IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024

Development of 4K-GM Cryocooler and Its Applications for Superconducting Magnets

Toru Kuriyama

Toshiba Energy Systems & Solutions Corporation, Japan

E-mail: toru.kuriyama@toshiba.co.jp

***Abstract*—In recent times, superconducting magnets cooled solely by cryocoolers, without the need for liquid helium, have widely adopted in both academic and industrial applications. The 4K GM cryocooler plays a crucial role in achieving cryocooler-cooled or conductively cooled superconducting magnets. In this presentation, the developments related to the 4K GM cryocooler and its application in superconducting magnet cooling will be shown. Before the 4K GM cryocooler was developed, conventional two-stage GM cryocoolers were employed to cool thermal shields of superconducting magnets which were cooled by liquid helium. These GM cryocoolers operating temperatures were limited around 10 K by their ineffectiveness of regenerators. To achieve lower temperatures of a GM cryocooler by enhancing regenerator efficiency, magnetic materials such as Er3Ni and HoCu2 were replaced the commonly used lead material. This breakthrough allowed for the first successful achievement of 4K cooling using a two-stage GM cryocooler in 1990.**

Subsequently, the challenge started to cool superconducting coils with the 4K-GM cryocooler only. A NbTi coil was installed in a vacuum vessel and connected to the 4K cooling stage via a thermally conductive path. Another significant advancement was the high-Tc superconducting current leads, which dramatically reduced the thermal load at the 4K level. In 1993, the world's first cryocooler-cooled superconducting magnet was successfully created. Over the past three decades, these magnets have become increasingly common and found applications in a wide range of research and industrial settings.

***Keywords (Index Terms)*—4K-GM cryocooler, cryocooler-cooled superconducting magnet**

Presentation slides are available through the ICEC29/ICMC2024 conference website:
Kuriyama_Wed-Pl-4.pdf (cern.ch)

IEEE-CSC, ESAS and CSSJ SUPERCONDUCTIVITY NEWS FORUM (global edition), Issue No. 56, Sept 2024.
Presentation given at ICEC-ICMC 2024, July 2024, Geneva, Switzerland.