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Fabrication and testing of Bi-2212 test coils for high field research magnets

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Abstract

High temperature superconductor (HTS) wire and tape materials are capable of increasing the maximum central field attainable from superconducting magnets due to their high critical current density and upper critical field. High fields may be achieved by the use of HTS insert coils operated at 4.2K inside high field low temperature superconductor (LTS) 'outsert' magnets. Use of HTS inserts in wide bore LTS magnets will enable central magnetic flux densities of 25T and beyond with typical research magnet bore sizes.

Oxford Instruments (OI) is engaged in a collaborative research programme with Dresden High Magnetic Field Laboratory (HLD) and Bruker-OST to fabricate a set of HTS test coils utilising Bi-2212 round wire for operation inside a 19T /150 mm LTS magnet, already in operation at HLD. The coils are designed and instrumented with the aim of determining safe operating limits of the HTS wire material and to test a range of processes used to wind, react, terminate and manage stress in insert coils of this type. Challenges with this type of insert coil include termination, quench protection and high mechanical hoop stress. We report on progress on this test coil programme and results of testing.

Introduction

Bi-2212 silver matrix wire is available from B-OST in round wire form, as such, the coil fabrication techniques that can be used are similar to those used for LTS round wires. A series of small HTS test coils have been manufactured using this wire. Dimensions of the coils are given in Table 1. Coils A and B have been tested in 17 T and 19 T background fields. Coils C and D are wide bore coils designed and instrumented for coil hoop strain tests and are yet to be tested.

Table 1 Coil	Wire diameter [mm]	Coil length [mm]	Inner radius [mm]	Outer radius [mm]	Coil layers	Heat Treatment Reaction Type
Coil A	1.5	50	14	35.7	14	Standard
Coil B	1.5	50	14	35.7	14	Over-pressure[b]
Coil C[c]	1.5	58	53	59.2	4	Standard
Coil D[c]	1.5	58	53	59.2[a]	4	Standard

[a] not including over-bind [b] Over pressure heat treated at 50 bar
[c] Coils C and D not yet tested in 19T background.

