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Numerical Simulation and Experiment of AC Loss in Quasi-isotropic Strand

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Introduction

In this paper, AC loss of quasi-isotropic strand stacked by REBCO coated conductors (CCs) and copper tapes at 77 K liquid nitrogen temperature is not only measured by four-probe experimental method but also modeled by finite element method (FEM). AC loss of the quasi-isotropic strand is calculated effectively by FEM model and basically agrees with the experimental result. The simulation and experiment results on the one hand show the amplitude of current has a great impact on AC loss. On the other hand, the skin effect, declining current capacity and rising eddy loss are linked to the rising frequency.

Structure of the Quasi-isotropic Superconducting Strand

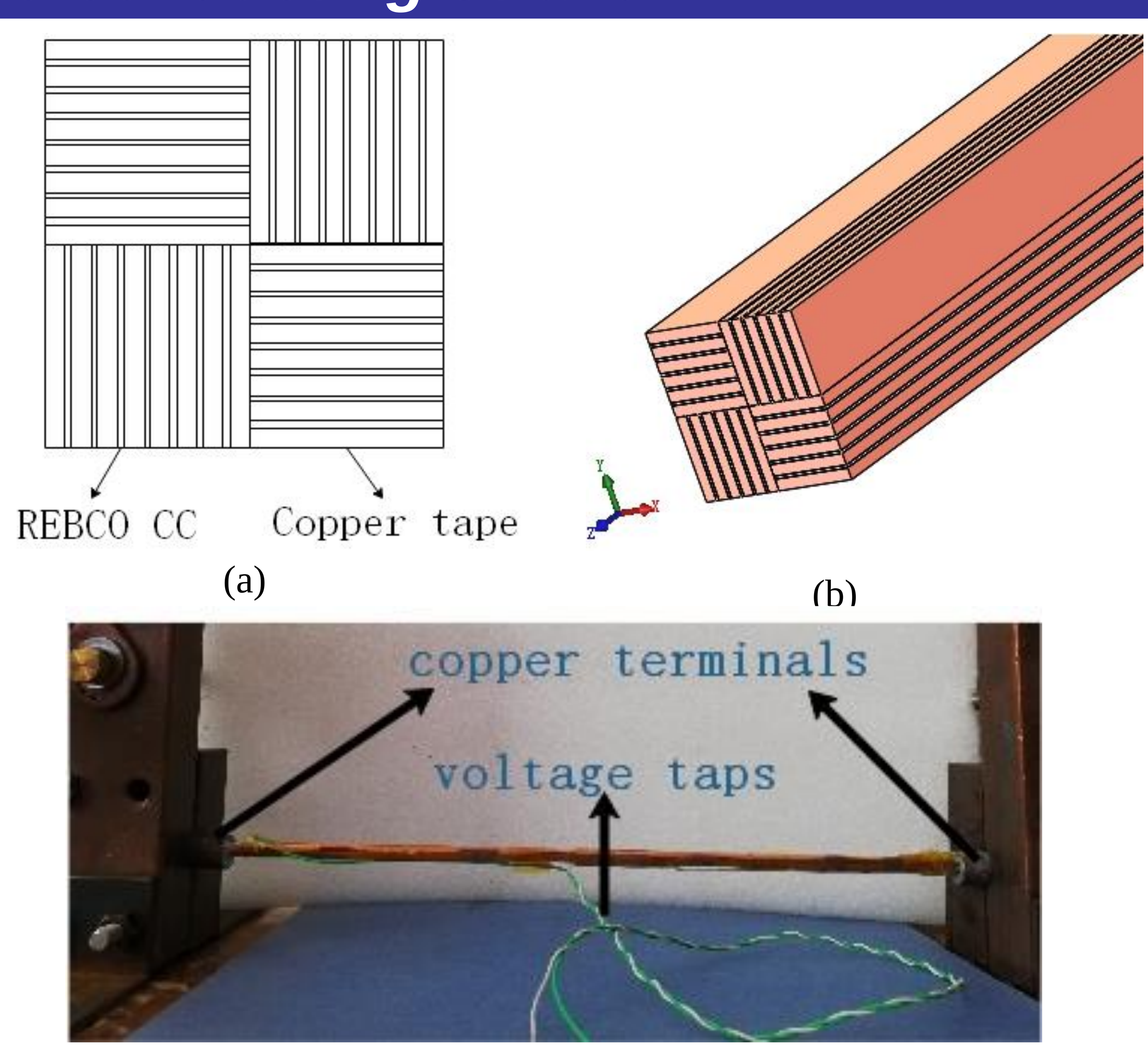

Fig. 1. (a) Cross-section view of the quasi-isotropic strand (4 mm×4 mm). (b) The three-dimensional view of the quasi-isotropic strand. (c) A photo of experiment with the quasi-isotropic strand.

