Optimized and Practical Electrical Joints for CORC type HTS Cables

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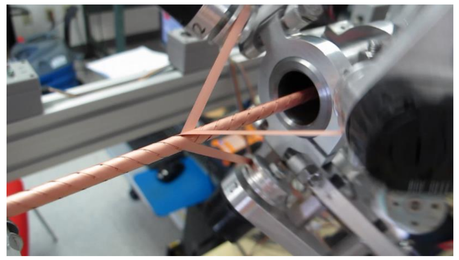
Introduction

CORC (Conductor On Round Core) is the youngest HTS cable technology. CORC is a flexible round cable featuring many layers of ReBCO tapes wound on a thin core.

CORC type HTS cables are pursued by CERN for application in future detector and accelerator magnets. Key issue is the design and qualification of joints. The challenge is to minimize the resistance in high current cable joints with a growing number of layers.



CORC cabling machine, photo by ACT

We

- developed a new joint design allowing low-resistive joints for CORC cables with many layers;
- developed a custom-built finite element model for simulating the behavior of joints;
- performed measurements in the FRESCA cable test facility at CERN to validate our design.

Joint Design and Fabrication

❖ Low-resistive joints are needed for CORC cables with a large number of layers, while keeping the manufacturing process practical and the size of the joint similar to the envelope of the CORC cable.

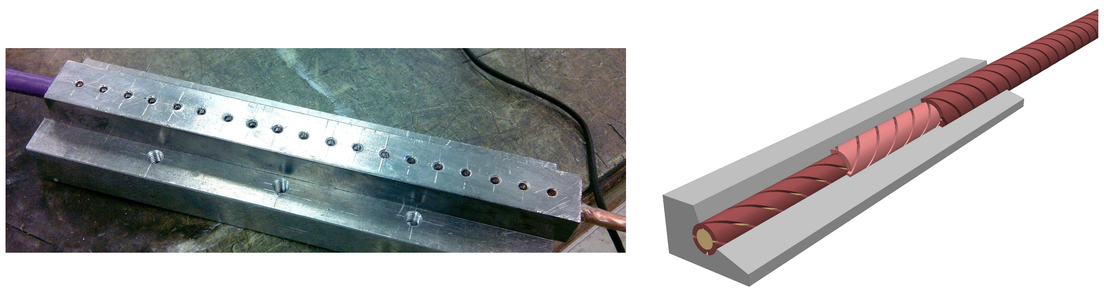
❖ The **new** design aims to **reduce the current transfer resistance to the inner layers by trimming the outer layers**. This improves the current distribution across all layers, but causes a slight increase of the joint resistance at low current.

Features of the design:

- CORC cable is placed in an OFHC copper casing;
- voids in the casing around the cable is filled with solder;
- ReBCO layers are trimmed to reduce high inter-layer resistance;
- joint casing is manufactured to fit the shape of the trimmed cable.

During fabrication, first both ends of the CORC cable are trimmed. A bandage of solder keeps the tapes together after trimming and allows insertion of the cable into a slim casing.

The CORC cable is inside an OFHC copper casing, voids filled in semi-vertical position with eutectic Sn63Pb37 solder. Small holes in the casing allow gas to escape while filling and are then closed.



A rectangular joint during the filling process (left) and a schematic overview of the geometry inside the joint (right).

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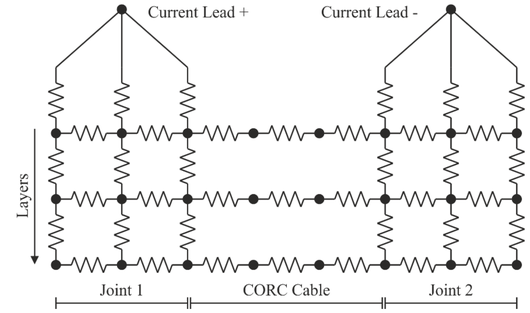
Model and Results

Finite Element Model was custom built for simulation and evaluation of the new joints.

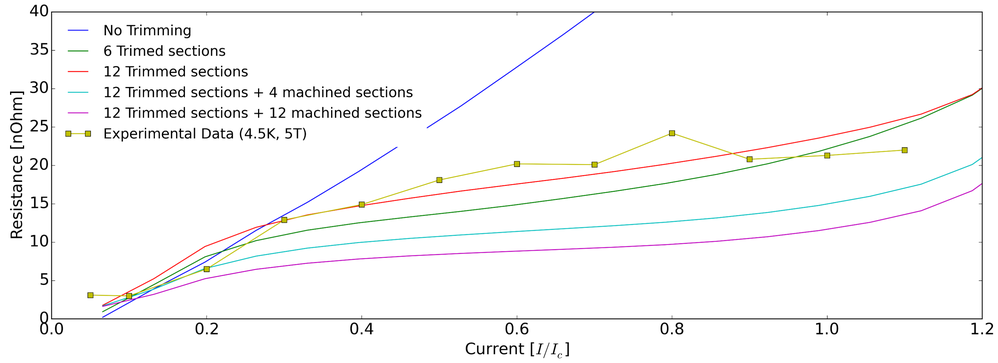
The model:

- solves a resistance network for linear and non-linear resistance;
- varies the number of layers and trimmed layer section;
- varies the machined sections in the casing;
- varies the length of the joint and length of the cable.

We have a 12 m long CORC cable with 38 tapes in 12 layers. The model uses the geometry of this cable in the simulations. Simulated joints are outside field and has a joint length of 20 cm at a temperature of 4.5 K.



Schematic of the resistance network.



Simulated and measured resistance of various joints.

Simulations show:

- Trimming the layers in a few steps reduces the joint resistance for this cable by some 50%;
- Best result for a 12 layer cable is achieved by trimming in 6 sections;
- Shaping the casing following the steps reduces the joint resistance by another 20%;
- In total the joint resistance can be reduced by some 70% or even more for longer joints;
- Resistance scales with length.

Measurement in the FRESCA facility at CERN has demonstrated the expected non-linear joint behavior but a slightly higher resistance. The difference can be explained by a non-optimal soldering between the joint and the lead.

Conclusion and Outlook

❖ The novel joint design is made to reduce CORC joint resistance.
❖ Joint model is built to better understand of the new joints.
❖ Trimming can reduces the joint resistance up to 70% for a cable with 12 layers.
❖ Measurements confirm the expected non-linear joint resistance.
❖ Research is ongoing and in the near future more joints with different cables will be tested.
❖ The design will be scaled up for CORC type Cable in Conduit Conductors.

CORC type CICC