§23. Stabilized Current Density in Hybrid Conductor with High-Tc and Lower-Tc Superconductor

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The stabilities of a hybrid conductor composed of both the Cu-clad NbTi superconducting wire (LTS) and Ag-sheathed BSCCO-2223 wire (HTS) were analyzed from a view point of the Maddock' equal area criterion [1]. The critical current in the HTS was set to be only 10 to 20 % of the total critical current of the hybrid conductor. The stabililzed critical current densities Jr's of the hybrid superconductor were calculated as a function of $\alpha_{HTS}(\%)$, the ratio between critical current densities in the HTS and that in the hybrid conductor, a total transport current I, and i, a ratio between I and a critical current I_{c0} in the hybrid conductor at a liquid helium temperature. In the analises, α_{HTS} was varied from 0 % to 20 % for the case where I_{c0}=5,000A and i=0.5. The calculated stabilized current density Jr's were increased from about 62 A/mm^2 when α_{HTS}=0 to about 86 A/mm^2 when α_{HTS}= 20%. When α_{HTS}=15%, a stabilized current density Jr was 78A/mm^2 which would be larger by 25% than that of the usual Cu-clad NbTi conductor. These calculations were confirmed by experiments using a hybrid conductor composed of both Cu-clad NbTi and BSCCO flat tapes. In the present study, the propagation velocities of a normal zone were measured in the hybrid superconductor where the values of I_{c0} and α_{HTS} are 240 A and 11.4% at 1T, 164 A and 11.8% at 2T, 133 A and 10.3% at 3T and 106 A and 10.5% at 4T, respectively. The result is shown in Fig.1. The minimum propagation currents Ir's are obtained from the data in Fig.1 and about 100 A , 120 A ,140 A and 170 A at 1T, 2T, 3T and 4T, respectively . In Fig.2, the heat generation and cooling are conceptually drawn in which a curve (θ_{iL} - P - B) is the heat generation for the usual LTS and a curve (θ_i - Q - A) are the heat generation for a hybrid conductor. Those two curves are drawn so as to satisfy the Maddock's equal area criterion. Since the value of θ_{iL} is not so much different from that of θ_i, g_Q has to be approximately equal to g_P, and g_R and g_P will be proportional to $Ir^2_{(Hybrid)}$ and $Ir^2_{(LTS)}$, respectively. When $g_Q = \gamma g_R$, $Ir_{(Hybrid)}$ will be approximately equal to $\gamma^{-1/2} Ir_{(LTS)}$ from those relations. By using the values of γ obtained from the experiments, the recovery current was calculated and confirmed to be improved by as large as 9.8 % for the case where I=170A, i=0.71 and α_{HTS}=11.4% compared with that of $Ir_{(LTS)}$. These improvements are shown to be roughly consistent with the above-mentioned calculations.

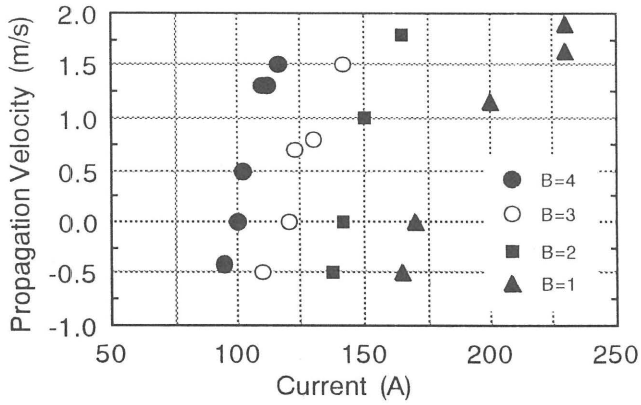

Fig1.Propagation Characteristics

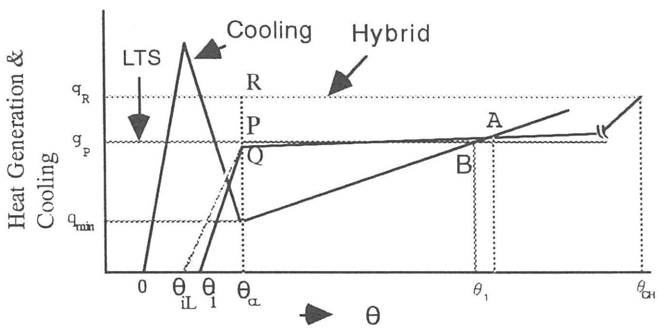

Fig.2 Heat generation and cooling characteristics for LTS and HTS conductors.

References

1) Maddock, B.J., James , G.B., and Norris, W.T., Cryogenics (Aug., 1969) p. 261
2) Okumura, A, Onishi, T : Proc. Annual Conf. of Power & Energy Society. IEE of Japan (July, 1996)
3) Okumura, A, Nii, A, Onishi, T : Proc. 5th Meeting on Cryogenics and Superconductivity (May, 1997) E1-6