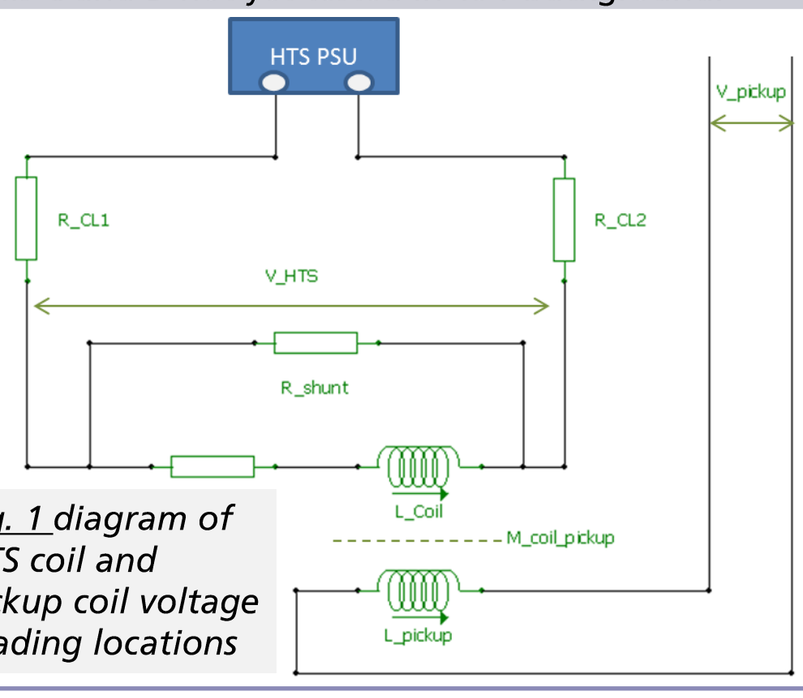

Fig. 1 diagram of HTS coil and Pickup coil voltage reading locations

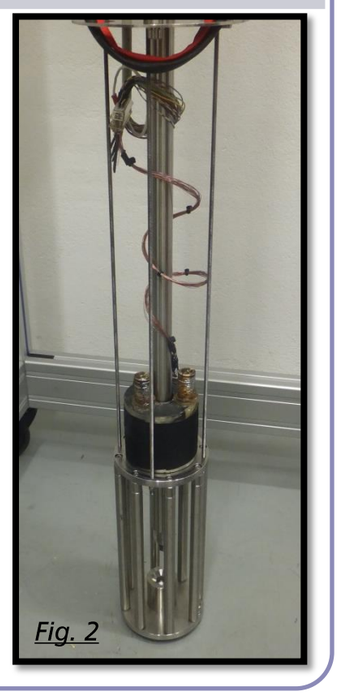

Fig. 2

Testing and Results

Background field and cryogenic environment for testing were provided by the 19Tesla, 150 mm bore outsert magnet system, manufactured by OI and in operation at HLD.This LTS magnet does not have a persistent switch so was driven by its PSU.

Test coils were loaded into the system on a specially designed magnet support stand (Fig.2).The coils were protected by a parallel passive shunt resistor. A pickup coil was located around the hall probe such that an inductive voltage could be monitored. Heater driven quenches were performed with coil A and B at background fields up to 17T and we monitored temperature, hall probe reading, and HTS coil and pickup coil voltages.

Fig. 4 shows the normalised results of a forced quench driven by increasing heater power in steps.

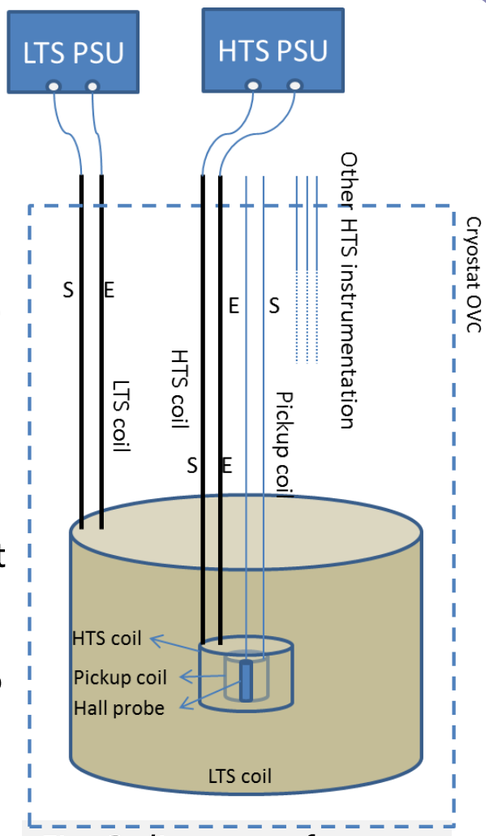

Fig. 3 diagram of experimental set-up.

