DESIGN AND CONSTRUCTION OF THE MINERAL INSULATED MAGNETS

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Abstract

The radiation resistant magnets with mineral insulated coils are designed and constructed. The electrical insulation of the cable is maintained by magnesium oxide in the form of a powder held around the copper hollow conductor by a copper shieth. By the direct water cooling through a hollow conducter the sometimes conflicting requirements of good insulation and high field are fulfilled. The magnets can withstand more than 10^{12} rad of absorbed dose.

1. Introduction

In some regions around the slowly extracted proton beams from KEK 12 GeV proton synchrotron, the radiation dose is expected to amount to more than 10^{10} rad/year; those places are around the production targets and at the beam splitting system. Under such a high radiation field, conventional electrical insulation of magnet coils, which usually consist of a few layers of glass-fiber tape impregnated with epoxy resin, fails due to loss of mechanical and electricalproperties. As a solution, we have designed and constructed magnets with mineral insulated coils.

2. Cable to be used

The mineral insulated cable consists of three parts: a hollow copper conductor, magnesium oxide insulator and a copper shieth. As shown in figure 1, the magnesium oxide is in the form of a powder and held around the copper hollow conductor by a copper shieth. The hole in the center of the conductor allows direct water cooling. The current density of as high as 1000 ampers/cm^2 is attainable, which permit us to design high field magnets with very good insulation. In table 1, the parameters of the cable are summarized.

Table 1 Parameters of the cable

Overall size:	19.1 mm square
Conductor size:	14.2 mm square outside
	6.4 mm square inside
	3.0 mm minimum wall thickness
Insulation thickness:	1.52 mm nominal
	0.76 mm minimum
Shieth thickness:	0.76 mm
Materials:	conductor: copper, 100 % I. A. C. S.
	insulator: compacted magnesium oxide
	shieth: copper

In order to keep moisture out of the magnesium oxide insulation the sealing of the end of the cable is necessary. The seals must be non-organic since the high radiation level dictates the use of an in organic insulation in the cable. A fairy standard ceramic-to-metal seal is used. In figure 2, the seal are seen above and below the coils. Directly-cooled conductors also require insulating connections to water headers. Almina ceramic tubes are used as the insulation, since the conventional rubber horses are ruled out due to their radiation damage.

3. Magnets constructed

Four types of the magnets with mineral insulation are constructed. Two of them are Lambertson type iron septum magnets and act as the beam splitter. The loss of the primary proton beam at the septa causes high radiation field and necessitates the use of non-organic insulation. The remaining two magnets are the first magnets of the secondary beam lines. The distance between the front end of the magnets and the production targets is less than 30 cm. The maintenance of the magnets is extremely difficult owing to the residual radio activity of coils and yokes. In figure 2, the front end of the one of the two magnets (NQ618) is shown. This magnet is 30 cm diameter quadrupole magnet. The maximum field gradient is 0. 7 kG/cm. No organic materials are used in order to prevent radiation damage.

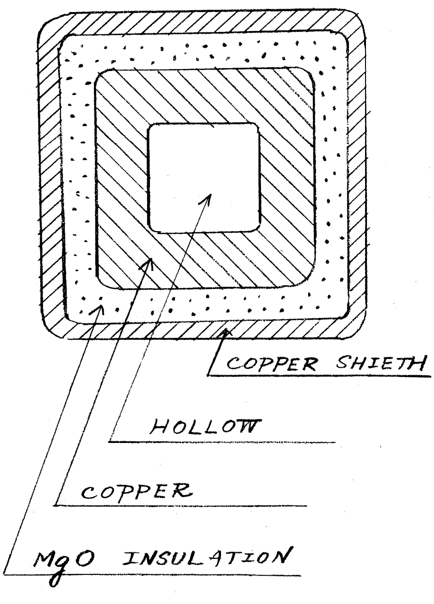

Fig. 1 Mineral insulated cable

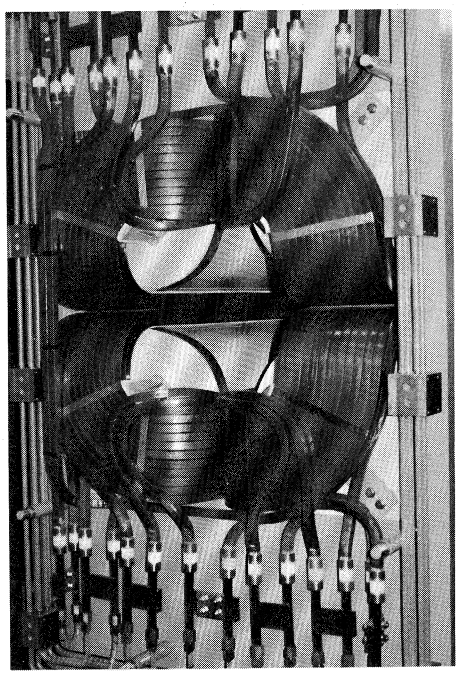

Fig. 2 NQ618 quadrupole magnet