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Transient finite-element simulations of fast-ramping normal-conducting magnets for a 10 TeV muon collider

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Ongoing conceptual studies for a 10TeV muon collider identified rapid cycling synchrotrons as major engineering challenge. Due to the muon's short lifetime of only 2.2µs at rest, normal-conducting bending magnets with field rise rates of well beyond 1kT/s are indispensable to support accordingly fast acceleration cycles. Energies of 100MJ will be interchanged between magnets and capacitor banks within few milliseconds. Accurate models of the magnets are thus required to optimize the overall system performance. The non-uniform temperature distribution in the magnet strongly affects material properties like the electrical conductivity of copper and must therefore be considered in the electromagnetic field problem. This contribution presents recent advancements in addressing this multi-physical problem by using problem-specific finite-element tools allowing to describe the inherently transient behavior. The ferromagnetic yoke is accurately resolved by using a novel combination of a Bergqvist hysteresis and a homogenized eddy current model. Finally, different magnet design concepts are compared in terms of material costs, magnetic energy, losses, field quality and temperature buildup.

Footnotes

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