§15. Application of High Tc Superconductor to a Fusion Reactor

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This study aims to apply various electromagnetic properties of high Tc superconductors (HTSC) to a fusion reactor in order to enhance its performance. For this purpose, two issues have been investigated: (a) development of an HTSC simulator to predict the superconducting phenomena and to contribute material development of HTSC, and (b) investigation of new applications of HTSC to fusion reactors.

In 1998, we investigated three issues to develop HTSC simulators, which is summarized as:

(1) Evaluation of magnetization in HTSC using the Fluxoid Dynamics (FD) method,
(2) Numerical and experimental investigation of dynamic behavior of HTSC ,
(3) Evaluation of various properties of HTSC cables which will be important for its application to fusion reactors.

1. Evaluation of magnetization in HTSC

The code based on the FD method was upgraded to evaluate magnetization in HTSC. Main modification is the consideration of various interactions between fluxoids and the surface of HTSC. Figure 1 shows an example of M-H curves estimated with the modified code. On the other hand, effects of thermal fractuation has been already implemented to the code. In future, the irreversible field, which is important in view of HTSC application, will be evaluated with the FD method.

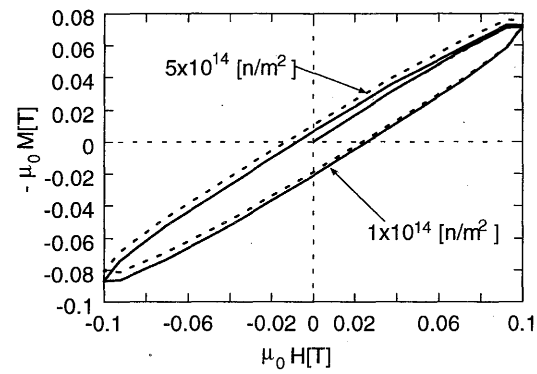

Fig.1: Dependency of neutron dose on M-H curve of HTSC

2. Dynamic behavior of HTSC

In order to elucidate the dynamic behavior of HTSC, the electromagnetic force due to HTSC under AC field was estimated numerically and experimentally. The experimental apparatus is shown in Fig.2. An HTSC sample was immersed and cooled in liquid nitrogen. A permanent magnet and a coil were placed above the HTSC sample, fixed by a cantilever. Electromagnetic force due to HTSC was measured based on the strain of the cantilever. Numerical analysis was also carried out based on T method (the current vector potential method) in the same configuration as the experiment. Figure 3 shows the experimental and numerical results of the electromagnetic force decay due to AC field. Both results agree well with each other, which supports for the validity of numerical analysis. This numerical code will be implemented to the HTSC simulator.

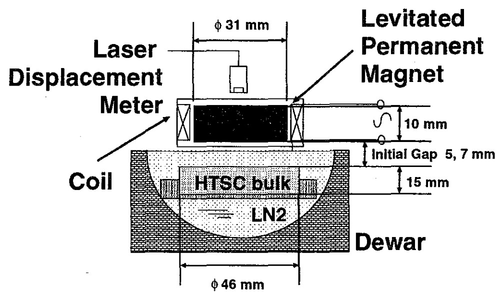

Fig.2: Experimental apparatus

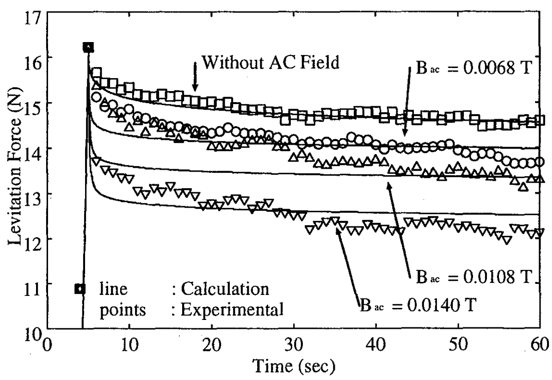

Fig.3: Comparison between numerical and experimental results of electromagnetic force due to HTSC.

3. Various properties of HTSC cables

Extensive investigation of Bi-2223 superconductive tapes was experimentally carried out in order to evaluate their physical properties as well as the potential for the application to fusion reactors. The main results can be designated as follows:

1) The irreversibility lines were determined. The indicated cross over is attributed to different field-temperature dependency of the pinning potential. This is indicated by the exponent n in the relation of the irreversibility field with the temperature - $B_{irr} \propto (1-T/T_c)^n$.
2) The Bi-2223 superconducting tapes are found to be sensitive to mechanical treatment due to the brittle ceramic filaments. The onset of Ic degradation is estimated as $\varepsilon_{irr} = 0.4\%$. After this level severe fracture occurs in the core. The critical current is decreased by 75% after being subjected to strain $\varepsilon = 0.7\%$. and released. It is concluded that ε_{irr} is material parameter independent on measurement conditions.