Observation of Helium Gas Bubble Trapped in HTS Coil Test

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Introduction

32 T high field superconducting magnets are cooled in a liquid helium bath. For the magnets built previously with fields less than 20 T, the vaporized helium gas bubble rises to the top of the liquid bath because of the buoyancy on the bubble. When the field is above 20 T, the boiled-off helium gas (bubble) can be trapped in the liquid helium bath, in regions where $B_z \cdot dB_z / dz$ is less than -2100 T^2/m (Bz is the vertical magnetic field and Z is the vertical axis) [1]. A test to observe the trapped helium gas was conducted when the prototype coil of 32T magnet was tested in the large bore resistive magnet [2].

Experimental

A prototype YBCO coil was made and tested in the large bore resistive magnet in Cell 4. To observe the trapped helium bubble, a level sensor consisting of 6 capacitors with a total height of 106 mm was fabricated (shown in Fig. 1) and installed vertically in the bore of the prototype coil, with the bottom sensor below the mid-plane of the coil and the other five capacitors above the mid-plane. The sensors are identified as C1 to C6 from the top to the bottom. During cooldown of the coil, the capacitance of the capacitors were measured and proved that it can clearly differentiate the liquid helium and gas helium. After cooldown, the resistive magnet was first ramped up to provide a 15 T background field and then the YBCO coil was ramped up with an extra field up to 8 T. We observed that the helium gas bubble was trapped and released in the bore of the YBCO coil during ramping up and down of the YBCO coil.

Fig.1. Level sensor

Results and Discussion

Fig. 2 shows the capacitance variation during ramping up and discharging of the YBCO coil (the Y-axis is the percentage of capacitor covered by gas and the X-axis is the time in seconds). We observed gas bubble was trapped at the location of capacitor C4, C3 and C5 during ramping up and went away immediately when the coil was discharged in the case of quench. This was repeated dozens of times during the test of the prototype coil. Fig. 3 shows the position of trapped bubble based on the capacitance measurement data. Y-axis is the distance to the mid-plane in mm. The bubble was trapped first above the mid-plane and then grew bigger when the field was ramped higher. This agrees well with the analytical results.

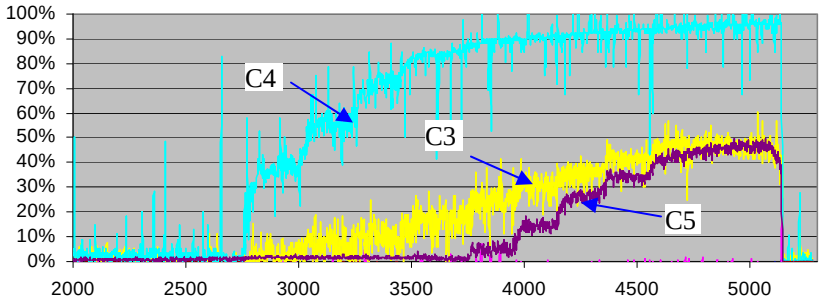

Fig. 2. Trapped bubble growth during ramping up of YBCO coil.

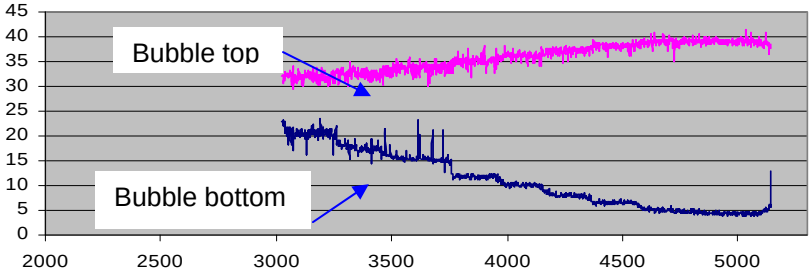

Fig. 3. Trapped bubble growth during ramping up of YBCO coil.

Acknowledgements

This work was supported in part by the U.S. National Science Foundation under Grant No. DMR-0654118, DMR-1157490, DMR-0923070 and the State of Florida.

References

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