Study of high magnetic field and AC operation of a high temperature superconducting magnet

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A HTS magnet has some advantages in principle in comparison with a LTS magnet, although only a few magnets have been built using HTS coils in the accelerator field. Since the HTS system has higher operating temperature than LTS system, a simpler cryogenic system can be used for cooling. In addition, as the temperature range to keep superconductivity is wider than that of the LTS system, a larger thermal margin is expected.

We have designed and manufactured two solenoidal coils with a HTC wire [1]. Specifications of the design parameters of the present solenoid coils are summarized in Table 1. After the successfull operartion as a solenoidal coils, the magnet was converted into a high-magnetic-field dipole magnet with only installing iron poles and a return yoke. The magnetic field measured and calculated by TOSCA code is shown in fig. 1 for the iron-core HTS dipole magnet as a function of a coil current. The magnetic field is saturated more than 50 A. With 197 A coil current, the magnetic field of 2.04 T was obtained. Figure 2 shows the magnetic fields with coil current on an AC operation. Coils were excited by a homo-pole direct current (DC) power supply in 0.05 Hz. The coil current was controlled from 4 to 115 A with a triangle waveform. The magnetic field ranges from 0.14 to 1.73 T and reproducibility was quite well. No linear correlation of the observed magnetic fields to the coil current is due to saturation of the magnetic field shown in fig. 1. Since the magnetic field well followed up to the current, no significant effects from eddy currents were found. Coil temperature increased less than 2 K after 5 minutes operation. More rapid cycling tests were also performed. Ramp rate of the magnetic field was observed about 0.5 T/sec at maximum in a 0.25 Hz operation. Present results clearly show that a large applicability of HTS wires to AC magnets, such as scanning magnets for the cancer therapy and high duty synchrotrons, etc. Beam scanning test with this HTS magnet will be carried out this April.

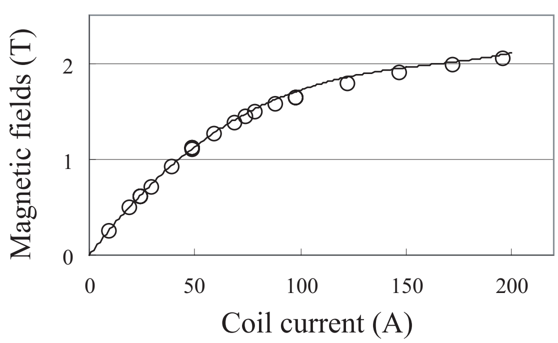

Figure 1. Magnetic fields Bz at the center of the air gap as a function of coil current(circle). Calculated magnetic fields are also shown(line).

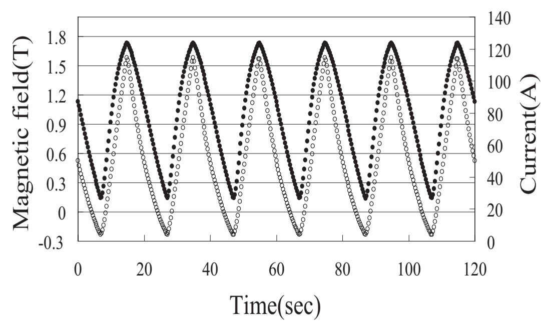

Figure 2. Observed magnetic fields on an AC operation(solid circle). The frequency is 0.05 Hz. Coil current measured at the current lead by a DCCT is also shown(open circle).

Table 1: Design parameters of the HTS-magnet

HTS-coils	Superconductor	Bi2223/Ag tape, total length 360 m
	No. of turns	292 × 2 coils
	Windind construction	4 pancakes/coil
	Critical current expected at 77 K	30 A
	Rated current	90 A at 30 K
	Maximum magnetic field in the coil	0.25 T in parallel to tape, 0.36 T in normal to tape
Cryostat	Cooling method	Conduction cooling by a G-M refregirator
	Thermal insulation	Vacuum isolation, 80 K shield and super-insulation
	Cooling power of the G-M refregirator	9 W at 20 K, and 18 W at 80 K

References

[1] K. Hatanaka *et al.*, RCNP Annual Report 2002, p141.