Measurement of heat transfer from cable to outside the insulation

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Recent progress

Goals

Resources

Collaborations

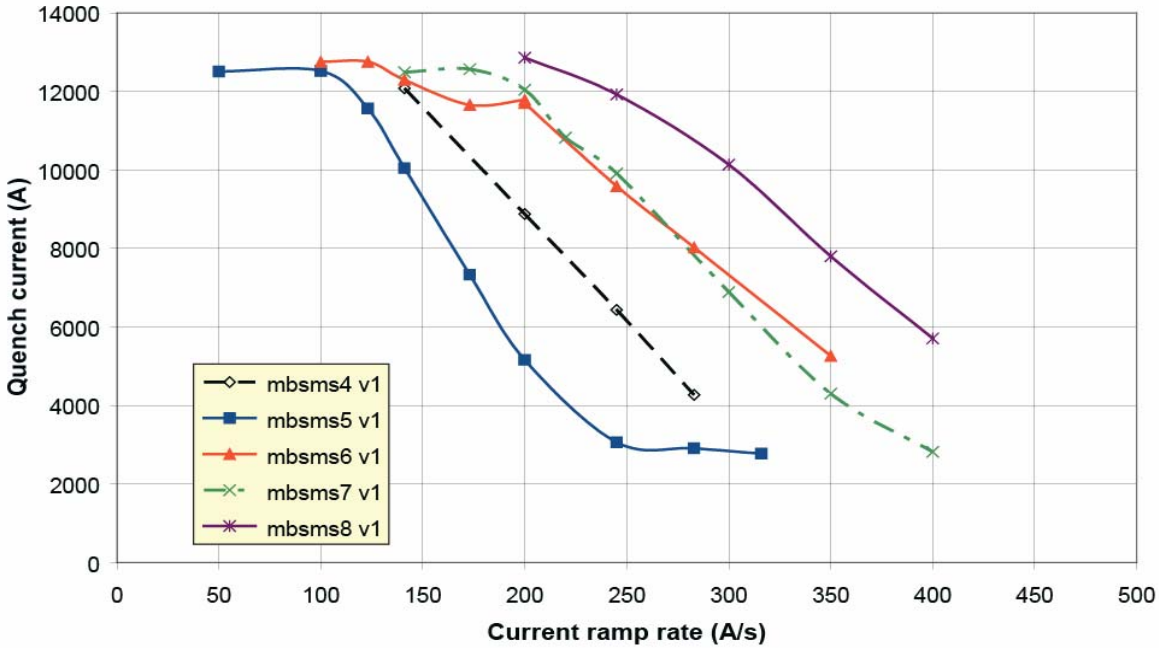
Goals - I

- In general
  - To furnish experimental data
    characterising the ability of concrete conductor-insulation-coil configurations to release heat into their He coolant.
  - To study the thermal link between He inside a cable/coil and the bulk LHe.

