Technology options for the accelerator magnets

The resistive dipole magnets to be designed for the Muon Collider accelerator are characterized by the following main specifications:

1) Magnetic field in the aperture about 1.8 T

2) Ramps from $-B_{max}$ to + B_{max} in the order of ms. The objective for the value of Bmax is 2.0 T

3) Limit the magnetic stored energy (crucial design specification to limit the supplied power). This is the first priority of the magnet design.

4) Limit the total losses (iron + copper). This is the second priority of the magnet design.

5) Magnetic field homogeneity within 10 × 10-4 in the good field region (30 mm * 100 mm). This is the third priority of the magnet design.

The design methodology adopted is based on the *following guidelines*.

The first priority for the design of the resistive magnets is the minimization of the total energy stored in the magnet. The very fast ramps (1 ms) specified require a huge amount of power (order of GWs) from the power supply, which can only be reduced by minimizing the stored energy.

The second priority is minimizing the losses in the magnet during the fast ramps, as they affect the overall operation costs and sustainability of the machine. The losses occur both in the ferromagnetic core, in the copper coils and in the mechanical structure. The reduction of losses in the copper can be obtained by proper segmentation of the conductor, also accounting for the local direction of the magnetic field.

The third design target is the magnetic field quality in the gap. Its optimization can be performed by properly modifying the geometric configuration of the magnet.

An optimization study in DC conditions performed on three resistive magnet configurations provided useful information on the most suited configuration. The *H-type magnet* leads to a low value of both the stored magnetic energy and the losses and was selected for the following analyses.

A simplified model of the magnet, to be coupled with the power supply system model, is under development (non-linear magnetic circuit model and analytical formula for the losses in ferromagnetic materials identified).

As for the future activities, a validation of the 2D FEM model of the magnet is required, which can be obtained by studying the electrodynamic transient with non-linear materials (the AC model implies linearizing the ferromagnetic materials). Further studies will be performed to optimize the selection of ferromagnetic materials, reduce the iron and copper losses, and identify a proper cooling technology. To achieve these goals, a thermal model of the magnet including heat exchange with a coolant should be developed. Further development of the simplified model of the magnet are required for a simultaneous optimization of both the power supply system and the magnet.