Impact of Trapped Helium Gas Bubble on the Cooling of YBCO Coils in 32 T Magnet

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Introduction

When the magnetic field is ramping up in high field magnet, the boil-off helium gas generated by heat losses in the coil, can be trapped in the liquid helium bath in a region where Bz·dBz/dz is less than -2100 T^2/m due to the weakly diamagnetic property of helium. It results that the surfaces of the magnet or samples are covered partially with the accumulated helium gas instead of liquid helium. The very low thermal conductivity of helium gas may cause an inefficient cooling for the magnets or samples. In the beginning stage of YBCO coils development, the trapped gas bubble caused a temperature increase in the region of trapped gas bubble and prevented the test coils ramped up to a higher current [1]. This raised an issue for the cooling of the 32 T magnet. Relevant tests were performed and the trapped gas bubble was observed in recent tests of the 32 T magnet prototype coils. The impact of the gas bubble on the cooling of the 32 T YBCO prototype coils was tested.

Experimental

The test of dual prototype YBCO coils was performed in a background field of 11.5 T provided by the outsert of 45 T hybrid. It consists of two nested YBCO coils which have 6 double pancakes each. The trapped helium gas bubble was observed again and its position and size coincide very well with the expectation shown in [2]. Five temperature sensors were installed at the same location of the inner coil as that of first prototype coil test, shown in Fig. 1.

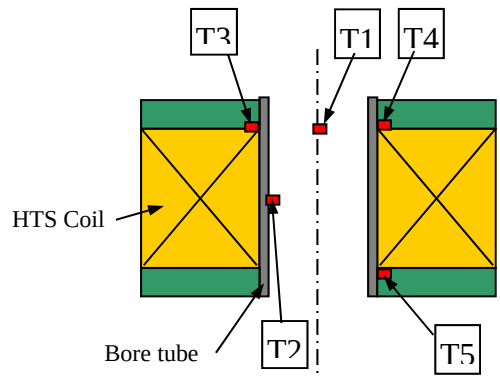

Fig. 1 Positions of five temperature sensors installed in the coils.

Results and Discussion

Fig. 2 shows the temperature measurement during a current ramp up to 200 A at the 11.5 T background. All the sensors showed a stable temperature close to 4.2 K. The temperature in the gas bubble also maintained at about 4.2 K during ramping up and when the current stayed at 200 A, which is considered negligible for the cooling of the YBCO coils. We can also see the ramping loss clearly from the temperature spike of T3, T4, and T5 in the figure.

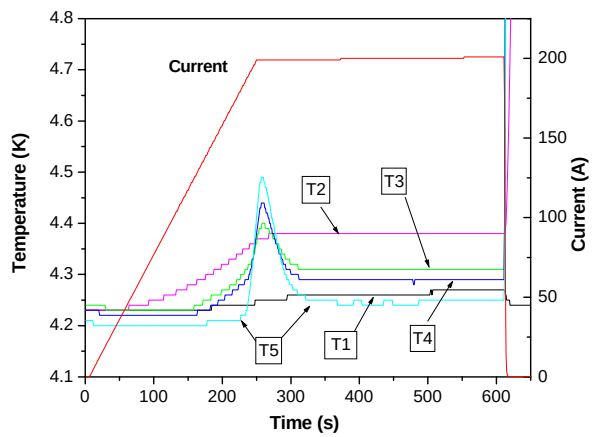

Fig. 2 Temperatures in the test of the dual YBCO prototype coils when it was ramped up to 200 A.

Conclusions

The trapped helium gas bubbles were observed in high magnetic field where the production of the vertical field and its gradient Bz·dBz/dz is less than -2100 T^2/m. Test results of the prototype coils showed that the temperature of the trapped gas bubble remained steady and close to liquid helium temperature because of using a cryostat of a relatively bigger inner diameter, and this is different from the measured high temperature in the trapped bubble when small coils were tested in long tail insert cryostats.

Acknowledgements

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References

[1] Markiewicz, W. D., *et al*. *Adv. in Cryo. Eng*., Vol. 55, 225-230(2010).
[2] Bai, H., *et al*., *Appl. Phys. Lett*., **104**, Art. No.133511 (2014).