Principal Research Results

Evaluation of Realizability of High-\(T_c\) SMES

Background

Recently, development of high-\(T_c\) superconducting wires and tapes is progressing. In particular, it is expected that YBCO-coated conductors are applied to SMES due to an advantage of wide operation temperatures. Therefore, feasibility study of High-\(T_c\) SMES including some experiments using model coils and some numerical simulations have been carried out in a national project of “Technology Development of SMES System” from 1999 to 2003. This work is supported by METI and conducted by NEDO as a feasibility study of High-\(T_c\) SMES as a part of development of SMES system.

Objectives

Clarification of technical realization of high-\(T_c\) SMES and more cost reduction than that of low-\(T_c\) SMES

Principal Results

a) Technical realization of high-\(T_c\) SMES

- Investigation of high current conductors for high-\(T_c\) SMES
  
  The world record of critical current (\(I_c\)) for the one turn model coil using the Bi2212 Rutherford conductor conductively cooled using a cryocooler is achieved 4 kA at 26 K, which is satisfied to develop high-\(T_c\) SMES. Fig. 1 shows the equipment of critical current measurement for Bi2212 Rutherford conductor and the results of critical current measurement. It is also indicated that possibility of high-current superconducting conductors using a displacement of 6 Bi2223 superconducting tapes as a result from the examinations of trial conductors and trial model coils.

- Magnet technology
  
  In the magnet technology, the conductive cryocooling technology and the current leads are indicated to be important issues to realize high-\(T_c\) SMES using model coils. In the current leads, the new current leads with the pulse tube cryocooler are developed, whose insulation characteristics are independent on vacuum pressures. Fig. 2 shows the photo of the developed current leads.

b) Cost estimation of high-\(T_c\) SMES

One of the advantages of high-\(T_c\) SMES is the wide operation temperature due to use of the cryocooling system. Initial costs of high-\(T_c\) SMES on the basis of the results from the conceptual design for the toroidal coil system are estimated at each operation temperature. According to the comparison with the cases using high-\(T_c\) superconductors and low-\(T_c\) superconductors, it is found that the cost reduction using the YBCO-coated conductors at all of the temperature range is more expected than that of the low-\(T_c\) superconductors due to use at relatively high magnetic fields. Fig. 3 shows the results of the cost estimation and the coil shape of high-\(T_c\) SMES designed at 20 K.

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Reference

4. Power Delivery - Development of new technology of transmission facilities

Fig. 1 Critical measurement equipment of Bi2212 Rutherford conductor carried 4 kA under conductive cooling conditions and critical current measurement results.

Fig. 2 A photo of developed current leads with the GM pulse refrigerator and a construction of the high-Tc coil and the current leads.

Fig. 3 Summation of wire cost and refrigerator cost of power system stabilization of 500 kW/h (1.8GJ) at each operation temperature and the conceptual design of high-Tc SMES using YBCO coated conductors at 20 K.