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Summary

A design of a 50 kA cable at 8 T for superconducting ohmic heating coils is presented. The cable, which will be cryostable with relatively low ac losses, is composed of 24 basic cables and stainless steel backbone. A non-metallic cryostat for the test of pancake coils of the cable is developed.

Introduction

The conceptual design studies of tokamak reactors undertaken at Argonne National Laboratory (ANL) and elsewhere over the past several years have identified the requirement of superconducting ohmic heating coils. The ohmic heating coils will have stored energies of the order of 1 GJ and a peak operating current of between 50 and 100 kA with dB/dt of approximately 9 T/s. Because of the large stored energies, the coils should be cryogenically stable and still have tolerable low ac losses during the high ramping rate of the magnetic field. Recently, ANL has developed a 11 kA cable and demonstrated the cryostability of the coil made from the cable.[1,2,3] The purpose of this paper is to describe a 50 kA cable. The design of the cable is based on the design and test results of the 11 kA cable.

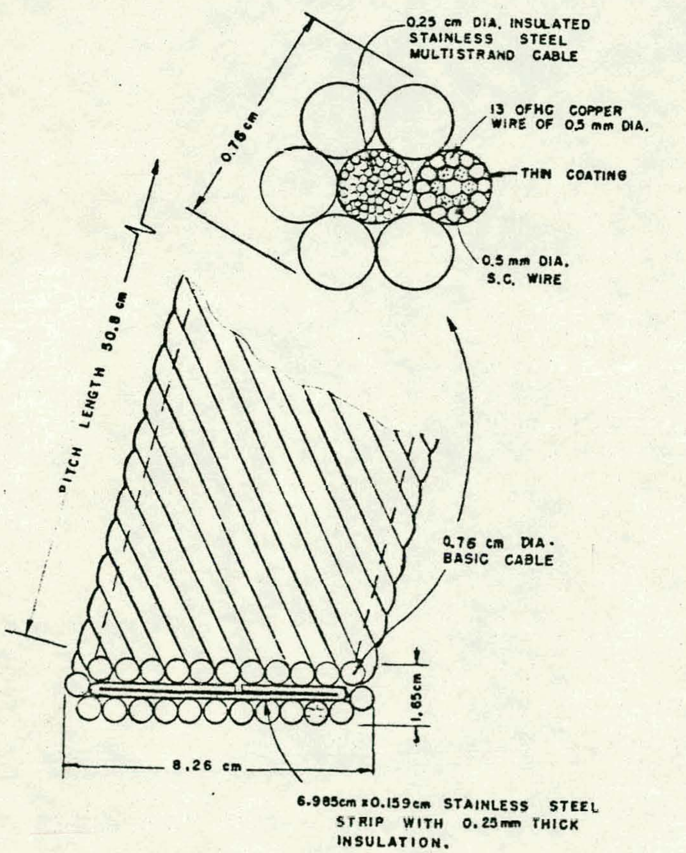

Fig. 1. 50 kA AC Superconducting Cable and its Basic Cable

Design of the 50 kA Cable

The structure of the 50 kA cable is shown in Fig.1. The cable is assembled by twisting 24 basic cables around an insulated stainless steel or G-10 strip with a twisting pitch of 50.8 cm. The cabling device will provide sufficient stranding tension and pressure to assure a tightly packed cable assembly having an effective cable cross section of 8.26 cm by 1.65 cm.

The basic cable, shown in the upper part of Fig. 1, is composed of six 19-wire cables by twisting together around an insulated multi-strands stainless steel cable with a twisting pitch of 2.5 cm. The stainless steel cable is introduced to reinforce the tensile strength of the basic cable.

The 19-wire cable consists of three layers of wires with a copper wire at the center, six superconducting wires in the second layer and 12 copper wires in the outer layer. The lay of wires is as tight as the geometry allows with a twisting pitch of 0.8 cm for the second layer and 1.25 cm for the outer layer. Then the 19-wire cable is soldered with Staybrite and the surface of the cable is weakly insulated by coating a thin organic film. The soldering and the weak insulation are intended to achieve both the cryostability and relatively low ac losses of the cable in pulsed field.

Cable Test

The performance of the 50 kA cable will be tested initially in a form of pancake coils. For two pancake coils, ac losses at a central field rate of 9 T/s are estimated to be approximately 5 kW. In Table 1, parameters are listed for a 65 MJ coil with 22 pancakes.

