Study on Electromagnetic Characteristics Of HTS Cable Consisted Of YBCO Coated Conductor

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Introduction
At present HTS devices generally have large current carrying capacity. Therefore, many kinds of HTS cables with high current density have been established and become a key point for the application of HTS power devices. In this paper, firstly two kinds of HTS cable are introduced, the CORC cable and the double coaxial cable. Subsequently, a three dimensional (3D) finite element method numerical model is built for CORC cable and double coaxial cable. The model is based on the T-A formulation by assuming a sheet approximation for conductors. The maximum magnetic flux density B/and B1 of 1st conductor layer of the CORC cable is 0.05T and 0.047T, the maximum magnetic flux density B/and B1 of inner conductor layer of the double coaxial cable is 0.03T and 0.03T. The ac loss of the double coaxial cable is less than the CORC cable. Finally, the short CORC cable and double coaxial cable samples are made, which consist of YBCO coated conductor with a former diameter of 6 mm, and the critical current of about 400 Ampere @77 K, self-field. According to the results, the critical current of the double coaxial cable is higher than the double coaxial cable, and it has a high performance. The double coaxial cable is better to be applied in HTS power devices (such as HTS transformer).

Electromagnetic Characteristics Analysis and Discussion

A. Methodology of numerical model

T-A formulation

\[ J = \nabla \times T \]

\[ E = \mathcal{E}_{0} \left( \nabla \times T \right) / I_{i} \]

\[ \nabla \times E = \frac{\partial B}{\partial t} \]

\[ \nabla \times \nabla \times A = \mu \frac{\partial J}{\partial t} \]

A. Structure of the HTS Cable

Fig.1 Structure of the CORC cable and double coaxial cable

B. Analysis of HTS Cable

Fig.2 shows magnetic flux density norm of the CORC cable and double coaxial cable. Fig.3 shows magnetic flux density B1 of the CORC cable and double coaxial cable. Fig.4 shows the maximum magnetic flux density B/ of the CORC cable and double coaxial cable.

Experiment And Analysis

A. Prototype HTS Cable

The prototype CORC cable mainly consists of a flexible copper former, 1st -2nd HTS conductor layer (from inside to outside), the prototype double coaxial cable mainly consists of a flexible copper former, inner conductor layer and outer conductor.

Experiment And Analysis

B. Measurement System Design

Fig. 6. Schematic diagram of V-I characteristic measurement.

C. Result and Analysis

Fig. 7. Critical current characteristic curve of CORC cable and double coaxial cable

Conclusion

In this paper, a 3D finite element method numerical model is built for two kinds of HTS cables, which is based on the T-A formulation, and to analyze the magnetic field distribution and ac loss. In addition, a 0.3 m short CORC cable and double coaxial cable samples are made. When the sample cables are tested, the critical current of double coaxial cable is as high as 314 A at 0 T and 77 K, and the critical current of CORC cable is as high as 264 A at 0 T and 77 K. The results demonstrate the feasibility of the double coaxial cable with higher critical current and lower ac loss for HTS power devices. In future, the current distributions and ac loss of the double coaxial cable shall be researched through the experiment to validate the numerical model value.

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