Simulation Result

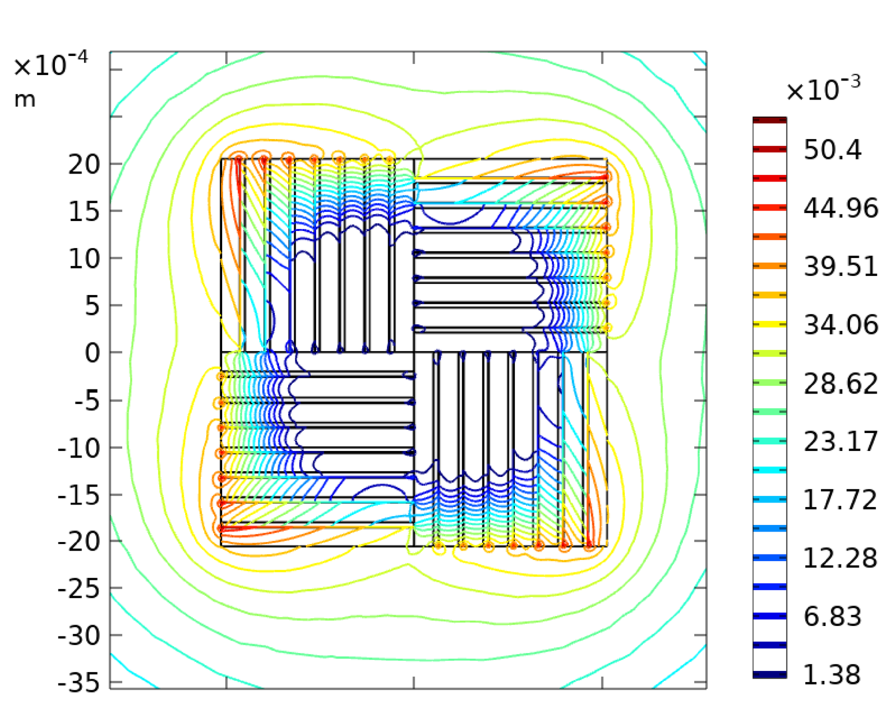

Fig. 2. The contour of the magnetic flux density.

In a 2-D model, based on Bean critical current model, H-formulation and E-J characteristics of superconductor, we have obtained the electromagnetic characteristics and calculated AC loss of the quasi-isotropic strand by simulation.

Experiment

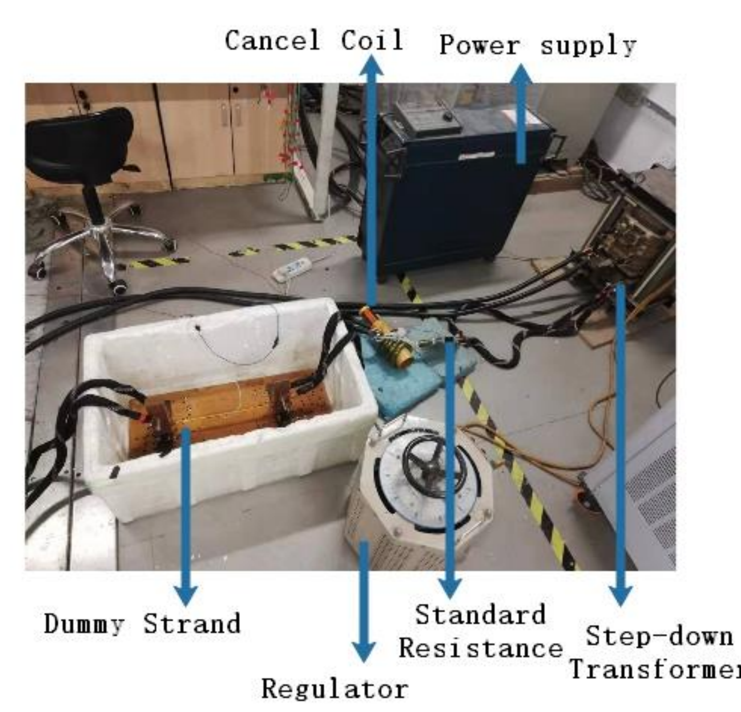

Fig. 3. The overview of the experimental set-up.