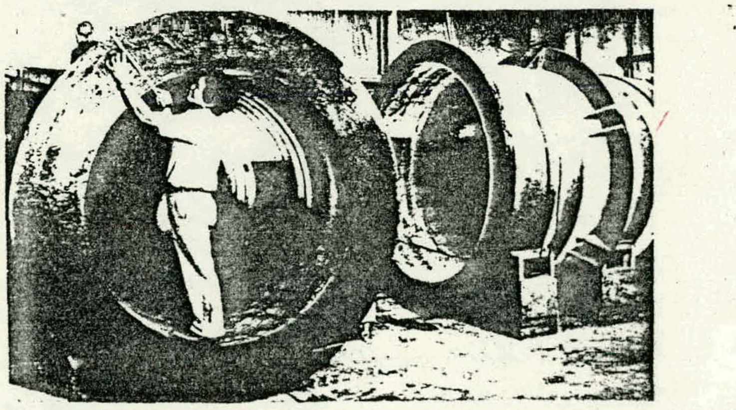

Fig. 2. Inner (Left) and Outer (Right) Tanks of the Non-Metallic Cryostat

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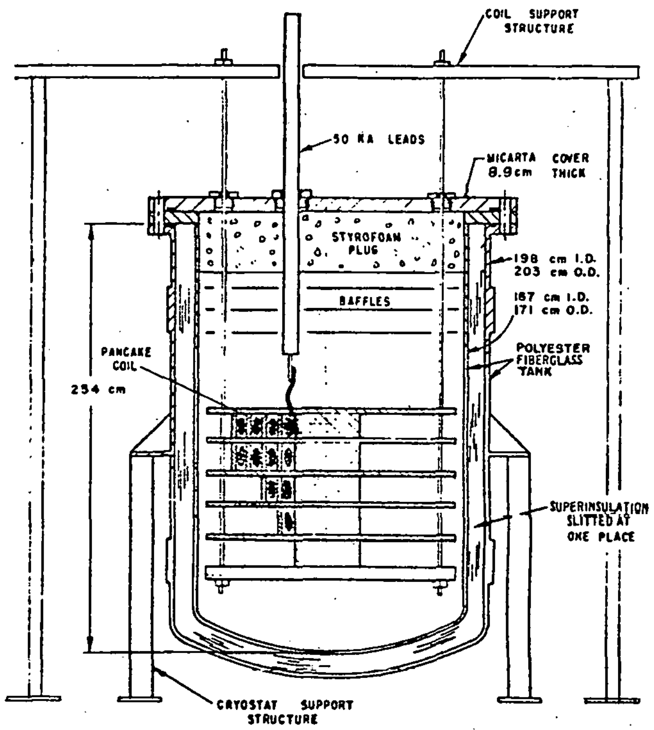

Fig. 3. Set-Up of the Non-Metallic Cryostat for the Test of the Pancake Coils

A non-metallic cryostat for the test of the pancake coils is developed. The cryostat consists of two figerglass reinforced polyester tanks (Fig. 2) and 100 layers of superinsulation between them. Overall dimensions and support structures of the cryostat are shown in Fig. 3. The cryostat support structure is incorporated into the outer tank so that the cryostat could be supported in an upright position. To reduce the mechanical load to the top cover of the cryostat, an external support structure is introduced to sustain the pancake coils. Heat leak of the cryostat, estimated from the cryostat, developed in the past for the 1.5 MJ coil, is approximately 8 W (11 LHe/hr).

Table 1. Pancake Coil Parameters

Stored energy (MJ)	65
Central field (T)	7.9
Critical current (kA)	46
Inductance (mH)	60
Coil ID (cm)	100
Coil OD (cm)	165
Coil axial length (cm)	200
Number of pancakes	22
Total number of turns	316
Coil current density (A/cm^2)	2300
Cu/SC	7.9
Heat flux when normal (W/cm^2)	0.35
Hysteresis loss (kJ/cycle)	3.2
Eddy current loss at 9 T/s (kW)	135
Heat flux due to ac losses at 9 T/s (W/cm^2)	0.11
AC losses/stored energy (%)	0.1

References

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2. S. H. Kim, S.-T. Wang and M. Lieberg, "Operating Characteristics of the 1.5 MJ Pulsed Superconducting Coil," Advances in Cryogenic Engineering, (Plenum Press, New York) to be published.

3. S.-T. Wang and S. H. Kim, "Argonne National Laboratory Superconducting Pulsed Coil Program," International Symposium on Superconductive Energy Storage, Osaka, Japan, Oct. 8-9, 1979.