



6th International Workshop on Numerical Modelling of High Temperature Superconductors

Caparica, Portugal, 26 – 29 June 2018

Wrap Up Notes



Rotating Machines

- 2D models can always be used in a first approach, but 3D modelling is increasingly needed to capture fine effects, e.g. end effects and inhomogeneities between different sections that cause torque ripple and vibrations.
- AC loss of all HTS parts should be reliably computed.
- More physics should be added, in particular, fluid-dynamic for taking into account the effect of the turbulent flow of LN₂ in terms of inhomogeneity of heat exchange and friction.

Quench

- Current distribution and thermal effects of Röebel cables are inherently 3D phenomena and need to be determined along the cable length (2D model unsuited).
- Effect of contact resistance should be taken into account.
- Effect of low n-value should be investigated.
- Fluctuation of critical current should be considered.
- New techniques such as fluorescent imaging can be considered to carry out more experimental investigation and to validate the numerical predictions.

Bulks

- Similarly to rotating machines, 2D models (bar or axisymmetric) can be used as a first approach, but usually give a result which does not closely fit experimental data.
- Bulk magnetization processes such as pulse-field magnetization require to integrate the thermal effects. Heat exchange plays an important role and should be appropriately modeled.
- Many problems involving a large number of variables, such as levitating devices (with changing geometries), or large magnet systems, will likely benefit from parallel computing carried out on supercomputers.

AC loss and constitutive relations

- Models for taking into account the coupling currents of multifilamentary wires should be pursued.
- An effort should be done to define more precisely the terminology of AC loss.
- Typical AC loss (and screening currents) calculation for real geometries involves a large number of variables. Benefits can be obtained by supercomputer and parallel computation.
- Efficient parallel computing may be related to formulations and algorithms and requires one to think properly about the nature of the problem.
- Different one-to-one constitutive relations (e.g. power law and percolation law) can effectively be incorporated in existing numerical codes. The difference between results obtained with the different constitutive relations mainly arises in phenomena involving low electric field (relaxation phenomena). No substantial difference arise concerning, e.g., AC loss at power frequency.
- Other, simpler, E-J laws are also of relevance, such as those worked out by Phil Anderson in his theory of thermal creep.
- Reliable identification of the parameters of the constitutive relations is essential. In particular, characterization at low electric fields is required. Papers from the past might contain information on this aspect.

Mechanical aspects

- Delamination problems are in some ways very similar to issues which have already been tackled by scientists in the semiconductor industry. A cross-field approach may be fruitful here.

3D Modelling

- The methods which have been discussed in the session were the variational approach and the T-A formulations. Both offer interesting perspectives, and work is needed to determine whether there is a method of choice in a given application with given constraints.
- Superconductors and ferromagnets can be used for both cloaking applications and shielding applications. These approaches are complementary. The choice of materials, or combination of materials, depends on the application scope and the magnetic field strengths.

High-field magnets and Grid applications

- An effort is needed to define a terminology for the critical current, as different authors tend to use similar terms for referring to a "minimal critical current", an "average critical current", an "average per turn", or an "end-to-end" critical current. It would be interesting to involve the industry and standardization organisms (IEC, IEEE) in this process and base the definitions on well-defined experimental procedures.

Maglev and bearings

- There is a need for a mechanism for researchers to share tricks and tips on commercial software packages (e.g. COMSOL).