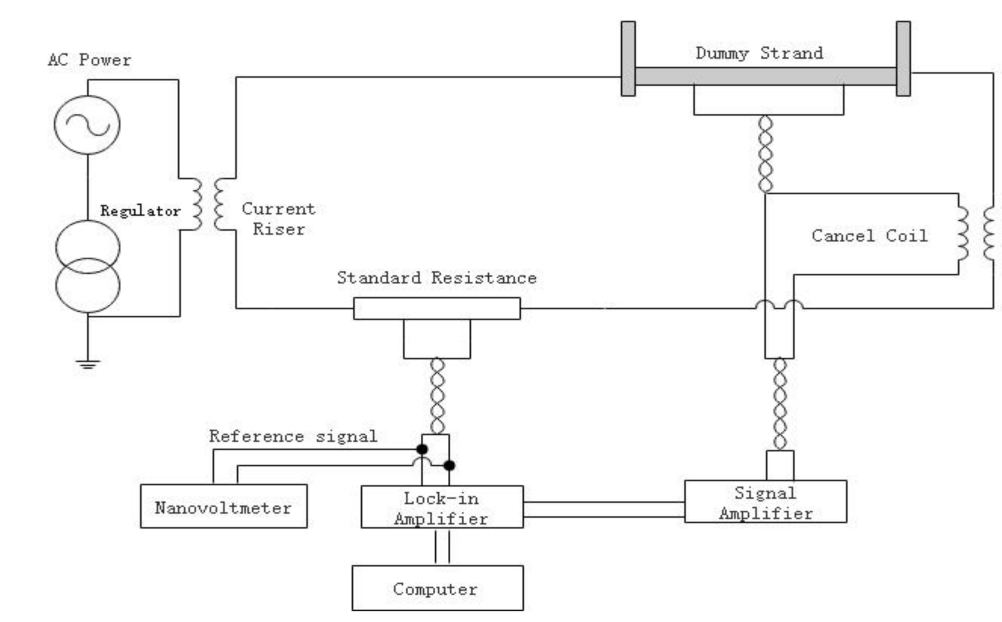

Fig. 4. Four-probe measurement method.

In this experiment, the quasi-isotropic strand was completely immersed in a liquid nitrogen (LN2) bath for cooling. The voltage and current can be measured by a four-probe method when the quasi-isotropic strand carries alternating current. Combining power supply with a current booster is used to provide high current. Changing the voltage of the secondary winding by using the regulator, the value of current flowing through the quasi-isotropic strand can be controlled.

Discussion

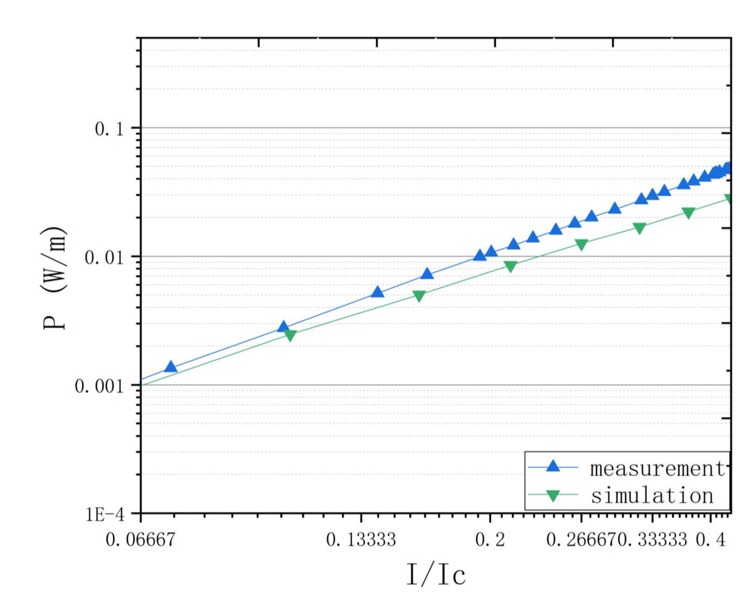

Fig. 5. Calculated and measured AC loss of the quasi-isotropic strand at 50 Hz

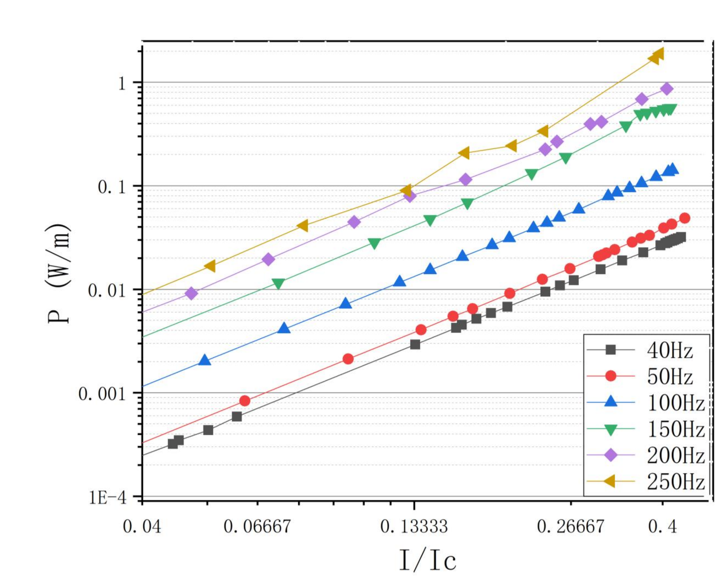

Fig. 6. AC loss and normalized current curve at different frequencies.

The plotted curve of the numerical simulation result has approximately agreement with experimental one, except the numerical simulation result is smaller. The main reason is probably that the influence of the magnetic field and the Joule heat on the critical current of the superconductor is ignored in the simulated model. At the same time, experimental measurement on AC loss at different frequencies has also been carried out, which shows that the loss is affected by the current frequency as well.

Conclusion

- AC loss of the quasi-isotropic strand is calculated effectively by FEM model and basically agrees with the experimental result.
- The relationship between AC loss and amplitude of current is exponential.
- AC loss of the quasi-isotropic strand is linear with the frequency of current.

Fig. 5. Calculated and measured AC loss of the quasi-isotropic strand at 50 Hz