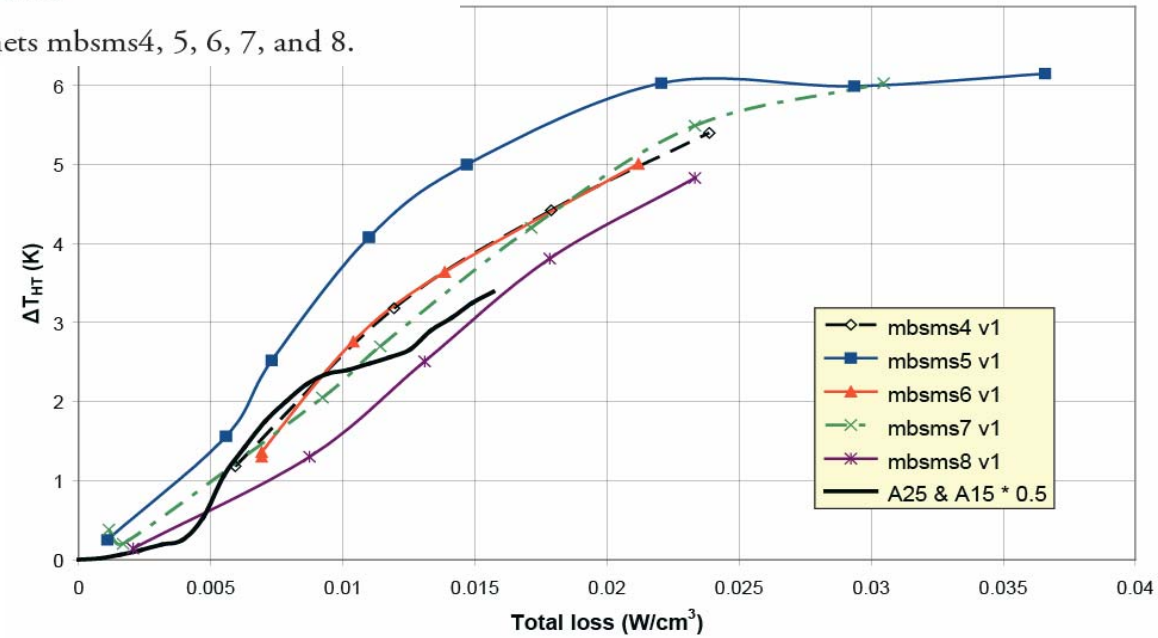
Recent progress

- Our work started as a resumption of few far sighting activities of the HERA/SSC/LHC R&D period, in particular:
  - Of the high ramp rate quench analysis done by A. P. Verweij, pub. 1995, and
  - Of the direct heat transfer measurements on stacks of stainless steel mock-up cables by Ch. Meuris, B. Baudouy (CEA Saclay) and L. Burnod, D. Leroy, B. Szeless, pub. 1991 ÷ 1999.
- Two parallel activities:
  - Analysis of High Ramp Rate Quenches in 1 m MBSMS/T model magnets.
  - Direct heat transfer measurement on segments of production magnet coils.
- Work started in the fall of 2005, main part done in January through August 2006, on hold since then.
- Paper/poster at the ASC 2006.
- AT/MCS seminar October 3, 2006.

HRRQ and HT data for the mbsms4 ÷ 8 magnets



HRRQ with pre-cycle quench data for the model magnets mbsms4, 5, 6, 7, and 8.

