Experimental investigation of cooling capacity of 4K GM cryocoolers in magnetic fields

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Introduction

4K GM cryocooler has been widely used for cooling superconducting magnets, such as, magnets in MRI systems.

4K GM cryocoolers with magnetic regenerator materials are inevitably exposed to the magnetic field.

The cooling capacity of 4K GM cryocoolers will be affected by specific heat variation of magnetic regenerator materials under magnetic fields. The experimental investigation of the cooling capacity of SHI commercial 1W 4K GM cryocoolers in magnetic fields was carried out from the viewpoint of magnetic regenerator materials (HoCu2 only or HoCu2/Gd2O2S(GOS) hybrid).

SHI type RDK-40BD3 cold head using HoCu2/GOS hybrid magnetic regenerator materials can keep at about 4.2 K up to 2.0 T magnetic fields.

The purpose of experiment

To verify the cooling capacities of SHI commercial 1W 4K GM cryocoolers in magnetic fields (Focused on the effect of magnetic regenerator materials, HoCu2 only or HoCu2/GOS hybrid)

To study magnetic field direction dependence on cooling capacity

Experimental System

The source of magnetic fields

Experimental configurations

Experimental results

In axial magnetic field

In radial magnetic field

Discussion of AC magnetic noise

When the cold head is operated, the primary factors of AC magnetic noise are

The moving magnetic regenerator with magnetism fluctuates in external magnetic fields. The magnetism fluctuation of magnetic regenerator caused by an operated cold head.

Conclusion

- By using HoCu2/GOS hybrid regenerator, the cooling capacity of an SHI 1W 4K GM cryocooler can be kept under a magnetic field up to 2.0 T. (about 4.2 K with heat load of 1.0 W at 2nd stage in 2.0 T magnetic field)
- The magnetic regenerator material GOS is necessary for maintaining the second stage below helium boiling temperature, 4.2 K, up to 2.0 T.
- In magnetic field below 0.5 T, the dependence of magnetic field direction dependence on cooling capacity performance is not observed.
- It is considered that the amount of magnetic noise caused with operated cryocooler will be lower by using HoCu2/GOS hybrid regenerator.

In typical temperature and magnetic field, M, dM/dH and dM/dT of GOS are less than those of HoCu2.

When the position of coli center is 5.0 T

The magnetism fluctuation of magnetic regenerator caused by an operated cold head.