Comparison of magnetizing characteristics of superconducting bulk magnet cooled by Stirling and GM refrigerators during pulsed field magnetization

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Background

- We developed several type superconducting bulk magnets with the goal of their industrial application, and study to improve the trapped field by pulsed field magnetization.
 - It is important to select a suitable refrigerator to cool a bulk superconductor.

<u>Purpose</u>

- Magnetizing characteristics were investigated when using different refrigerators;
 - **D** Stirling: 11 W@77 K

Magnetic drug delivery system Large-scale wind turbine 10 **Superconducting** (Tesla) bulk magnet Linear shinkansen (maglev) field Superconducting MRI Magnetic magnet Superconducting bulk magnet Permanent magnet Electromagnet

Introduction

Dual-stage GM, air-cooled compressor: 5 W@20 K
Dual-stage GM, water-cooled compressor: 12 W@20 K

Small • Inexpensive • Big • Expensive Scale • Price

Fig. 1. Comparison of various magnets



Table 1. Specifications of the bulk magnet systems



Fig. 2. Application examples of bulk magnet

Experimental

- - 75.0 wt.% Gd123, 24.5 wt.% Gd211, 0.5 wt.% Pt powder
 - A stainless steel ring (SUS316L) 2 mm thick was embedded for mechanical reinforcement.
- The bulk was mounted on the sample stage connected to the cold head of each refrigerator shown in Table 1, and it was cooled to 50 K regulating with a temperature controller.
- A single pulsed field was applied while measuring flux density.
 - Applied field: $\mu_0 H=3.1-7.0 \text{ T}$ (rising time: 10 ms)
 - Flux density was monitored using a Hall sensor (BHT-921, F.W.BELL) adhered on the bulk surface (sampling rate: 100 μ s).
- After magnetization, trapped field distribution was measured on the vessel surface.
 - A three-dimensional Hall sensor (HGT-3030, LakeShore) was scanned on the vessel at a 2-mm pitch.
 - A total magnetic flux was calculated using the measured flux distribution data.

	Stirling	5 W GM	12 W GM
Photo	Hall sensor bulk sample		
Refrigerator	Stirling type(CryoTel CT, SUNPOWER)	Dual-stage GM type (RS271, AISIN)	Dual-stage GM type (RM20, ULVAC)
Lowest temp.	< 60 K	< 20 K	< 20 K
Cooling cap.	11 W @ 77 K	5 W @ 20 K(2 nd)	12 W @ 20 K(2 nd)
Power consumption	160 W / Single-phase 100 V	1.6 kW / Three-phase 200 V	5.0 kW / Three-phase 200 V
Compressor	Unnecessary	Air-cooled	Water-cooled





Conclusions

- We compared magnetizing characteristics of superconducting bulk magnet cooled by Stirling and GM refrigerators.
- Even the bulk magnet using Stirling refrigerator with relatively low cooling capacity could trap a high magnetic field.
- rightarrow The bulk magnet with high cooling capacity could not necessarily generate a high magnetic field.
- We will make the data which is the guideline to select a refrigerator for industrial application of bulk magnets by performing the magnetizing test in bulk magnet systems using several type refrigerators.

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