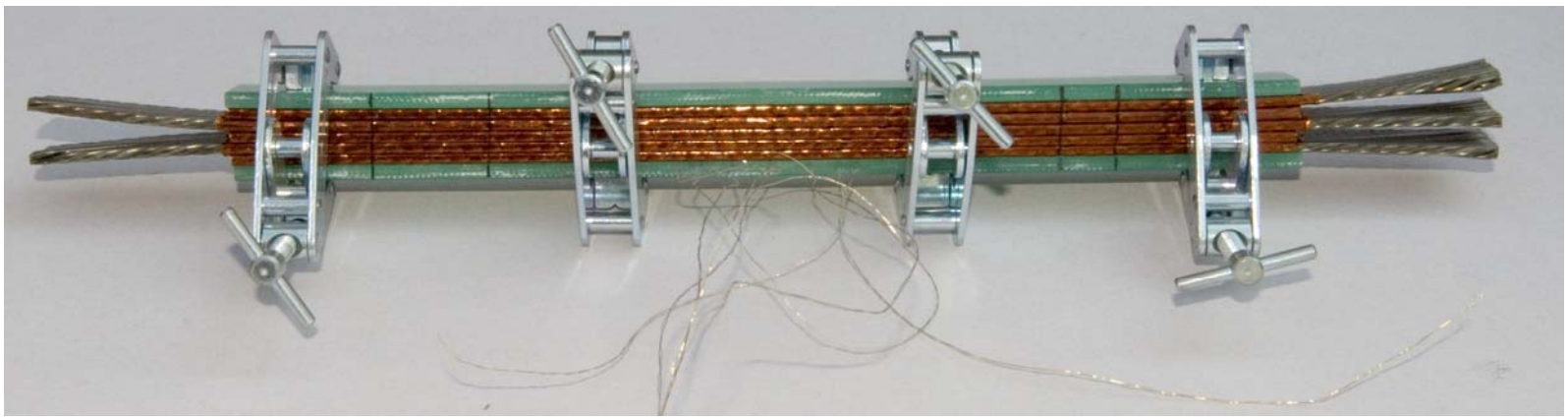


HT data for the model magnets mbsms4, 5, 6, 7, and 8. For comparison is shown the 'A25&A15*0.5' HT curve.

DR, 3/10/2006

Measurement of HT on a segment of an LHC dipole coil

- The sample is a segment from a production coil of an LHC main dipole.
- Temperature of the superconductor is measured using arc-welded $AuFe_{0.07at\%}$ / Chromel thermocouples.
- Heat is generated in a way inspired by the DC method used for the inter-strand contact resistance measurement:
  Current is injected into a few strands of the Rutherford cable, generating heat in the contacts between all strands.



Conclusions

- We have 1) analyzed the heat transfer properties of a number of 1 m long LHC model dipoles and 2) devised a method for measurement of HT on segments of magnet coils.

  Both methods gave results that can be understood on the basis of the previous measurements by CEA, ref. [2]-[6].

- Evaluation of HT from HRRQ data is a unique method offering characteristics of a real magnet in close-to-real heating conditions.

  According to the condition of the magnet, it may be difficult to obtain results for lower heat fluxes. The agreement obtained with the CEA data [2]-[6] is rather good.

- The HT measurement of the coil segment was an attempt to test a real coil in smaller scale experiment with more freedom in power setting and in sampling. As performed, the experiment suffered some flaws but proved feasible and promising.

  Comparison with the CEA data [2]-[6] indicates the possibility of heat leak from the sample extremities. Several remedies were proposed. Once the technological problems are solved, the method could give new information about HT in SC coils.

Goals - II

- High Ramp Rate Quench analysis:
  (Analysis completed for the easier part of the 5 block single aperture 1 m MB models.)
  - Could be done for some other MBSMS magnets and for the MBSMT magnets.

Goals - III

- Direct heat transfer measurements on coil segments:

  (Feasibility of the approach demonstrated.)

  - Transforming the technique into a mature self-contained experiment.
  - 'Standard measurement' of the transfer of heat from the conductor to the coolant:
    - The LHC main dipoles, the LARP & KEK IR quadrupoles, the MQM, MQY, MQ LHC quadrupoles, … (if the technique confirms valid).
  - Tests taking advantage from the small size of the TCJ, and from the non-uniform heating by currents flowing through the inter-strand contacts:
    - Role of He inside the cable (temperature measurement between strands).
    - Temperature of helium in the coil.
    - Heat re-distribution inside a cable in stationary regime (temperature difference between the most heated strands and the cooler pool of strands).

Resources at CERN

- Material:
  - Equipment
    - Re-using 100 % of an $I_{C,STRAND}$ test station + 50 % of an R_C test station in bld. 163.
  - Consumables
    - Thermocouple wire for instrumentation.
    - Segments of magnet coils as samples.
- Human:
  - Jan – Apr 2006: 1 staff
  - Apr – Aug 2006: 1 student + 1 staff
  - Starting from Sep 2006 : 0

Collaborations

- No contractual collaboration.
- With the CEA Saclay collaboration de facto:
  - B. Baudouy, CEA, coordinates the NED Thermal Studies and QP package.
  - Working with stacked stainless steel plates, CuNi cables, and discs.
  - CEA on turn collaborating with KEK.
- Other centres, where similar work is done:
  (No collaboration)
  - LARP in FNAL: High Ramp Rate Quench analysis.
  - KEK: Stacked CuNi cables.