Experimental Study on AC Loss of a Quasi-isotropic Strand Fabricated by Coated Conductors in AC Magnetic Fields

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Background

A new calorimetric method for measuring AC loss in AC magnetic field by optical fiber Bragg grating (FBG) is able to solve problems occurred in the process of conventional electric and calorimetric measurements. Since the FBG temperature sensor has advantage of rapid response and anti-electromagnetic interference, the calorimetric method based on FBG is very suitable for AC loss measurement of HTS applications in much more complicated electromagnetic circumstance due to thin geometrical sizes and optical characteristics of FBG temperature sensors.

Objectives

- AC loss calculation of a quasi-isotropic HTS strand in AC magnetic field by Comsol Multiphysics using A formulation.
- AC loss measurement of a quasi-isotropic HTS strand in AC magnetic field by optical sensing interrogator based on calibration of the wavelength shift of FBG and energy loss of strand.

Calculation of AC loss

The AC loss of quasi-isotropic HTS strand in AC magnetic field is simulated by Maxwell’s equations together with appropriate constitutive laws for the superconducting layer using A formulation. The distribution of electric field, magnetic field, and frequency.

FBG Properties at Cryogenic Temperature

In order to apply FBG temperature sensing technology in superconducting research, it is essential to calibrate the dependence of wavelength shift on temperature for FBG in AC magnetic field temperature range of LN2. The experimental setup is used for measuring wavelength of FBG on temperature. The resistive wire is fixed on cold-head of cryocooler by thermal conductive adhesive. The wavelength of FBG is measured by optical sensing interrogator with fiber sensors system.

Results

The calculated results of hysteresis loss, eddy-current loss and coupling loss in the HTS strand illustrate the eddy-current loss and coupling loss are smaller than the hysteresis one, all of the three components of AC loss increase with the amplitude of AC magnetic flux density B0, and frequency.

Conclusion

- The calculation of AC loss contains hysteresis loss, eddy-current loss and coupling loss. The calculated results show that hysteresis loss dominates the AC loss of the quasi-isotropic HTS strand at LN2 temperature and power frequency.
- The response of FBG in low temperature range is measured, the measurement results indicate that FBG has good repeatability on temperature measurement around LN2 temperature.
- AC loss of quasi-isotropic HTS strand in AC magnetic field is measured by optical sensing interrogator based on calibration between energy loss and FBG response. The measured results of AC loss are in agreement with calculated ones, which suggests that calorimetric method using FBG technique can be effectively feasible for measurement of HTS strand or cable and help us to improve understanding AC loss properties in any complicated electromagnetic environment.

Measurement of AC loss

The resistive wire in the center of the HTS strand is powered by Agilent E3631A instrument, the energy loss can be obtained by E3631A, and the wavelength shift of FBG owing to temperature rise resulting from the energy loss is measured by optical sensing interrogator. Then a calibration curve between energy loss and wavelength shift of FBG response is finished. The resistive wire is switched off after calibration.

The wavelength shift of FBG and the amplitude of AC magnetic field in the gap produced by magnet can be acquired during the process of the experiment. AC loss can be obtained according to calibration of the wavelength shift of FBG and energy loss of strand.

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