SUPERCONDUCTING CABLE FOR SYNCHROTRON

Y. Furuto*, T. Suzuki**, M. Ikeda*, Y. Tanaka*, S. Nakayama**, S. Meguro*, I. Inoue**

* The Central Research Laboratory, Furukawa Electric Co.,Ltd.

** The Nikko Research Laboratory, Furukawa Electric Co.,Ltd.

1. Introduction

As we reported at the First Accelerator Science Conference(1), we developed several kinds of Nb-Ti superconducting cables for the synchrotron magnet. Succeeding to that program, recently, we manufactured compacted and stranded cables with 23 strand wires for Fermi National Accelerator Laboratory and for some others. In this paper we describe the fabrication process and characteristics of the cable in some details.

2. Cable Fabrication

In order to produce a certain quantities of superconducting cable with homogeneously high quality and at the same time with a reasonable price, the fabrication process is not always decided simply from the standpoint of cable characteristics. This is why, in the case of Nb-Ti superconducting cable, to optimize the superconducting property sometimes contradict with the workability of the cable as the metal composite. For instance, too fine Nb-Ti filament cannot be cold-worked without partial fracture. To optimize the critical current density, high dislocation density or many fine precipitates are necessary but they often cause the fracture of strand wires. Compacting the cable the higher packing factor is more desirable for the over-all current density but it causes frequently crushing of the cable. To say the truth, when one decides the pitch of twisting one must consider carefully whether saving of the refrigeration cost by shorter twisting is more profitable than increase

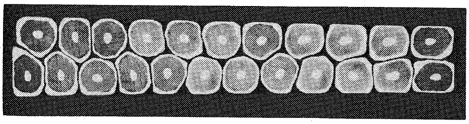

Figure-1 Cross-sectional view of the producted cable

Table-1 Specifications for the produced cable

Stranded Cable

1) Size: 1.37-1.17 × 7.80 mm (keystone-shaped)
2) Number of strand wires: 23
3) Stranding pitch: 50 mm
4) Critical current: 5200 A (at 4.2 K and 5T)

Strand wire

1) Equivalent diameter: 0.69 mm
2) Superconductor: Nb-50 wt.% Ti alloy
3) Cu to superconductor ratio: 1.80
4) Equivalent diameter of Nb-Ti filament: 8.6 μm
5) Number of Nb-Ti filaments: 2300
6) Twisting pitch: 5 or 10 mm
7) Solder: Ag-95 wt.% Sn alloy

Table-2 Fabrication Process

1) Arc-melting Nb and Ti into Nb-Ti ingot of 100-300 kg by weight
2) Extruding high-purity Cu clad Nb-Ti billet and rolling down to size (single-cored composite rod)
3) Extruding again high-purity Cu clad billet with 2300 composite rods (billet: 8 or 10 inches in diameter, 200-300 kg by weight)
4) Rolling and drawing down to appropriate size (e.g. 50mm to 1mm in diameter)
5) Heat- treating accompanied with the precipitations for the critical current enhancement
6) Cold drawing for the further critical current improvement
7) Twisting and Ag-Sn solder tinning (strand wire)
8) Stranding 23 strand wires and compacting into the finished cable

in the cable cost.
In considerations of above saying we decided the fabrication process shown in Table-2 for the production of the superconducting cables shown in Table-1 by the amount of 0.5 ton per month.

3. Current Carrying Property of the Cable

In Figure-2 we show the critical current density of Nb-Ti alloy of this production (curve-2) and that of differently treated Nb-Ti alloys. For the usual superconducting cable the critical current density is controlled to have the balanced property over the wide magnetic field range. (curve-1). However the cable of this production is operated mainly at 5T and we tried the special heat-treatment to achieve the optimized critical current density near about at 5T (curve-3). Furthermore, to make sure of the workability of the cable we practically chose the condition shown in curve-2.
At Fermi Laboratory dipole magnets wound with this cable are now under the test. Figure-3 is a training curve of 1-foot model dipole magnet wound with the similar cable which we delivered formerly. The cable constitutes of 23 strand wires but compacted into the flat cable and not keystone-shaped. The short sample critical current is 4860 A at 5T for the smaller dimensions and after several times of quenching almost full critical current for the short sample is achieved. (2)

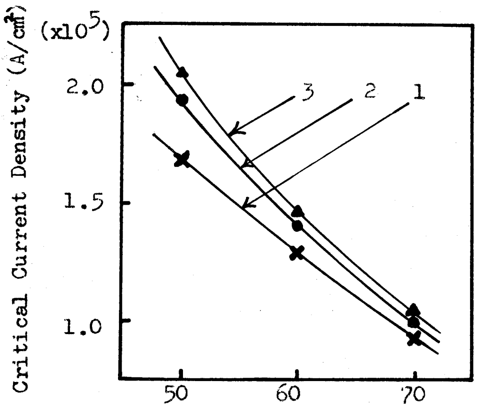

Figure-2 Critical Current Density of Differently Treated Nb-Ti

Acknowledgements

Authors are very grateful to M. Ban, T. Shinozaki, H. Hamaoka, H. Terai, Y. Nagasu and N. Tanaka of our laboratories for their considerable technical assistance in this work.

References

(1) Y. Furuto et al. Proceedings of The First Accelerator Science Conference p.173

(2) " The Energy Doubler " Printed for the 1976 Summer Study on Use of the Energy Doubler

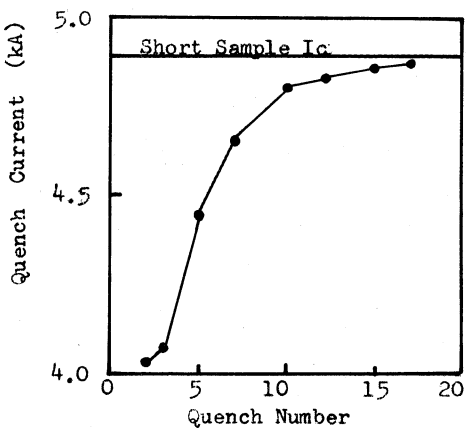

Figure-3 Training of 1-Foot Dipole Magnet