Investigation of Characteristics of No-Insulation Coil Considering the Influence of Stress Distribution on the Turn-to-Turn Contact Resistivity

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Abstract—The No-Insulation (NI) winding technique is a utility approach to realize high field magnet. As operation current can pass through adjacent turns, turn-to-turn contact resistivity becomes one of the decisive factors that influence the thermal stability and excitation delay behavior of NI magnet. The turn-to-turn contact resistivity is mainly affected by the material of tape and turn-to-turn contact stress. Since the stress distribution in most design examples are scarcely considered, a mean resistivity is obtained through experimental test. In order to design the contact resistivity and ensure the NI magnet achieve the engineering standards, this paper investigates the pre-tightening force, thermal stress and electromagnetic force in the process of manufacturing, cooling and excitation of the high temperature superconducting NI magnet. A distribution of the contact resistivity is obtained considering the varying tendency of the contact resistivity while stress changing. Equivalent circuit model and finite element model are applied to analyze the excitation characteristics of the NI coil. The results are compared with the mean resistivity value model and can provide theoretical basis for the design of the NI magnet.

I. Measurement of contact resistance dependence of pressure.

The contact resistance of different number of tape stacks is measured: R1, R2 and R3 are the total resistance when the number of layers are 2, 3 and 4. The contact resistance is obtained by subtracting each Ri and take the average value as the resistance value of the turn to turn contact. The contact resistance dependence of pressure is shown below:

<table>
<thead>
<tr>
<th>Total resistance</th>
<th>Number of layer</th>
<th>Consist of the resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2</td>
<td>Rc</td>
</tr>
<tr>
<td>R2</td>
<td>3</td>
<td>2Rc</td>
</tr>
<tr>
<td>R3</td>
<td>4</td>
<td>3Rc</td>
</tr>
</tbody>
</table>

II. Stress analysis of single no-insulation coil.

A. Radial stress by constant winding stress of 50MPa and 5MPa

B. Radial stress by winding stress F(1) and F(2)

C. Contact resistivity and contact resistance

D. Energy loss analysis of the DC SFCL prototype

III. Contact resistance distribution under different prestress

A. Radial stress by constant winding stress of 50MPa and 5MPa

B. Radial stress by winding stress F(1) and F(2)

C. Contact resistivity and contact resistance

D. Energy loss analysis of the DC SFCL prototype

This paper based on the analysis of stress distribution, loss distribution in the process of self excitation was calculated, and the calculation results are compared with uniform Rci model. The total loss is equal while the distribution are quite different. The establishment of the calculation model for the accurate analysis loss of NI coil. The effect of changing stress distribution to reduce the characteristics of the NI coil at 77K is not obvious, the method may be more applicable when the electromagnetic stress is greater and the temperature is lower, which remain to be further discussed.

IV. CONCLUSION