§10. Development of Observation and Diagnosis Systems for Superconducting-coil Operations Using the Poynting Vector Method

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For the operation of devices composed of several superconducting coils, a system which can detect the abnormal conditions produced at one part of the coils and diagnose the conditions of the coils after maintenance is of considerable importance. The purpose of this study is to develop a system which can observe and diagnose coils in devices composed of several coils and electrically measure the losses in the coil by measuring the Poynting vectors around the coil. We have already clarified that our proposed system can measure the losses in both a normal conducting coil and in the individual coils of a device where two coils are combined. In order to investigate whether the system can measure ac losses in superconducting coils, measurement of the distributions of Poynting vectors and ac losses in the Bi-2223 sample, which were wound loosely into a single layer solenoidal coil shape with a Bi-2223 multifilamentary tape, were carried out.

As shown in Fig. 1, the sample was wound into a solenoidal coil shape with long length necessary for measurements. We measured Poynting vectors on the inner and the outer surfaces near the center of the sample coil for a few turns. The measurements were carried out by using the pairs of pick up coils and potential leads which were set as shown in the figure. And the Poynting vectors were locally measured along the coil axis by moving these pairs between 1 pitch length of the sample coil, and then losses were calculated from the summation of all Poynting vectors. The Bi-2223 multifilamentary tape of 1m in length, 3.8mm in width, 0.21mm in thickness, was wound on a bobbin of 80mm in outer diameter into a solenoidal coil, with 10mm pitch, and 4 turns. Furthermore, the current leads of the Cu wires were wound in series at both ends of Bi-2223 tape into a solenoidal coil shape with the same pitch as Bi-2223 tape. In order to discuss the measured distributions of the Poynting vectors, we also measured two dummy samples wound with Cu tape of 4mm width, 1.5mm thickness, and stainless steel tape of 4mm width, 0.2mm in thickness.

Figure 2-a shows the measured results of Bi-2223 tape in the external magnetic fields of 20mT in amplitude, 20Hz in frequency. The measured Poynting vectors around the Bi-2223 sample are shown by circle symbols. From 4mm to 8mm, the range of width of the Bi-2223 tape, the observed Poynting vectors are large. This indicates the possibility of identifying the points at which large energy flows exist. Calculated ac losses from these Poynting vectors agreed with theoretical values.

The profile of Poynting vectors is sloped. In order to discuss the slope, measurements were carried out on dummy samples. The square symbols in Fig. 2-a represent the measured data on the Cu sample. As the resulting slope of the profiles of Poynting vectors is the same as the Bi-2223 sample, it is found that the slope is not a characteristic of the Bi-2223 tape. Fig. 2-b shows the results on the stainless-steel sample. The measured data is considered not to be the signals of the sample itself, because the losses in the stainless steel sample are smaller by five orders of magnitude than that of the Bi-2223 sample and Cu sample. We found that a slope similar to the Bi-2223 sample and the Cu sample exists on the stainless-steel sample. In addition, for the results at room temperature, which are shown by circle symbols in the figure, the slope of Poynting vectors become small compared with the results at 77K. From the above mentioned it is clear that the slopes of the profiles of Poynting vectors are signals which are produced by the measuring system, in particular the Cu magnet to apply the external magnetic fields to the sample. Accordingly, measurements of Poynting vectors can give us not only ac losses but also some information on the location of existing energy flow. It was found that our system has the potential to be applied to an observation and diagnostic system for large-scale coils.

References

H. Kasahara, et al., IEEE Trans. Appl. Supercond., Vol. 14, No. 2, pp. 1078-1081.

Y. Kawabata, et al., Abstracts of CSJ Conference, Vol. 71, p. 126 (2004).

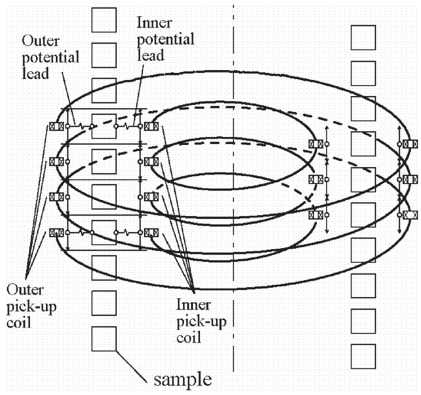

Fig.1 Apparatus of the Poynting vector method

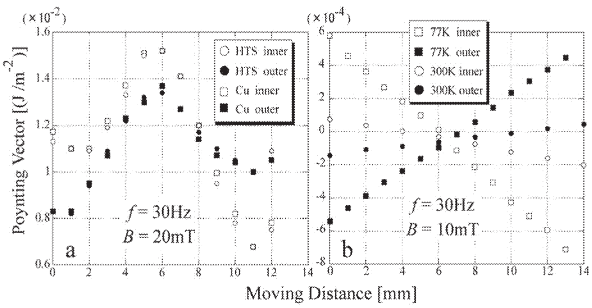

Fig. 2 Profiles of Poynting vector around a sample in external ac magnetic fields, a - HTS and Cu tapes, b − SUS tape