Abstract

In all superconducting applications it is necessary to bring the current from the power supply, always at room temperature, to the cold mass using current leads. In order to reduce the heat transferred to the cold mass, those connections must be carefully designed. In a big amount of applications those current leads are composed by different stages and in particular by a HTS (High Temperature Superconductor) superconducting stage. Those materials are extremely efficient for carrying current but at the same time they are very expensive and extremely fragile. This poster presents the result of a geometrical and soldering technique optimisation in order to build an high current superconducting lead minimizing the amount of expensive materials and avoiding the use of helium.

Introduction

A well designed current lead has to minimize the two heat contributions to the cold mass: heat conduction and Joule dissipation. In this case those two contributions are minimized optimizing the length and the cross section of the resistive part and using a superconductive stage with a low thermal conductance and zero Joule generation.

The goal of this project is to design a current lead able to carry 5 kA from room temperature to a cold mass at 25 K. The current lead is composed by 3 different stages as shown in Figure 1:

1. Resistive stage (RT – 77 K)
2. BSCCO stage (77 K – 30 K)
3. ReBCO stage (~30 K – 25 K)

The more expensive and critical stage is the BSCCO one because of the large amount of tape and the big temperature gradient.

BSGCO properties

For this study BSGCO Type – G tape by Sumitomo Electric®is used. This type of BSGCO was chosen for some of its good properties:

• Thermal conductivity

A low thermal conductivity helps to thermally decouple the different stages of the current lead, allowing to have a big thermal gradient in a small space.

• Critical current and temperature

![Figure 3. Thermal conductivity of Type H and Type G BSCCO from Sumitomo Electric®](image)

Using this constrain it is possible to find a geometrical configuration that minimizes the amount of the BSGCO tape, and consequently the cost, maintaining a sufficient margin on the critical current. The parameter used for the optimization is the integral of the perpendicular magnetic field through the section of the tape. In particular, the integral of the self-field generated at 160 A was taken as reference value.

\[ \int_{0}^{\text{B_{c1}}} \text{d}x \]

![Figure 4. Critical current as function of temperature, perpendicular and parallel external field, from Sumitomo Electric®](image)

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Design Optimization

As shown in Figure 4, BSGCO tape is very sensible to the external field, in particular to the perpendicular one. In order to reduce the amount of tape used for the current lead a minimization of the external field is done implementing a FEM simulation using Cohom Opera®.

The parameter used for the optimization is the integral of the perpendicular magnetic field through the section of the tape. In particular, the integral of the self-field generated at 160 A was taken as reference value.

![Figure 5. Cross-section of BSGCO tape.](image)

Conclusions

HTS current leads have two advantages: a reduction in the thermal input and a reduction in volume and spaces. On the other hand, HTS, and BSCCO in particular, are expensive and difficult to handle.

With this work, ASG showed that an industrial use of BSGCO tape is possible. It is possible to achieve the same result of very expensive HTS current lead using less material with great economic benefits. However, it remains a difficult material to handle because of its fragility. It is necessary, for industrial use, improve the manufacturing process in order to reduce the waste due to the material brittleness.

After many test, a specific soldering procedure has been developed.

The overall voltage drop of the developed modular lead BSGCO stage (Copper to Copper) is less than 1 uV/cm.

References


Contact

Alessio Capelluto Ph.D.
R&D Manager at ASG Superconductors S.p.A., Genova, Italy
Email: capelluto.alessio@asg-it
Website: https://www.asgsuperconductors.com/
Phone: (+39) 010 64 89 111