Superconducting RF Cavity Performance Degradation After Quenching in Static Magnetic Field

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Abstract

A magnet placed in the vicinity of a superconducting cavity, like in accelerating modules of RF linacs, can be a source of degradation of the cavity performance, which manifests itself as a drop in the cavity quality factor. This degradation is due to the appearance of normal conducting zone associated with each magnetic flux quantum trapped in the superconducting material; its extent is proportional to the total magnetic flux (or the number of the magnetic flux quanta) trapped in the cavity walls. The drop of the quality factor results in the increase in the RF power needed to keep the electric field in the cavity on a desired level; one of the main goals of RF system design is to limit this increase. As superconducting materials are perfectly diamagnetic, walls of RF cavities can serve as a natural shield that prevents the magnetic field generated outside from reaching inside. During quenching, which is a thermal instability in the cavity wall causing an abrupt dissipation of electro-magnetic energy stored in the cavity, a part of the cavity surface becomes normally conducting. As a result, the magnetic field can get inside the cavity and subsequently be trapped in the cavity wall after it cools down to become superconducting again. The amount of the trapped flux depends of the level of the magnetic field and the size of the normally conducting zone in the cavity wall during quenching. Both this size and the trapped flux can be found by modeling using COMSOL Multiphysics. Results of the modeling made for one of superconducting cavities built at FNAL were compared with the data obtained in a specially designed experiment, where the magnetic field was generated by a superconducting magnet. Figure 1 compares the measured and predicted change of the quality factor; current feeding the test magnet was used as an independent parameter here. This study helped to define a formal acceptance criterion for the level of magnetic field on walls of superconducting cavities and to develop a computational approach to verification of this criterion for combination of any cavity and any magnet in modules of superconducting linacs.

Figures used in the abstract

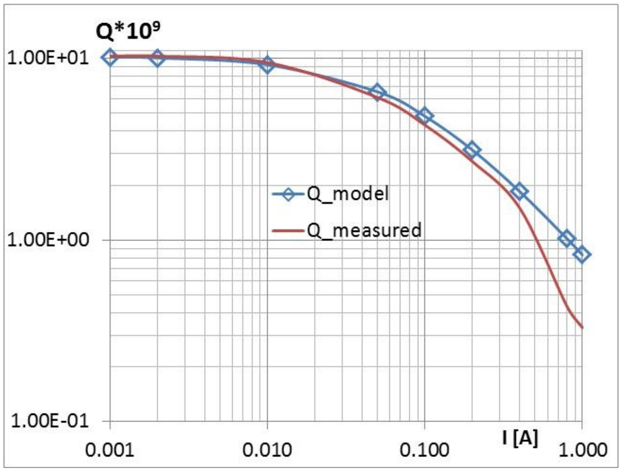

Figure 1: The modeled and measured quality factor after quenching in magnetic field.