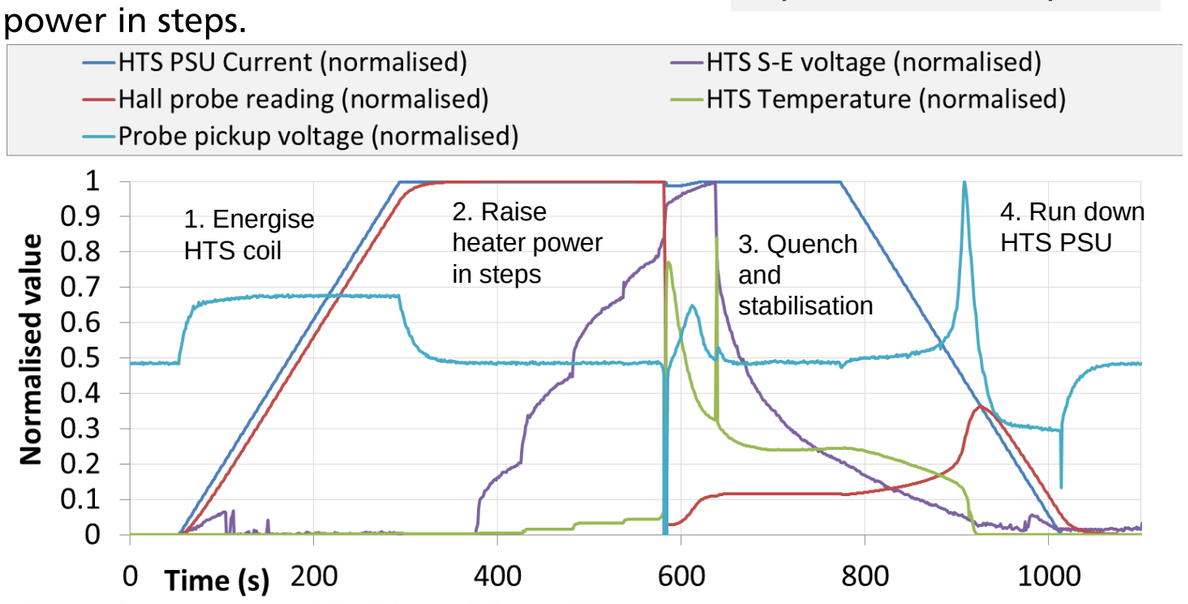

Fig. 4 Quench at 17T LTS + 400A HTS by raising the heater power in steps

Conclusion and next steps

- Both coils A and B reached 400 A in 19T LTS background field, limited by the available HTS PSU.The measured central field was 21.75T for both HTS coils, indicating a field of 2.75T provided by the HTS.
- Heater driven quenches were performed with coil A and B at background fields up to 17T.The shunt resistor adequately protected the coils - no degradation of coil performance as a result of quenching was seen in either coil.
- A new PSU of 1000 A is on order and will allow higher HTS currents.
- The strain limit on the Bi-2212 coils and use of over binding to control strain will be explored with coils C and D, as planned.

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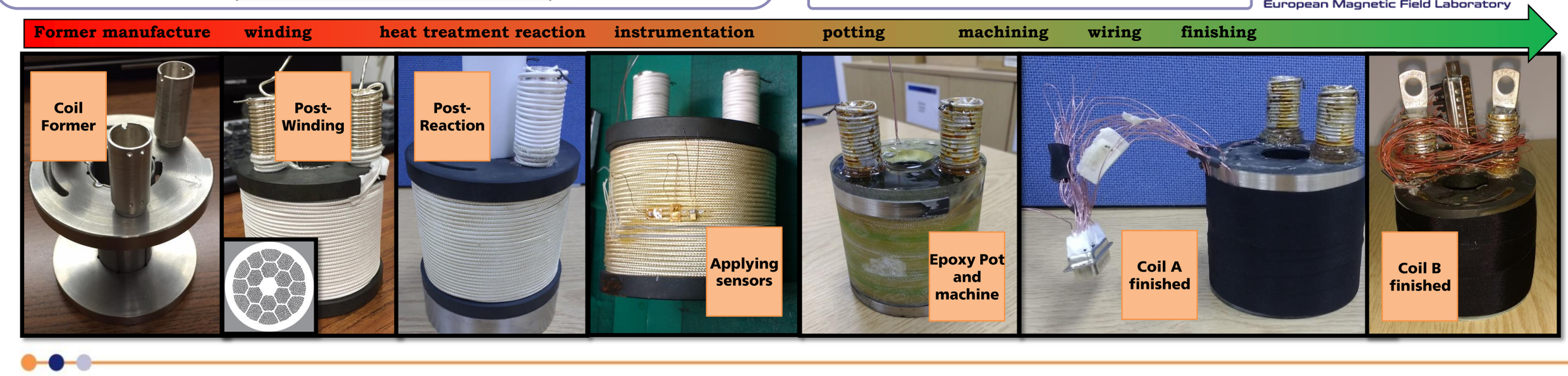

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