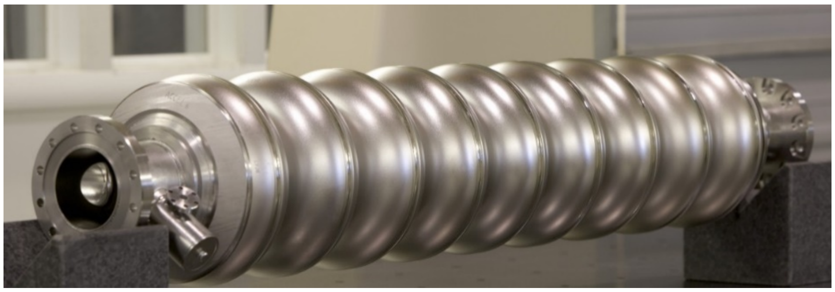
Application Note: Field in SRF Cavities



Source: https://td.fnal.gov/srf-department/

OVERVIEW

As particles accelerators aim to increase their energy levels, there is also a requirement to limit the increase in costs of operating the facilities.

In order to do so, it is important to reduce heat loss by increasing the quality factor (Q factor) of the superconducting radio frequency (SRF) cavities. One of the elements which drives the increase in Q factor is the reduction in trapped magnetic field within the niobium cavity.

The Mag-01H and Mag F probes, or the Cryomag are used to monitor the field at the surface of the cavities or within the magnetic shield which surrounds the cavities.

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Equipment

- Single and Three-axis Fluxgate Magnetometer

Applications

- Monitoring the field around SRF cavities

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The use of Fluxgate magnetometers for the measurement of field around SRF cavities

Superconducting Radio Frequency (SRF) cavities are used to accelerate particles beams in linear accelerators. In high energy linacs, heat dissipation will lead to a requirement for increased plant size (cooling), increasing the overall cost of the project. Plant requirement can be reduced by reducing the cavities surface resistance (increasing the cavities quality factor Q_0), thus limiting the amount of heat loss.

Recent efforts for the construction of SLAC's LCLS-II have focused on increasing the quality factor achieved for the SRF cavities. Reducing the surface resistance of the cavities contributes to the increased quality factor. Heat and surface treatment of the niobium cavities have been the focus of extensive work in order to optimize the cavities and reduce the occurrence of trapped magnetic flux in the cavity will also contribute to an increased in surface resistance and reduction in the quality factor.

To reduce field trapping, magnetic shields are used in the Cryomodule (combining multiple SRF cavities) to reduce the amplitude of the environmental magnetic field applied to the cavities. The field inside the shield is also monitored using cryogenic fluxgate magnetometers to ensure that the background field is below a predefined threshold.

The Mag F Probe together with the Mag-01H are perfect for the monitoring of the magnetic field at cryogenic temperature and have been widely used both on the LCLS-II, and for R&D work in other labs. The recently developed 3-axis cryogenic magnetometer – Cryomag allows for the monitoring of the field in all direction at the surface of the cavities.

In addition to the use of the probes during the manufacturing process, the fluxgate sensors are also widely used during development of new cavities as the measurement of trapping/expulsion mechanism is essential to understand which treatment and process provide the best means to reduce the amount of trapped magnetic field within the cavities.

Cryomag with its three-axis sensing elements can add a level of information by measuring the field in not just one axis, but in both radial and transverses directions at the surface of the cavity.

https://gmw.com/product/mag-01h/

https://gmw.com/wp-content/uploads/2021/04/CryoMag_DS4476.pdf

https://gmw.com/product/mag-03-mag-13/

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