HIGH QUALITY SPLICES OF SUPERCONDUCTORS

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1. Introduction

Important developments have been made in the technology over the last 50 years for the large-scale applications of superconductivity in terms of field strength, scale, field volume, and stored energy. The development of new conductors has increased their capabilities to withstand high current densities and large mechanical forces and stresses. The use of superconductors allows production of high field magnets. The magnets for NMR and MRI generally require superconducting splices.

Splice: a join consisting of two ropes, pieces of tape, etc. joined together at the ends.
(Definitions from Oxford Languages)

Reasons to prepare splices in NMR and MRI magnets:

- connection to power supply
- joining the preprepared superconducting units

Thus, the splicing technology is very important in developing applied products and expanding the practical applications.

To prepare splices is crucial from point of quality of the superconducting circuits: to ascertain superconducting quality of the splices is not an easy task.

Main requirements regarding the superconducting splices:

- Mechanically and electrically sound (low sub nΩ electrical resistance)
- Dismountable if necessary – multiple times
- Compact – space many times is an issue
- Use of tooling easy to multiply
- Possibly industrially based tooling

Based on our preliminary experiments, the explosive welding technique could satisfy all the criteria above for making high quality splice joints.

2. Experimental

Systematic R&D work was carried out for splicing together copper stabilized superconductor cables using the explosive welding technique. This technique represent new paradigm in the field of metalprocessings: joining of the materials can be carried out directly, by high speed, high energy shock waves. The shock waves can be created by high explosives.The high explosives are chemical systems, produced in different forms as powder, plastic or detonating cords. During the chemical reactions of these systems high pressure gases are created resulting high energy shock waves which prssed together the metals to be bonded. Advantages of the explosive cladding process over the conventional ones:

- Bond can be created between normally incompatible metals (e.g. titanium and copper)
- There is no practical limit to the ratio of thickness of the metals to be bonded
- The explosive cladding process requires minimum facilities and tooling

The general concept of the splicing technology is the following:

The superconducting cable will be embedded into a copper matrix (sleeve) by using the explosive welding technique. A shallow angle cut is introduced that splits the cable (where the sleeve is located) into two pieces.

NbTi foil is placed in between the two cable pieces at the location where the cut has been made. The NbTi foil will cover only the superconducting cable cross-section. The sleeve area will not be covered.

The two cable pieces will be cold welded together using the explosive welding technique. Series of experiments were performed according to the arrangement in Fig.1.

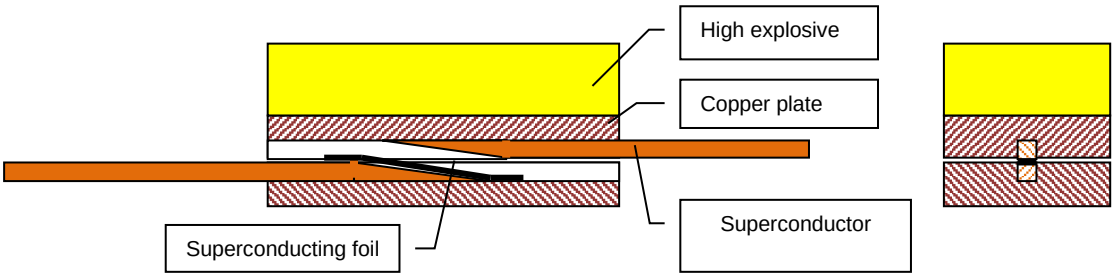

Fig.1. Arrangement of explosive splicing technology

Characteristic parameters of the components used for the experiments:

- Superconducting cable: NbTi 2,17mm*1,45mm
- Copper plate: CuE 50mm*35mm*4mm
- Superconducting foil NiTi 20mm*1,45mm*0,15mm
- High explosive: Permon 55 gramm

3. Results

The method applied for qualify the quality of the splices is based in making the splice in a loop of cable, inducing a current in it and measuring its decay time constant.

The electrical resistance of superconducting cable splices is in the 10^{-9} Ω range.

Conclusions:

- By applying the properly calculated and directed shock waves on a carefully designed experimental arrangement it is possible to weld superconducting wire ends creating splices
- Explosive material selection is of outmost importance, as critical diameter of the explosive will impose a minimal size constraint. By decreasing the critical diameter the splice size can be decreased. Performing of further systematic R&D work is needed to achieve practical application of this technique.
- NiTi foil can be welded on copper surface, material properties permit the use of foil insert. In splices the realization of foil insert needs further research

References:

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