Design and Test of a double pancake coil wound by HTS Roebel cable

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Introduction

When the HTS SMES system charges or discharges current rapidly, it may have two problems:

1. Numerous magnet turns number
2. Current and Magnetic field distribution among conductors

To solve these two problem, the probable solution is:

HTS Roebel cable

1. Conductors in parallel
2. Conductors transpose position regularly

In this work, a HTS Roebel cable double-pancake coil module was manufactured and its \( I_c \) was measured at 77 K. This coil module was designed for toroidal SMES using conduction cooling method.

Coil General Parameter

<table>
<thead>
<tr>
<th>Parameter \ Item</th>
<th>Value \ Statement</th>
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<tbody>
<tr>
<td>Coil Type</td>
<td>Double Pancake</td>
</tr>
<tr>
<td>Total length of cable</td>
<td>&lt; 10 m</td>
</tr>
<tr>
<td>HTS material</td>
<td>ReBCO (Fujikura, Japan)</td>
</tr>
<tr>
<td>Number of cable Strands</td>
<td>10</td>
</tr>
<tr>
<td>Transposition Length of Roebel Cable</td>
<td>300 mm</td>
</tr>
<tr>
<td>Trun number of coil</td>
<td>8</td>
</tr>
<tr>
<td>Inner Diameter of winding</td>
<td>340 mm</td>
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</tbody>
</table>

This Roebel cable was manufactured by General Cable Superconductor, Ltd, New Zealand.

Structure Design Detail

Bobbin & PCP Holder: epoxy resin for insulation
Middle & Cover Pad: Al alloy for cooling condution; carve slots to avoid eddy current
Conduction Block: Al alloy, for supporting and cooling condution
Reinforcing Strip: stainless steel, for reinforcing the coil winding strength
Impregnation: paraffin wax, avoid delamination and maintain thermal contact between conductors

Current Terminal: PCP (Protective Copper Plate)

PCP Dimension:

- as long as Roebel cable transposition length for ensuring good contact with every strand

PCP merits:

1. Protect the ReBCO layer when need soldering to external current source
2. Make current distribution homogeneous

Ideal additional resistance of coil due to PCP (Soldering material: 60Sn-40Pb)

77 K: \[ 2.2 \, \text{n}\Omega \text{ (solder layer)} + 4.2 \, \text{n}\Omega \text{ (PCP) } \times 2 = 12.4 \, \text{n}\Omega \]

20 K: \[ 0.3 \, \text{n}\Omega \text{ (solder layer)} + 0.34 \, \text{n}\Omega \text{ (PCP) } \times 2 = 1.28 \, \text{n}\Omega \]

One coil has two PCPs

Voltage Probe soldered on PCP

Probe 2 & 3 were chosen for four-probe measurement (as shown in above segment)

Measurement Instruments

\( I_c \) Measurement

Voltage Probe soldered on PCP

Measurement

Central flux density

\( I_c \) measurement result

The Roebel cable coil \( I_c \) : 1025 A

(77 K, self field, 1 \, \mu\text{V/cm criteria})

The PCP has little interference on \( I_c \) measurement

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