Optimal design of coils made of coated conductors

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Nowadays, devices made of coated conductors are being designed for several applications including magnets, rotating machinery, transformers, superconducting magnetic energy storage (SMES) and fault current limiters (FCL) among others. At the core of each of these applications is the superconducting coil. The high current capacity of coated conductors at high fields has made them the candidate of choice for manufacturing compact and light coils that can be used in the large scale power applications described above. However, the performance of such coils is limited by their critical current, which is determined by several factors, including the coil's geometry and the tape's material properties. In this work, we present coils whose design has been optimized whit respect to: mass, volume, critical current, AC losses and magnetic field produced at their center. The optimization process is done by means of a self-consistent model that considers a continuous E-J relationship and takes the angular dependence of the critical current density (Jc) on the magnetic flux density (B) into account. The model is based on the asymptotic limit when time approaches infinity of Faraday's equation written in terms of the magnetic vector potential. Overall, a considerable increase of the coils' performance has been achieved. Using the same amount of superconducting coated conductor tape of a non-optimized coil, we found a 20% increase of the coil's Ic and a similar increase of the magnetic field in the coil's center. Furthermore, the optimal design showed a 38% reduction of AC losses.