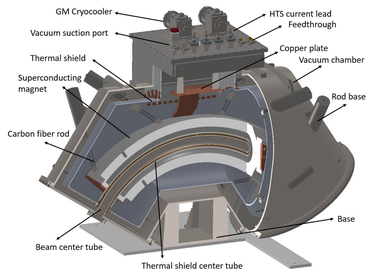
Abstract

A 90° curved cryostat that can rotate on a rotating gantry is developed and manufactured. To ensure the stability of the 90° DCT superconducting magnet during rotation, it is fixed on the surface of the cryostat with 12 carbon fiber rods. The heat leakage of first and second stages of the cryostat is calculated. The strength check is simulated at different angles (mainly at 0°, 30°,60°, 90°, 120°,150° and 180°). Cooling test and quench training are carried out.

Structure Design



Main structures

- vacuum chamber,
- thermal shield,
- HTS current lead
- refrigeration system
- superconducting magnet
- thermal shield center tube
- beam center tube.

Cryostat

- At present, cooling test and quench training have been completed.
- In the future, it will be installed on a rotating gantry for stability testing.

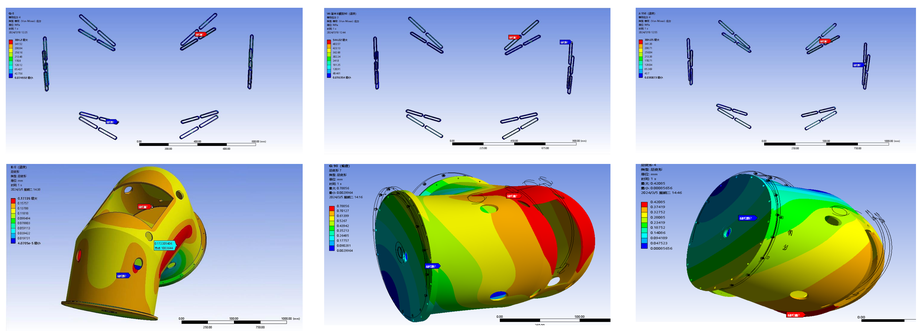
Heat Leakage Calculation

Form	Item	Heat leakage(W)	
		First stage	Second stage
Heat Conduction	Rods	13.2	0.03
	HTS current lead	54.6	0.26
	Others	2.8	0.01
Heat Radiation	~	4	0.86
Total	~	74.6	1.16

- Therefore, two 418 cryocoolers are selected to cool the cryostat.

Strength Check

Structure	Item	Angle(°) 0	30	60	90	120	150	180
Rods	Max force（N）	6060.9	6315.9	4149	4886.1	5158.5	5619.7	5155.1
	Max stress (MPa)	384.2	384.1	384.6	544	385	384	385
Vacuum chamber	Max deformation(mm)	0.177	0.398	0.633	0.789	0.644	0.421	0.21
	Max stress (MPa)	124.9	124.3	190	94.5	191.9	146	121.7
Base	Max deformation(mm)	0.012	0.018	0.019	0.033	0.02	0.02	0.013
	Max stress (MPa)	40.6	47.2	46.9	88.8	47.1	55	43.7

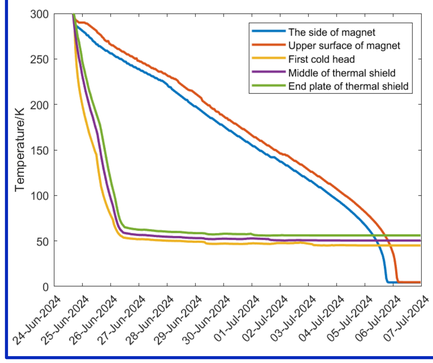


- The maximum force and stress on the rod are the largest when the rotation angle is 30 ° and 90 °, respectively.
- The max deformation and stress on the vacuum chamber are the largest when the rotation angle is 90 ° and 120 °, respectively.
- The max deformation and stress on the base are the largest when the rotation angle is 90 °.

Conclusion

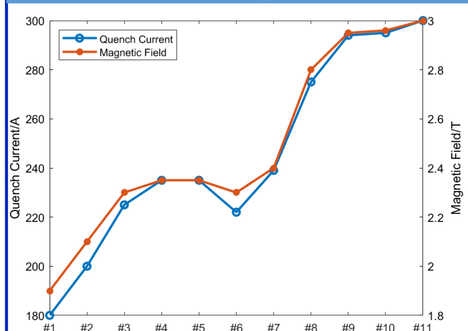
- A 90° curved cryostat that can rotate on a rotating gantry is developed and manufactured.
- The heat leakage calculation shows that two 418 cryocoolers are needed.
- The strength check shows that 12 carbon fiber rods, vacuum chamber and base meet the strength.
- It takes 13 days to cool down the whole system from room temperature until thermal equilibrium.
- The magnetic field reaches 3T at the current of 300A after 11 times of quench training.
- A single cycle operation is realized.

Cryostat Cooling Performance

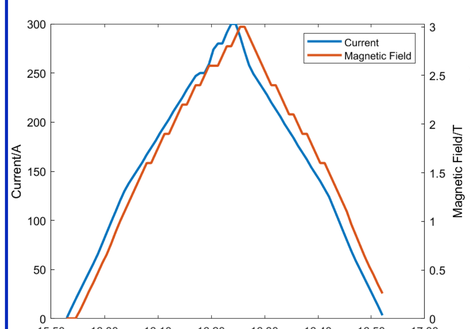


- It takes 13 days to cool down the whole system.
- The temperature of the first-stage cold head takes 3 days to drop to 54.7K rapidly and then decreases to 45.1K slowly.
- There is a temperature difference between the thermal shield and the first-stage cold head, but the cooling trend is consistent.
- The temperature of superconducting magnet decreases rapidly on the 11th day.

Quench Training



- The first quench occurs at 180 A.
- Finally, the magnetic field reaches 3T when the current is 300A after a total of 11 times of quench training.



- A single cycle operation mode is set up after completing the quench training.
- During the power-on process, it stays for 1 minute at the current of 250 A and 280 A, respectively.

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